Proceedings of DRS 2020 International Conference: Volume 4 Education.

Stella Boess, Ming Cheung y Rebecca Cain.

DRS2020 | BRISBANE | SYNERGY

11–14 August 2020

Proceedings of DRS2020

Volume 4 Education

Edited by:

Stella Boess

Ming Cheung

Rebecca Cain

ISSN 2398-3132

This page is intentionally left blank

Proceedings of DRS 2020

Synergy

Volume 4

Editors

Stella Boess, Ming Cheung, Rebecca Cain

Proceedings of DRS
2020 International Conference
11-14 August 2020, held online.
Organised by Griffith University, Brisbane, Australia.
Volume 1, 2, 3, 4, 5

Conference visual identity concept: Tahnee Barnett
Conference proceedings cover design: Ray Lei
Proceedings compiled by Jeanine Mooij, Carlos Precioso Domingo and Stella Boess

Editors: Stella Boess, Ming Cheung, Rebecca Cain
Series Editors: Peter Lloyd and Stella Boess. Formerly, Erik Bohemia

DRS SIG section editors: Nithikul Nimkulrat, Ann Petermans, Derek Jones, Naz Börekçi, Lesley-Ann Noel, Liv Merete Nielsen, Nicole Lotz, Ingvild Digranes, Tom Fisher, Hua Dong, Emma Dewberry, Kristina Niedderer, Erik Bohemia, Sarah Kettley, Renata M. Leitão, Emmanuel Tsekleves

Proceedings of DRS 2020 International Conference: Synergy

ISSN 2398-3132

ISBN 978-1-912294-37-4 Proceedings of DRS 2020 Volume 1 Synergy Situations (ebook)
ISBN 978-1-912294-38-1 Proceedings of DRS 2020 Volume 2 Impacts (ebook)
ISBN 978-1-912294-39-8 Proceedings of DRS 2020 Volume 3 Co-Creation (ebook)
ISBN 978-1-912294-40-4 Proceedings of DRS 2020 Volume 4 Education (ebook)
ISBN 978-1-912294-41-1 Proceedings of DRS 2020 Volume 5 Processes (ebook)

Published by the Design Research Society
85 Great Portland Street
London W1W 7LT
United Kingdom

Design Research Society Secretariat
email: admin@designresearchsociety.org
website: www.designresearchsociety.org

Founded in 1966 the Design Research Society (DRS) is a learned society committed to promoting and developing design research. It is the longest established, multi-disciplinary worldwide society for the design research community and aims to promote the study of and research into the process of designing in all its many fields.

DRS International Conference Series
DRS 2002 London; DRS 2004 Melbourne; DRS 2006 Lisbon; DRS 2008 Sheffield; DRS 2010 Montreal; DRS 2012 Bangkok; DRS 2014 Umeå; DRS 2016 Brighton; DRS 2018 Limerick; DRS 2020 Brisbane online

DRS 2020 Conference team

Conference Chair
Ming Cheung, Griffith University, Brisbane, Australia

DRS Co-Chair
Rebecca Cain, Loughborough University, UK

Organising Committee
Ming Cheung, Griffith University, Australia (Conference Chair)
Rebecca Cain, Loughborough University, UK (Co-Chair)
Alan Liew, Griffith University, Brisbane, Australia
Blair Kuys, Swinburne University of Technology, Australia
Dale Patterson, Griffith University, Australia
Eleni Kalantidou, Griffith University, Australia
Rongrong Yu, Griffith University, Australia
Stella Boess, Delft University of Technology, The Netherlands

Programme Committee
Stella Boess, Delft University of Technology, The Netherlands (Chair)
Rebecca Cain, Loughborough University, UK
Ming Cheung, Griffith University, Australia
Hua Dong, Loughborough University, UK
Robert Harland, Loughborough University, UK
Peter Lloyd, Delft University of Technology, The Netherlands
Emmanuel Tsekleves, Lancaster University, UK

Conversations Committee
Eleni Kalantidou, Griffith University, Australia (Chair)
Heather Wiltse, Umeå University, Sweden
Niklavs Rubenis, University of Tasmania, Australia
Rafael Gomez, Queensland University of Technology, Australia

Workshops Committee
Alan Liew, Griffith University, Australia (Chair)
Kei Hoshi, Auckland University of Technology, New Zealand (Co-Chair)
Anna Jackson, Auckland University of Technology, New Zealand
Dian Tjondronegoro, Griffith University, Australia
Hui Tian, Griffith University, Australia
Leigh Shutter, Griffith University, Australia
Sune Klok Gudiksen, Design School Kolding, Denmark

Postgraduate Research Committee
Ming Cheung, Griffith University, Australia (Chair)
Dale Patterson, Griffith University, Australia
Gerhard Bruyns, The Hong Kong Polytechnic University, Hong Kong
Helle Marie Skovbjerg, Design School Kolding, Denmark

Hua Dong, Loughborough University, UK
Veronica Garcia Hansen, Queensland University of Technology, Australia

Marketing Committee
Ming Cheung, Griffith University, Australia (Chair)
Blair Kuys, Swinburne University of Technology, Australia
Rongrong Yu, Griffith University, Australia

Advisory Group
Tracy Bhamra, Loughborough University, UK
Cees de Bont, Loughborough University, UK
Lin Lin Chen, Technical University Eindhoven, The Netherlands
Rachel Cooper, Lancaster University, UK
Kees Dorst, University of Technology Sydney, Australia
Kun Pyo Lee, Hong Kong Polytechnic University, Hong Kong
Peter Lloyd, Delft University of Technology, The Netherlands
Paul Hekkert, Delft University of Technology, The Netherlands
Terry Irwin, Carnegie Mellon University, US

DRS Special Interest Group Chairs
Experiential Knowledge (Eksig)
Nithikul Nimkulrat, OCAD University, Canada
Design for Health, Wellbeing and Happiness (Sigwell)
Ann Petermans, University of Hasselt, Belgium
Design Pedagogy (Pedsig)
Derek Jones, Open University, UK
Objects, Practices, Experiences and Networks (Opensig)
Tom Fisher, Nottingham Trent University, UK
Inclusive Design (Inclusivesig)
Hua Dong, Loughborough University, UK
Design for Sustainability (Sussig)
Emma Dewberry, Open University, UK
Design for Behaviour Change (DBC sig)
Kristina Niedderer, Manchester Metropolitan University, UK
Design and Innovation Management (Dimsig)
Erik Bohemia, Oslo Metropolitan University, Norway
Design for Tangible, Embedded and Networked Technologies (Tentsig)
Sarah Kettley, University of Edinburgh, UK
Pluriversal Design (Plurisig)
Lesley-Ann Noel, Tulane University, US
Renata M. Leitão, OCAD University, Canada
Global Health
Emmanuel Tsekleves, ImaginationLancaster, Lancaster University, UK
Fatima Ghani, United Nations University, Malaysia

DRS2020 International Board of Reviewers

Carlos Aceves-González, Universidad de Guadalajara, Mexico
Tom Ainsworth, University of Brighton, United Kingdom
Yoko Akama, RMIT University, Australia
Canan Akoglu, Design School Kolding, Denmark
Katerina Alexiou, The Open University, United Kingdom
Andrea Augsten, University of Wuppertal, Germany
Stephen Awoniyi, Texas State University, United States
Camilo Ayala Garcia, Universidad de los Andes, Colombia
Joon Sang Baek, Yonsei University, South Korea
Yekta Bakırlıoğlu, Koç University, Turkey
Carol Bales, IBM, United States
Carolyn Barnes, Swinburne University of Technology, Australia
Nigan Bayazit, Istanbul Technical University, Turkey
Taslima Begum, Cardiff Metropolitan University, United Kingdom
Eeva Berglund, Aalto University, Finland
Tracy Bhamra, Loughborough University, United Kingdom
Richard Bibb, Loughborough University, United Kingdom
Noemi Bitterman, Technion, Israel
Stella Boess, Delft University of Technology, Netherlands
Erik Bohemia, Oslo Metropolitan University, Norway
Elizabeth Boling, Indiana University, United States
Boudewijn Boon, Delft University of Technology, Netherlands
Jacky Bourgeois, Delft University of Technology, Netherlands
Simon Bowen, Newcastle University, United Kingdom
Stephen Boyd Davis, Royal College of Art, United Kingdom
Philip Breedon, Nottingham Trent University, United Kingdom
Charlie Breindahl, Københavns Universitet, Denmark
Sarah Brooke Brooks, IBM, United States
Jacob Buur, University of Southern Denmark, Denmark
Rebecca Cain, Loughborough University, United Kingdom
Maria Emília Capucho Duarte, IADE, Universidade Europeia, Portugal
Elena Caratti, Politecnico di Milano, Italy
Meira Chefitz, IBM, United States
Chien-Hsiung Chen, Taiwan Tech, Taiwan
Chun-Di Chen, National Taipei University of Education, Taiwan
Ming Cheung, Griffith University, Australia
Bo Christensen, Copenhagen Business School, Denmark
Henri Christiaans, Ulsan National Institute of Science and Technology, Netherlands
Abdusselam Cifter, Mimar Sinan Fine Arts University, Turkey
Nazli Cila, Amsterdam University of Applied Sciences, Netherlands
Violeta Clemente, University of Aveiro, Portugal
Stuart Cockbill, Loughborough University, United Kingdom
Anne Corlin, Design School Kolding, Denmark
Paul Coulton, Lancaster University, United Kingdom

Alma Leora Culén, University of Oslo, Norway
Biljana Culibrk Fredriksen, University of South-Eastern Norway, Norway
Helene Day Fraser, Emily Carr University of Art + Design, Canada
Cornelis de Bont, Loughborough University, United Kingdom
Amalia de Götzen, Aalborg University, Denmark
João de Souza Leite, University of the State of Rio de Janeiro, Brazil
Federico Del Giorgio Solfa, National University of La Plata, Argentina
Halime Demirkan, Bilkent University, Turkey
Emma Dewberry, The Open University, United Kingdom
Orsalia Dimitriou, Central Saint Martins, United Kingdom
Judith Marlen Dobler, University Potsdam, Germany
Hua Dong, Loughborough University, United Kingdom
Kees Dorst, University of Technology Sydney, Australia
Michelle Douglas, Griffith University, Australia
Alex Duffy, University of Strathclyde, United Kingdom
Delia Dumitrescu, University of Borås, Sweden
Wouter Eggink, University of Twente, Netherlands
Philip Ely, Curtin University, Australia
Ozlem Er, Istanbul Technical University, Turkey
Carolina Escobar-Tello, Loughborough University, United Kingdom
Mark Evans, Loughborough University, United Kingdom
Luke Feast, Auckland University of Technology, New Zealand
Jonathan Joseph Felix, RMIT University Vietnam, Vietnam
Kate Tanya Fletcher, University of the Arts London, United Kingdom
Biljana Culibrk Fredriksen, University of South-Eastern Norway, Norway
Aija Freimane, Art Academy of Latvia, Latvia
Koray Gelmez, Istanbul Technical University, Turkey
Georgi V. Georgiev, University of Oulu, Finland
Colin M. Gray, Purdue University, United States
Camilla Groth, University of South-Eastern Norway / University of Gothenburg, Sweden
Ian Gwilt, University of South Australia, Australia
Penny Hagen, Auckland Co-design Lab, New Zealand
Chris Hammond, IBM, United States
David Hands, Imagination, Lancaster University, United Kingdom
Preben Hansen, Stockholm University, Sweden
Robert Harland, Loughborough University, United Kingdom
Dew Harrison, University of Wolverhampton, United Kingdom
Juha Hartvik, Åbo Akademi University, Finland
Tero Heikkinen, University of the Arts Helsinki, Finland
Ricardo J. Hernandez, Pontificia Universidad Católica de Chile, Chile
Ann Heylighen, KU Leuven, Belgium
Clive Hilton, Coventry University, United Kingdom
Michael Hohl, Anhalt University of Applied Sciences, Germany
Lara Houston, City University London, United Kingdom
Chung-Ching Huang, National Cheng-Kung University, Taiwan
Salvatore Iaconesi, Human Ecosystems Relazioni, Italy
Elaine Igoe, University of Portsmouth, United Kingdom

Nanna Inie, Lix Technologies / IT University of Copenhagen, Denmark
Robert Jerrard, Birmingham City University / Manchester Metropolitan University, United Kingdom
Wolfgang Jonas, Braunschweig University of Art, Germany
Derek Jones, The Open University, United Kingdom
Peter Jones, OCAD University, Canada
Sabine Junginger, Lucerne University of Applied Sciences and Arts, Switzerland
Titta Jylkäs, University of Lapland, Finland
Faith Kane, Massey University, New Zealand
Guy Keulemans, UNSW Art & Design, Australia
Louise Kiernan, University Limerick, Ireland
Chajoong Kim, Ulsan National Institute of Science and Technology, South Korea
Jinsook Kim, Georgian Court University, United States
Holger Klapperich, University Siegen, Germany
Ksenija Kuzmina, Loughborough University, United Kingdom
Tarja-Kaarina Laamanen, Aalto University, Finland
Sotiris Lalaounis, University of Exeter Business School, United Kingdom
John Z. Langrish, Salford University, United Kingdom
Renata M. Leitão, OCAD University, Canada
Pierre Lévy, Eindhoven University of Technology, Netherlands
Rungtai Lin, National Taiwan University of Arts, Taiwan
Stephen Edgar Little, University of Bolton, United Kingdom
Sylvia Xihui Liu, Hong Kong Polytechnic University, Hong Kong
Peter Lloyd, Delft University of Technology, Netherlands
Dan Lockton, Carnegie Mellon University, United States
Wei Leong Leon Loh, Kyushu University, Japan
James Lomas, Delft University of Technology, Netherlands
Nicole Lotz, The Open University, United Kingdom
Geke Ludden, University of Twente, Netherlands
Jeremy Madden, Galway Mayo Institute of Technology, Ireland
Anja Maier, Technical University of Denmark, Denmark
Maarit Mäkelä, Aalto University, Finland
Nathalie M. Martin, IBM, United States
Ramia Mazé, Aalto University, Finland
Chris McGinley, Helen Hamlyn Centre for Design / Royal College of Art, United Kingdom
Muireann McMahon, University of Limerick, Ireland
Massimo Menichinelli, Aalto University, Finland
Paul Micklethwaite, Kingston University, United Kingdom
Richie Moalosi, University of Botswana, Botswana
Michael Moore, Ulster University, United Kingdom
Nicola Morelli, Aalborg University, Denmark
James Moultrie, University of Cambridge, United Kingdom
Jeanne-Louise Moys, University of Reading, United Kingdom
Ingrid Mulder, Delft University of Technology, Netherlands
Yukari Nagai, Japan Advanced Institute of Science and Technology, Japan
Marco Neves, University of Lisbon, Portugal
Kristina Niedderer, Manchester Metropolitan University, United Kingdom

Nithikul Nimkulrat, OCAD University, Canada
Lesley-Ann Noel, Tulane University, United States
Conall O Cathain, Past Chairman DRS, United Kingdom
Anastasia Katharine Ostrowski, Massachusetts Institute of Technology, United States
Elif Ö**zcan Vieira**, Delft University of Technology, Netherlands
Verena Paepcke-Hjeltness, University of Texas at Austin, United States
Valeria Pannunzio, Delft University of Technology, Netherlands
Oscar Person, Aalto University, Finland
Ann Petermans, Hasselt University, Belgium
Silvia Pizzocaro, Politecnico di Milano, Italy
Philip Plowright, Lawrence Technological University, United States
Vesna Popovic, Queensland University of Technology, Australia
Mia Porko-Hudd, Åbo Akademi University, Finland
Emmi Pouta, Aalto University, Finland
Sharon Prendeville, Loughborough University, United Kingdom
Isabel Prochner, Syracuse University, United States
Sebastien Proulx, The Ohio State University, United States
Muralidhar Reddy, CMR University, India
Dina Riccò, Politecnico di Milano, Italy
Paul Rodgers, Imagination, Lancaster University, United Kingdom
Robin Roy, The Open University, United Kingdom
Noemi Maria Sadowska, University of the Arts London, United Kingdom
Fatina Saikaly, Co-Creando, Italy
Laura Scherling, Columbia University Teachers College, United States
James Andrew Self, Ulsan National Institute of Science & Technology, South Korea
Linda Shore, University of Limerick, Ireland
Anne Solberg, University College of South-Eastern Norway, Norway
Ricardo Sosa, Auckland University of Technology, New Zealand
Omar Sosa-Tzec, University of Michigan, United States
Eamon Spelman, Limerick School of Art & Design / LIT, Ireland
Nicholas Spencer, Northumbria University, United Kingdom
Gabriella Spinelli, Brunel University London, United Kingdom
Kay Stables, Goldsmiths, University of London, United Kingdom
Pieter Jan Stappers, Delft University of Technology, Netherlands
Shanti Sumartojo, Monash University, Australia
Kärt Summatavet, University of Tartu, Estonia
Qian Sun, Royal College of Art, United Kingdom
Ben Sweeting, University of Brighton, United Kingdom
Hsien-Hui Tang, National Taiwan University of Science and Technology, Taiwan
Sarah Teasley, Royal College of Art, United Kingdom
Ida Telalbasic, Loughborough University London, United Kingdom
Alison Thomson, Queen Mary University of London, United Kingdom
Clementine Thurgood, Swinburne University of Technology, Australia
Leandro Miletto Tonetto, Unisinos University, Brazil
Emmanuel Tsekleves, Lancaster University, United Kingdom
Mieke van der Bijl-Brouwer, Delft University of Technology, Netherlands
Johann van der Merwe, Independent Researcher, New Zealand

Mascha Cecile van der Voort, University of Twente, Netherlands
Karel van der Waarde, Swinburne University of Technology, Australia
Nicholas Vanderschantz, University of Waikato, New Zealand
Theodora Vardouli, McGill University, Canada
Arno Verhoeven, The University of Edinburgh, United Kingdom
Penelope Webb, Philips, United States
Heather Wiltse, Umeå Institute of Design, Sweden
Matthew Watkins, Nottingham Trent University, United Kingdom
Joyce S. R. Yee, Northumbria University, United Kingdom

Table of Contents

Section: Design for Belonging

Section: Experiential Knowledge

Highlights: Pluriversal Design SIG

Highlights: Inclusive Design SIG

Volume 2: Impacts

Highlights: Objects, Practices, Experiences, and Networks SIG

Highlights: Sustainability SIG

Highlights: Design Innovation Management SIG

Volume 3: Co-creation

Highlights: Global Health SIG

Highlights: Behaviour Change SIG

Volume 4: Education

Volume 5: Processes

This page is intentionally left blank

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

DRS President's Foreword

Rachel COOPER
doi: https://doi.org/10.21606/drs.2020.128

The Design Research Society is a unique organisation comprised of people dedicated to the value of design and design research and its value to our people and our planet. Without a dedicated group of volunteers, we would not exist; people who offer their services to the management of the organisation, people who host conferences and people who submit papers and their combined intelligence to further knowledge of design and its contribution to the world. This year the fragile nature of the planet, of human relationships and the basis of our economy and society has been illuminated (fires, floods and a virus). We have seen the effect of radical changes in patterns of behaviour; both positive influences on the environment and negative influences on health and wellbeing and livelihoods. There are many design challenges and design researchers have come to the fore. This conference is a triumph of that creativity and fortitude, embracing the virtual world and bringing together all those people who so want to exchange ideas. Many of the papers are pre-Covid, and whilst we should not forget the conversations and research directions before this pandemic, it will, of course, shape our future and our conversations. People make the DRS and whether online or in person the conversations will continue. Let us together build a wider, deeper and stronger global design research community.

As a foot note I would like to say that 2020 marks a turning point for DRS in so many ways, we have a new structure of the organisation, that is a new International Advisory Council and executive who are eager to continue to move forward. We have a new virtual conference and I would like to thank the conference team for such a triumph in changing format and delivery mode, and also to you the members and delegates who are embracing this with your attendance. Enjoy the conference and the future DRS.

Rachel Cooper
DRS President 2020

DRS2020 Editorial

Stella BOESS, Ming CHEUNG and Rebecca CAIN

doi: https://doi.org/10.21606/drs.2020.100

Never before has a Design Research Society Conference happened in such uncertain and changing times. When we embarked on planning the DRS2020 Conference in Brisbane, Australia, we were in a different time, when unrestricted travel and meeting-up face-to-face at academic conferences was the norm. Then the COVID-19 global pandemic happened, which prompted us to rethink and reimagine DRS2020 in a new format.

In recent times, the debate around the sustainability of physical conferences has been starting to surface. This was an issue the DRS was starting to grapple with, but the practicalities of a blended or entirely virtual conference were still uncharted territory. Even before the pandemic was born, the devastating Australian bushfires were causing people to consider whether it would be safe to travel to Australia. Ultimately, the pandemic made a physical conference impossible, and the conference host Griffith University made a joint decision with DRS to convene DRS2020 as a virtual conference. DRS2020 marks an important turning point in the history of DRS conferences, being the first conference to go entirely virtual. We are very grateful to Griffith University for embracing this challenge, and for their leadership and management of the virtual conference in such complex and difficult times.

DRS conferences are international biennial events, held to further and promote design research. They are inclusive conferences, bringing together a wide range of disciplines and communities related to design research, with the aim of fostering new debates on the important issues of the time. Historically, DRS conferences have always taken place through gatherings of delegates in physical venues at a host organisation, with face-to-face presentations and discussions, accompanied by written conference proceedings. New collaborative formats have been added over time – for example, Conversations which were introduced in 2014. DRS2020 took on the challenge of transforming these formats into a virtual experience. Also worth mentioning, the DRS2020 Postgraduate Research Day is pioneering in that it is inclusive of both PhD and MPhil students and of their theory-driven and/or practice-led research projects. In this sense, DRS2020 becomes a prototype for a new type of virtual and inclusive conference experience and continues to build on the legacy of innovation from the previous conferences.

The 144 papers in these proceedings were conceived of and written in our pre-COVID world. Just three authors were able to make late additions to their papers addressing the current situation (165, 398 and 402). These proceedings therefore provide an interesting juxtaposition, whereby what is written represents design research in the world as we knew it, whereas the discussion that these papers will promote during and beyond the conference will almost certainly be viewed through the lens of the complexities and challenges we now face. The discussions and reflections in the proceedings are a timely barometer for what the international design research community is thinking about and working on, and they will surely prove inspiring and thought-provoking for design researchers worldwide. We hope that you enjoy reading them as much as we have enjoyed curating them.

Themes

The overall theme for DRS2020 is Synergy – the coming together of people and disciplines in design research to create a positive impact. On the one hand, design research champions the uniqueness of disciplinary knowledge and creativity, yet on the other hand, the complex world we now live in demands a more synergistic approach to creativity and problem-solving whereby different mindsets, backgrounds and perspectives come together to realise transformative visions of the future. DRS2020 celebrates these emerging synergistic approaches to design research and seeks to explore their exciting possibilities for addressing multi-faceted problems, supporting participation, and transforming problematic situations into desirable ones.

For DRS2020, we used an emergent approach to the development of the conference programme, with a general call for papers around five themes – Situations, Impacts, Co-Creation, Education and Processes. These themes emerged in discussions between the Organising and Programme Committees at an early stage of the conference planning and were felt to capture a broad spectrum of current design research topics from which we would be able to build more focused themed sections. Continuing the collaborative approach to theme building, we asked the international reviewers to indicate to which of these themes (or others) each paper contributed. Following the acceptance of papers, the reviewers' indications helped us to cluster the papers into the rich programme we have here, with the main conference theme of Synergy being an interwoven thread throughout.

Impacts and Co-creation are the biggest theme categories, reflecting the design research community's commitment to applied research. Situations are an emerging theme reflecting the community's increasing awareness of diverse circumstances and contexts. With Australia as the host country for DRS2020, it is worth noting that 12 out of the 144 papers mention Indigenous communities (108, 135, 165, 166, 177, 187, 198, 228, 277, 278, 387, 402). 32% of the accepted papers are from Oceania, 18% from Asia and 33% from Europe, compared with 5% each from Oceania and Asia and 64% from Europe at DRS2018. Themes such as pluriversal design and diversity, design for global health and wellbeing, collaboration, sustainability and education continue to attract new directions in research and illustrate the potential of design research to change the world for the better. The theoretical foundation of research into (design) Processes continues to be an enduring theme, the development of which can be traced back through all previous DRS conferences. Some sections were additionally clustered by domain, such as graphics, mobility, experience design or data. A point to note is that the paper clustering differs somewhat between conference programme and these proceedings, as the former also needed optimising by time zones to allow presenters from around the world to interact in their session discussion.

A further way we grouped the papers was around existing themes of interest within the DRS: those of the DRS special interest groups (SIGs). These open and dynamic groups of DRS members form around current and emergent issues in design research, and they welcome participation. The DRS SIGs are one of the main ways that the DRS drives forward debates and keeps a pulse on ongoing topics as well as emergent topics of the day. The DRS currently supports eleven SIGs, all of whom have contributed to these proceedings by selecting and grouping just over a third (55) of the submitted papers into SIG themed sections. Some of these sections are chaired as sessions by SIG members at the conference. This way, the SIGs hope to give authors the opportunity to get to know the SIGs and their members and to get involved. The eleven SIGs are Health, Wellbeing and Happiness, Global Health, Design Pedagogy, Pluriversal Design, Design for Behaviour Change, Experiential Knowledge, Human-Object Interactions, Inclusive Design, Sustainability, Networked and Embedded Technologies and Design Innovation Management. While the SIGs selected their set of papers because the papers speak to current and future themes of the existing DRS SIGs, many more of the accepted papers also relate to the SIG themes and all authors are welcome to engage with a SIG. DRS members are also free to propose new SIGs. One of the aspirations of the DRS conferences is to catalyse the creation of new SIGs, through the collective community building and knowledge sharing which takes place.

Review

Despite moving to a virtual conference format, what stays a predictable constant is the academic quality of the work presented at DRS conferences. Our standards remain high, through the excellent work of the authors, our Programme Committee and the community of reviewers. The Programme Committee is appointed by the DRS and chaired by a member of the DRS International Advisory Council. We are privileged to have many eminent scholars in the design research community within our reviewer pool, but also early career academics who are supported in writing peer reviews, a core part of their academic development, and who form our reviewer pipeline for future conferences. We endeavoured to match reviewers' expertise with papers through topic selection and automation, with some manual adjustments. The reviewers provided feedback to authors on how to improve their papers.

In total we received 280 full paper submissions in a one-stage submission procedure, of which 269 were viable to go to review. In total the 192 reviewers wrote 553 reviews, using reviewer guidelines. The reviews averaged 350 words. Each paper received two, sometimes three reviews. 87 papers (32%) were accepted with minor revision and a further 57 (20%) accepted following (major) revision. This represents a 52% acceptance rate. As in previous conferences, we used the ConfTool system to manage the submission process. The ability of authors to rate and comment on their reviewers as in previous years, helps to drive up the quality of the review process. The authors rated 237 (43%) of the reviews with an average of 4.4 on a scale of 1-5 on the criteria *justified*, *constructive*, *encouraging*, *fair* and *convincing*.

Words of thanks

DRS2020 would not have been possible without the contributions of many excellent people who have devoted their insight and experience to the conference. We would sincerely like to thank the Local Organising Team at Griffith University for their remarkable work in transforming the conference into a virtual experience, and the extra time, effort and resources that this has involved. In particular, undertaking this transformation 4.5 months before the conference launch has entailed a significant level of creativity, courage and perseverance. We also thank the DRS for their expertise and guidance in the programme and review aspects of the conference. The authors, the Programme Committee and all the reviewers all deserve thanks for their valuable time and expertise in ensuring the high academic quality of this conference, as well as the SIG convenors for their role in curating themed tracks. Finally, we thank Griffith University and the Design Research Society for supporting the conference.

We hope that you enjoy these proceedings, and that they provide a thought-provoking and inspiring read.

Stella Boess, DRS2020 Programme Chair
Ming Cheung, DRS2020 Conference Chair
Rebecca Cain, DRS2020 Conference Co-Chair

About the Authors:

Stella Boess is the DRS2020 Programme Committee Chair and a member of the DRS IAC. She has a design background and is Assistant Professor of Participatory Inclusive Design at Delft University of Technology and Director of the Inclusive Design Lab.

Ming Cheung is the DRS2020 Conference Chair. She is Professor of Experience Design, Director of Griffith University Centre for Design and Innovation Research, Head of Design Innovation Lab, and recipient of multiple research/teaching awards, with rich senior management experience in industry.

Rebecca Cain is the DRS2020 Conference Co-Chair and a member of the DRS Executive Board. She is Professor of Transdisciplinary Design and Associate Dean for Enterprise in the School of Design and Creative Arts at Loughborough University, UK.

This page is intentionally left blank

Volume 4
Theme Education

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Editorial: theme Education

Rebecca CAIN, Stella BOESS

doi: https://doi.org/10.21606/drs.2020.104

he theme of Design Education always attracts a great number of submissions at DRS conferences, and this year is no different. The call for papers asked for contributions which explored how design education is changing and needs to change, and how working designers and design researchers update their skills to meet the challenges of the present and the future.

When submitting papers, authors were able to pick appropriate keywords for their papers which allowed the emergence of seven sub-themes within the Education theme – Design Thinking, Design Techniques, Design Inspiration, Researching the Material, Ethics and Health, Community and Communication, and Transdisciplinarity. This is in addition to the DRS SIG PedSIG which also has a themed Education session within the proceedings in which they highlight a number of papers that speak particularly to current themes in Design Education. However, all of the papers in the education theme are relevant to PedSIG. The papers in this Education theme are wide-ranging in scope and address education in its broadest sense. There are both examples of design research within educational settings and also in applied settings where education is implied more through the developing and changing practices of those in the real-world.

The first Education sub-theme is **Design Thinking**, with papers which describe design thinking both within educational settings and within an applied public health context. Paper 334 describes an approach to design strategy as innovation for social impact and a pedagogical approach/curriculum for teaching design strategy is discussed as a core design research activity. Paper 166 traces how a Design Thinking approach can be introduced in public health services. It does so through the introduction of a workshop in which stakeholders were guided in using it to develop public health strategies in Taiwan, using adolescent tobacco prevention as a case for research. Paper 294 acknowledges the need to improve the narrative design of educational interventions such as digital simulations and scenario-based learning programmes to aid experiential learning. The reported study turns to the expertise of narrative designers for games, where storytelling for interactive narrative has a long history of testing, iterating and perfecting.

There are three papers clustered into the sub-theme of **Design Techniques**, describing research into different types of design technique. Paper 280 starts with investigating and discussing the changes in designers' conception throughout product innovation projects. The analysis revealed specific conditions that facilitate novel conceptual changes necessary to create an innovative product design concept. The next two papers both describe two specific techniques and the development needed for the future: Paper 109 critically examines brainstorming and the how to develop it to answer the need for it for collective creativity in the future, while Paper 256 does not report on pedagogy so much as it develops building blocks for it: new Design Heuristics as a tool to help boost designers' creativity in the early design process.

The **Design Inspiration** sub-theme specifically draws together papers using design research within student settings, thus inspiring the educational experience. Paper 203 reports on the development of a modular prototyping system for the design of space vehicle interiors, deploying it in a student class studio setting where designers utilised these elements throughout a team project. Paper 284 shares learnings from three case-studies across undergraduate, postgraduate, and design research projects, exploring the possibilities and limitations of VR tools for future industrial design practitioners. These projects detail the possibilities for VR in industrial design and illuminate some of the challenges in teaching these emerging technologies and tools to design students. Finally, Paper 298 explores the benefit of incorporating both distant and near sources of inspiration in concept generation in a design studio context. An idea-generation process implemented in a third-year industrial design studio for three years is discussed.

The **Researching the Material** sub-theme draws together papers which focus on research practices. Paper 229 present an interdisciplinary undergraduate course in which students interacted with clay and wool. By engaging novices in material-based craft processes, they examined renewed ways of experiencing the materials to reconsider everyday material interactions and dependency and responsibilities in regard to materials in general.
Paper 335 asks whether too much passion can be detrimental in the design studio, using autoethnographic accounts as design educators in a university recently established in the Middle Eastern and North African (MENA) region. Paper 337 investigates the use of five postphenomenological concepts by bringing them to design practice and using them as a "generative lens" in design research. The reflections point to a responsibility of the designer to incorporate ways of being, ways of knowing and values on top of specific uses and utility.

The **Ethics and Health** sub-theme describes two studies in which students work on ethics and health design problems, and another paper which looks at decision making. Paper 107 identifies how triads of student designers from user experience (UX) and industrial engineering (IE) disciplines frame the problem space and generate solutions, foregrounding the ethical character of their judgments in response to an ethically-nuanced design task.
Paper 110 tackles the support of contraception decision-making and examines the relevant goals of the immediate actors: personal goals of the patient and physician as well as the goals of the public health system. Paper 376 addresses the multifaceted problem of psychotherapy,

exploring what design can do for psychotherapy in a digital age. Student cohorts worked on this question in design classes.

The **Community and Communication** sub-theme draws together three papers which provide case studies of real-world educational initiatives in Australia and China. Paper 276 presents LiveSpace, a transdisciplinary work-integrated learning (WIL) design studio unit at Griffith University and highlights two highly successful community projects. Paper 291 presents Tongji-Huangpu School of Design and Innovation, a newly reformed educational institution in China. The case study gives an overview of the school, outlines the practice of since its establishment and elaborates the tensions during transition phases. Synergy, the concept of the whole being greater than the sum of its parts, is identified as the goal of reducing tensions. Finally, Paper 317 details the development of a new design curriculum at Queensland University of Technology, which prompted a study to revisit the nature and purpose of portfolios.

The final sub-theme before the Education special interest group highlights is **Transdisciplinarity.** These papers demonstrate transdisciplinary approaches for students and academics working with external partners, stakeholders and communities and represent a growing area of importance for design research. Paper 143 discusses how visual communication design education could be improved by incorporating transdisciplinary learning within the design curriculum and providing lifelong training to professional designers and design educators. The conclusion is that design education needs to be adapted to allow future designers to solve the gradually complex design problems and work in non-design industries. Paper 243 describes the work of the Department of Design (Brunel Design) at Brunel University London, which provides design innovation support programmes to businesses by involving its students and academic and professional staff. This paper presents a literature review on design innovation and its benefits in collaborations between academia and industry. Finally, Paper 344 acknowledges that society is dealing with challenges which are complex, dynamic and networked and posits that Transdisciplinarity is one of the responses to this. Transdisciplinarity, however, is seen as disruptive to existing university structures, and there is a need to examine the challenges to inform future directions. The paper presents an exploratory study into the existing challenges towards implementing transdisciplinary education through action research in a graduate degree program.

Overall, the papers within the Education theme demonstrate a body of design research which tackles education as a broad concept, both within educational settings, and also more widely within practice. There are examples of inspiring innovation within design education, with a variety of case studies and real-world examples within an international context. Many of the papers point to the need for further research, and in this sense, these papers provide inspiring directions for future design research. The area of Transdisciplinarity in particular is an evolving area of importance due to the complexity and networked nature of the problems that design can tackle. But how this translates into design education is currently less clear, given the static and traditional structures of many academic institutions. This calls for a new type of synergy within design education, as students develop new mindsets to think in transdisciplinary ways and become the agents of complex change.

The Education special interest group highlights will point to two issues of interest in this regard: the development of the individual learner, and the relationship between student and teacher.

Teaching Design Strategy for Social Impact: A Synergistic Pedagogical Framework

Brooke BRANDEWIE[a]*, Neha MANN[a], Claudia REBOLA[a]

[a] University of Cincinnati, United States of America
*Corresponding author e-mail: brandebc@ucmail.uc.edu
doi: https://doi.org/10.21606/drs.2020.334

Abstract: Design and strategy are inherently oriented toward change and innovation. Innovation is about invention and implementation, but dependent on design, strategic design requires management. This paper describes an approach to design strategy as innovation for social impact. A pedagogical approach/curriculum for teaching design strategy is discussed as a core design research activity. Future-focused yet human-centered methods are emphasized as the framework for structuring the projects to yield outcomes towards some of the most pressing global issues we face today.

Keywords: design strategy; design pedagogy; interdisciplinarity; social innovation

1. Introduction

Strategy is defined as either "a careful plan of action" or "the art of devising or employing plans toward a goal" (Merriam-Webster, 2019). The purpose of strategy in an organization is to direct action toward a desired outcome. In order to develop a shared and visceral understanding of the outcome, there needs to be a visual demonstration of this strategy. Employing design and design thinking mechanisms is ideal for this purpose. (Brown, 2005). Design and strategy are inherently oriented toward change and innovation. Innovation is about invention and implementation, and while innovation is dependent on design, strategic design requires management. It is about putting together a plan to achieve an objective, and is a goal-oriented planning process that examines the relationships between people, contexts, cultures, organizations.

The purpose of this paper is to describe a curriculum for teaching design strategy as a core synergistic design research activity. This course provides an introduction to Design as a combination of strategic problem-setting and problem-solving activities within a service/ social system levels approach for a multidisciplinary audience. Students explore methods of design thinking that apply to all design disciplines to identify and analyze key problems with the aim of conceptualizing innovative design opportunities. More specifically, this paper advances an approach towards a framework for teaching design strategy through three main focus areas: *Trend as Strategy, Empathy as Strategy, and Vision as Strategy.*

First, *Trend Forecasting* is defined as a strategic research practice that detects patterns or shifts in attitudes, mindsets or lifestyle options that run against current thinking or how people normally behave, live, dress, communicate or trade (Raymond, 2010). Designers use short-term trend forecasting to inform color, material, finish, function, and purpose decisions, as well as macro-trends to connect future shifts with design strategy through forecasting approaches like scenario planning (Evans, 2004). Trend forecasting articulates these shifts to reflect what is yet to become "status quo", yet it is also used to ensure resources (time, money, and materials) are utilized wisely. Having a steady flow of external provocation on what is possible encourages experimentation and exploration of new ideas. Ultimately, trend forecasting adds value by 1) providing clarity, 2) provoking meaningful newness, and 3) increasing self-awareness. For over 25 years, design faculty at the University of Cincinnati have emphasized and honed trend forecasting as an integrated design research methodology. For designers to learn and actively practice it in their work is a strategic advantage, thus we believe it is an essential competency that our design students should acquire. In learning this method, students become more aware of what is happening around them, and think more critically about change, and how to find patterns and identify meaningful connections. This in turn, prompts them to be more self-reflective thus aware of their own values, beliefs and behaviors, and to consider these attributes in a broader societal context. Therefore this methodology was used in the first part of the course to teach students about how to set objectives of a strategic design project.

Second, empathy places the "people" at the center of the process and is generally defined as "the action of understanding, being aware of, being sensitive to, and vicariously experiencing the feelings, thoughts, and experience of another" (Merriam-Webster, 2019). The second project focused on teaching students about how to identify opportunities for innovation within an organization. It focused on determining how to innovate contextually through user-centered mapping methods. In an era where technology is outpacing human capability in many ways, humanistic and empathic mindsets and approaches are valued in design thinking and practice more than ever. Therefore, designers need to develop crossover soft skills to conduct user research, analytical skills to interpret data, technical skills to translate it and strategy to anticipate the system in which the innovation thrives.

Lastly, design teams creating empathic design concepts must consider the non-tangible, business-oriented aspects of their work. It can be inferred that design strategists' real contribution lies in the actual business implementation, in addition to concept realization. This part of the course focused on teaching students about identifying success measures for a design project through critical assessment methods. It referenced the *United Nations Sustainable Development Goals* as a foundation for which students would frame their final projects (United Nations, 2015).

2. Background

2.1 A Brief History

In the past, design and business have operated in silos, with design taking on the role of a service to business and marketing. However, the success of a business or brand is reliant on its design practices. In order to be able to quantify this contribution, the role of design has expanded to encompass that of the innovator, facilitator and mediator, advocating the value of design in the organization and in the broader external context – 'as a creative, problem-solving response to change', and as a way to enable interdisciplinary action and a shift in organizational behaviors (Best, 2011). This shift from silos to synergistic interaction of design practices and business led to a systems-approach to problem solving – Design Strategy.

The face of design strategy in organizations has changed from annual top-down planning to heavy focus on big data, shorter innovation cycles and using techniques such as competency modeling and real-options analysis (Camillus, 2008). However even this revised process of developing strategies is insufficient in adapting to the complex environment of contemporary problems. There is a need for real-time primary insights, engaging multiple stakeholders, hybridity in skills and methods like rapid prototyping for agile innovation (Brown, 2005). Design Strategy applies the principles of traditional design to complex challenges like health care, education, and climate change. It redefines how problems are approached, identifies opportunities for action, and helps deliver well-rounded and resilient solutions (Helsinki Design Lab, 2017). When translated to products, design strategy focuses on what a company should invest in doing, and why it is important. As demonstrated in Figure 1, it is an intersection of user needs, business goals and technological viability (Brown, IDEO).

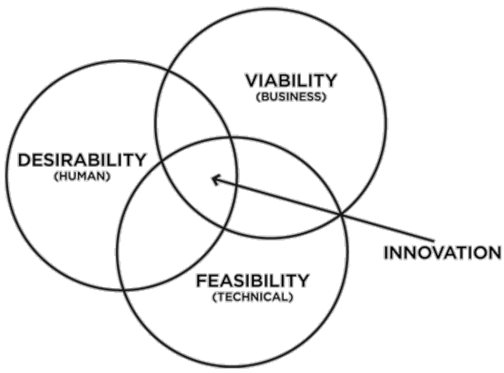


Figure 1 The intersection where design thinking lives, IDEO.

Now more than ever, designers are increasingly identifying as problem-oriented as compared to traditional solution-oriented design practitioners. These two approaches can be exemplified as noun vs. verb, where a traditional designer would design 'a chair', a design strategist would fulfil the need 'to sit' (Bengtsson, 2013). In order to solve complex problems of the modern world, designers need to immerse into unfamiliar situations and collaborate with non-designers, recognize emerging patterns, draw on their skillset and the expertise of others (Muratovski, 2016). The emerging profile of a design strategist is moving designers away from their individualistic notions of creativity, from "isolated genius" theories of innovation, towards an understanding of creativity as a social process. It is a holistic approach to innovation in organizations – of communities – rather than individuals. (Lester, Piore, & Malek, 1998).

2.2 Design Strategy, Businesses and Brands

The long-term success of organizations is heavily reliant on the consistency of their brand strategy and how it is reflected in each product while being mindful of emerging trends. Each product is a reflection of the company's decision-making and socio-political stance. The launch of the Aeron chair in 1994 by Herman Miller was a pivotal shift in strategy not only for the producer but for manufacturers across the seating industry. The company chose to produce a chair based on ergonomic comfort instead of one based on a traditional office hierarchy. This decision is a clear statement that Herman Miller supports—literally and figuratively—the concept of lateral management and comfort over rank. A breathable mesh seat with an ergonomic frame, the Aeron came not in secretary, manager, and executive styles, but rather in small hips, medium hips, and large hips sizes. The Aeron represented flat management and the IPO boom of the 1990s.

Brand strategies represent what the brand stands for and imply a close relationship with the target audience, creating functional and emotional ties. This positioning is a result of strategic understanding of the target audience to create relatability with the user's and brand's values (Cagan & Vogel, 2012).

John Camillus, an educator of Strategic Management, calls problems of the complex world as 'Wicked Problems'. He illustrates this idea with the problems faced by Walmart, in that they are unable to satisfy its multiple stakeholders with different values and priorities. The new consumer seeks social accountability towards the environment and values ethical and local production, which in their case, would warrant the adoption of new strategies, each leading to new challenges. Wicked problems like these tend to be unprecedented and do not have proven 'right answers' (Camillus, 2008).

2.3 Design Research in service to Strategy

In order to begin dissolving complex issues, design research with its hybrid methodologies and agile processes can benefit organizations. In the case of Walmart, they can understand their stakeholders' values better by involving them early-on in the strategy and planning process (Camillus, 2008). If multiple stakeholders brainstorm and develop future scenarios, there will be synergistic understanding of the unique values across the organization and how it relates to the large company vision. This also benefits the organization by introducing an early buy-in opportunity by multiple stakeholders (Simonarson, 2017).

There are different levels of design strategy: strategies to decide what to execute/design (products-oriented), strategies in the system (systems-oriented) and strategies to execute the design (organizations-oriented). To transition from a designer of 'things' to a strategist of 'systems', designers must develop core design research skills. These skills exceed incorporating research within the design process. To perform design research, designers need to have the tools to conduct 'observations' of complex human activities, then they will need to be able to 'describe' their observations, 'explain' what has been observed and described, and finally 'prescribe' possible solutions that could improve these activities (Dorst, 2008). It was important for the faculty to introduce and integrate a broad array of tools and methods of design research to equip the students with the skills described by Kees Dorst's 'Shaping a Design Revolution' as essential for designing strategies. Students would then have a broader toolkit to apply when developing a more comprehensive approach to solving complex problems of today.

Another principle of design research – Agility – is highly valuable in strategic decision-making. When dealing with complex problems, it is difficult to analyze all concepts before deploying them in action. Strategies can no longer be standardized and hence require abandoning the idea of arriving at a perfect solution before implementing it (Camillus, 2008).

The new norm requires organizations to construct and learn. Focusing on action, organizations need to build a minimum viable product, which in turn collects real-time data for them. This data will provide insights that will build up to refining and designing the strategy (Greenfield, 2014). Doing so enables them to analyze their options quickly and through specific insights from the stakeholders.

3. Methodology: Course Framework and Pedagogical Activities

Responding to the needs of advancing a methodology for design strategy for innovation, a pedagogical curriculum to teach design strategy is discussed as a core design research activity. The following paragraphs describe a course providing an introduction to Design as strategic problem-setting and problem-solving activities within a service/social system levels approach. The learning objectives of this course were:

- Understand research contexts
- Frame problems and define opportunities
- Analyse all relevant factors: social, technical, environmental, economic, political
- Model design thinking methods
- Synthesize research findings into conceptual strategies

The course was divided into three projects, all attempting to frame the *WHY / HOW / WHAT* of design strategy.

3.1 Project 1: Trend as Strategy (WHY)

The first five-week project focused on "Trends as Strategy". This part of the class aimed to teach students how to set the objectives of a strategic design project. The Trend Forecasting methodology provided an introduction for how to conduct well-rounded secondary research, as many students came from traditional design backgrounds that emphasized more of making as compared to researching. The goals of the project were to:

- Introduce students to best practices in trend analysis and forecasting when researching, collecting, analysing and synthesizing trend inputs
- Develop students' critical thinking skills by contextualizing their research through analysis of sociological, technical, economic, environmental and political factors (STEEP factors)
- Introduce methods and techniques for interrogating the trend topics to identify potential future implications

First, students wrote down categories of their interest, mapped on the wall and synthesized to form clusters. These topics were the starting point for the students to conduct their trend analysis. Students then worked in their groups (approximately 3-4 students per group) to develop a compelling, credible bibliography of sources as a foundation for their research.

Through several rounds of analysis and synthesis, students worked within their groups to identify common patterns across their evidence, or 'manifestations' (as referred to in trend vocabulary). They laddered up from these commonalities to establish themes, which represent near-term (2-5 years) trend shifts (Figure 2). Each member of the group took ownership of refining and articulating one of the trends. Faculty provided feedback on their synthesis in a critique session, and then facilitated class discussion to map larger macro themes from their initial round of analysis.

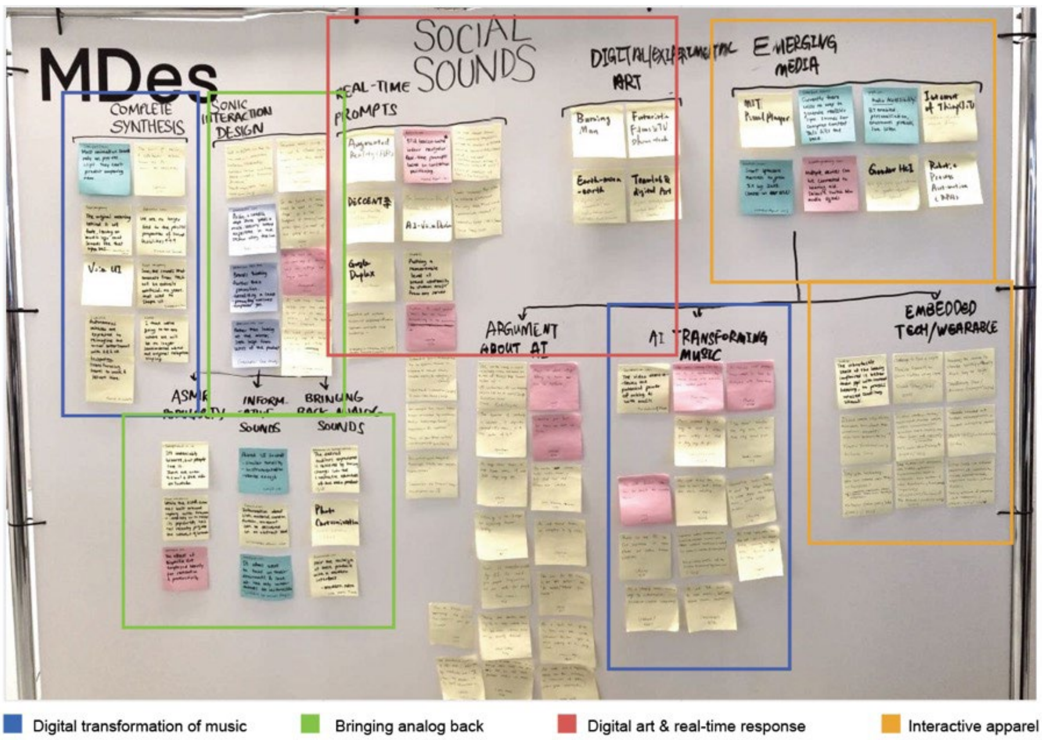


Figure 2 'Bucketing' process of emergent manifestations during the trend analysis

At the end, each group designed a handbook encompassing the group's near-term trends (Figure 3).

Figure 3 *Final trend book developed by a group of MDes students*

3.2 Project 2: Empathy as Strategy (HOW)

The next five-week project focused on "Empathy as Strategy". Students were introduced to user-centered mapping methods. Students utilized these methods to identify and propose strategies for systemic changes in a local organization of their choice.

The goals of this project were:

- Develop skills about strategic/system changes within an organization.
- Learn tools and methods for mapping systems including but not limited to offering maps, systems maps, customer journey maps, actors maps, touchpoint matrices, use cases, and blueprints.
- Develop visual and/or semi-functional prototypes
- This part of the course focused on teaching students about identifying opportunities for innovation within an organisation. To propose an intervention in a brand strategy, it is key for the designer to be able to empathize with the brand's vision, mission and culture. In this course project, students individually selected one local organization of their interest. They practiced primary qualitative research methods such as semi-structured interviewing, short ethnographies, etc.

combined with secondary research through the company website, other sources in news and media, to develop a holistic understanding of the organisation culture and dynamics.

For the research conducted to be translated into visuals, the students were introduced to several data visualisation tools. They captured the timeline of the organisation as a visual narrative. This brought insight into the journey of the organisation and how each milestone re-shaped their vision and mission. Each organisation was also plotted on a brand archetype wheel, which identified its basic characteristic or perceived brand point-of-view (Fiorelli, 2015). A student working with a local community of apparel designers and entrepreneurs where they learn how to build a brand; her organisation fell in the category of *Caregiver* - as it provides a collective learning experience (Figure 4).

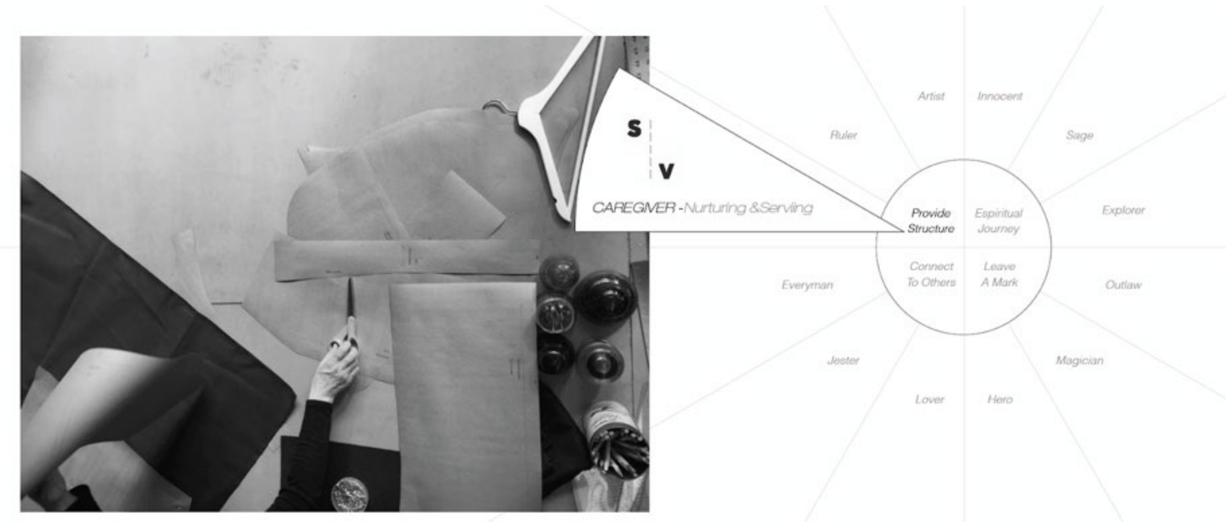


Figure 4 Brand archetype wheel of a local community apparel organization

Students also plotted the services provided or core competencies on a Strategy Wheel as demonstrated in Figure 5. The strategy wheel provides a picture of how a company differentiates itself from its competition (Montgomery, 2012). They determined the organizational characteristics that they want to evaluate by assessing the competencies of their selected organization and competitors. These characteristics were crucial to the success of the wheel as it represents ideal measures.

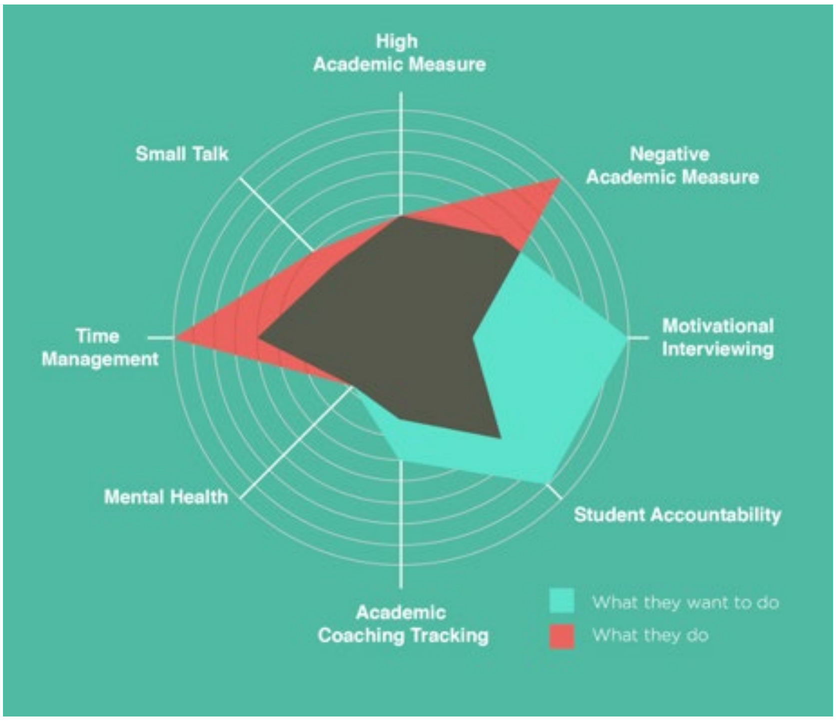


Figure 5 *Strategy wheel of an academic service organization*

Then they proceeded to determine a value for each of the characteristics to visualize the strategy wheel. Another essential tool for empathising with the organisation was Persona Mapping, as demonstrated in Figure 6. Personas are archetypal representations of users describing their behaviours, values and needs. A persona is based on a fictional character whose profile gathers up the features of an existing social group that represents the organization (Open Design Kit, 2019).

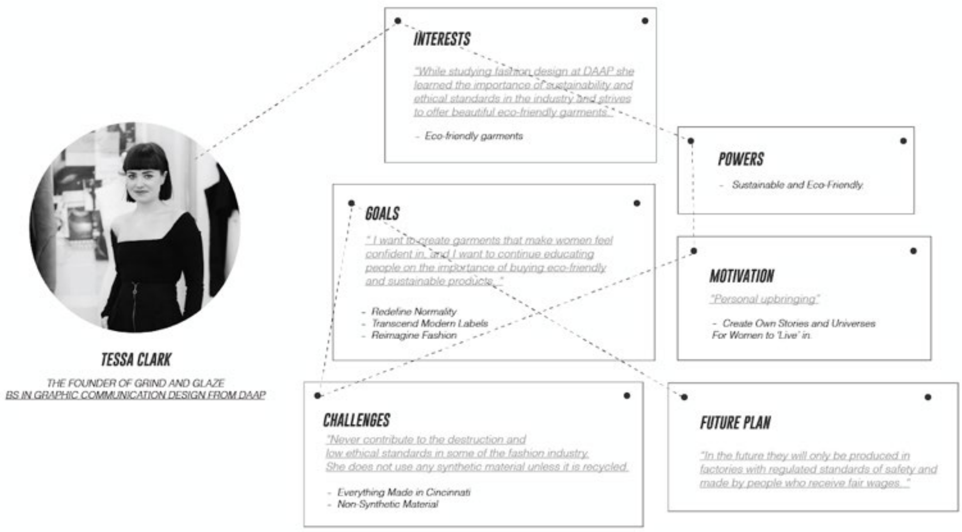


Figure 6 *Persona of one of the designers at a local community apparel organization*

Other tools mapped the journey of stakeholders, the brand, actors, offerings of the organisation and customer journey (Service Design Tools, 2019). These graphs were used to represent the system of actors with their mutual relations, providing a systemic view of the service and its context. A key mapping tool was the Empathy Map (Figure 7), frameworks that help develop deep, shared understanding and empathy for other stakeholders. The results were insights as considerations to affect the design process, e.g. improving customer experiences (Gray, 2018).

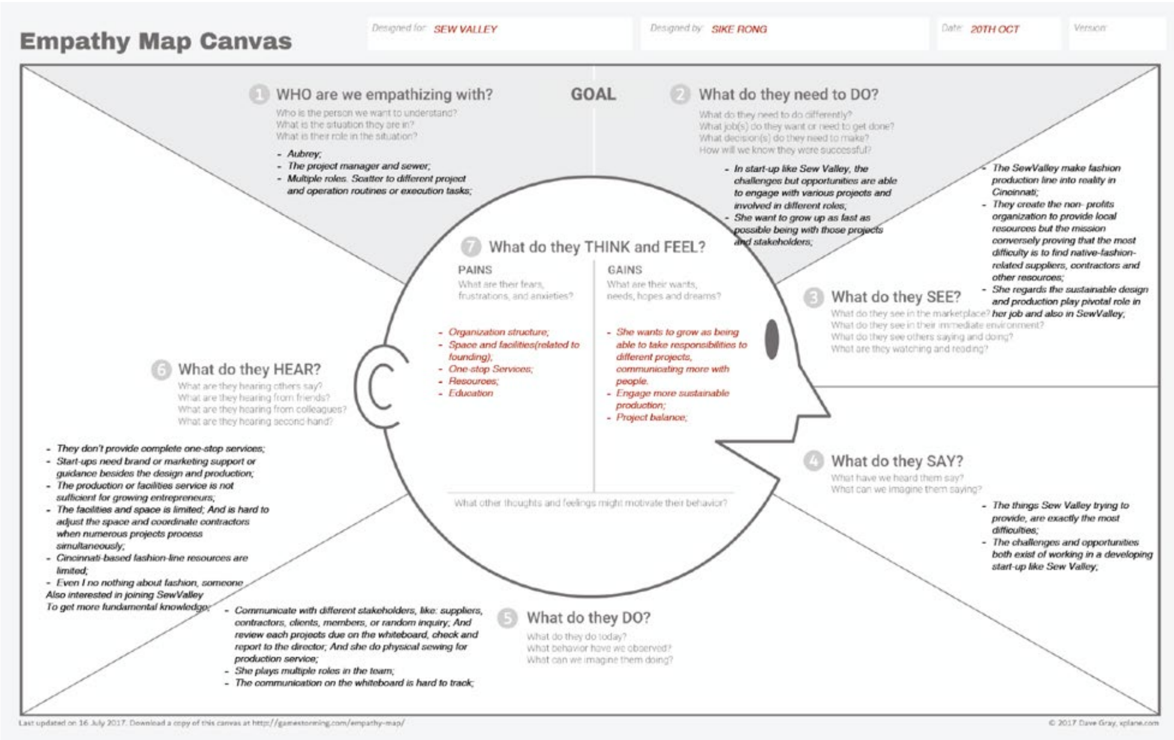


Figure 7 Empathy Map of a local community apparel organization

The findings from the research activities were combined in a displayed exhibition that captured the entire process (Figure 8 & 9). The insights from the research informed the interventions proposed by the students. Intervention opportunities ranged from revising the brand identity to a structural shift in the organisation hierarchy. Students were able to illustrate the opportunities for improvement in the organization and also created a shared vocabulary to present this holistic understanding to their peers and faculties. Selectively utilizing all of the diagrams developed in the previous phase, each student built a narrative of the organisation based on what was essential to understand the intervention.

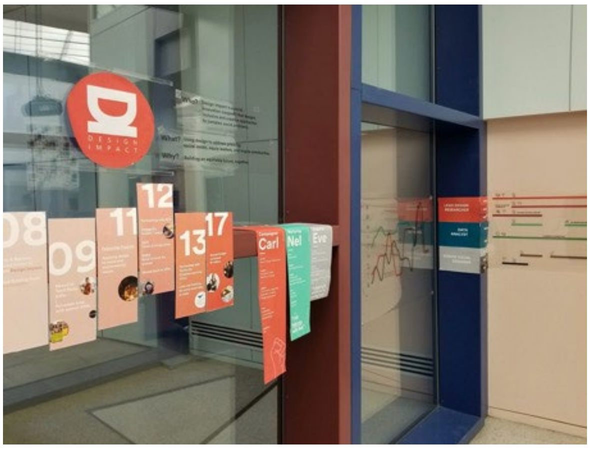


Figure 8, 9 Student work displayed as a final exhibition

3.3 Vision as Strategy (WHAT)

The final five weeks focused on learning critical assessment methods for developing design strategies. This part of the course focused on teaching students about identifying success measures for a design project.

After having practiced design thinking and research tools in the previous two course projects, the students were re-oriented through the *UN Sustainable Development Goals* to apply these skills to social innovation design. In groups, students picked topics of interest and utilized the UN goals as the framework for strategizing a brand concept. The brands conceptualized and visualized by the students ranged from products to services, addressing global challenges across water, sanitation, hygiene, energy and sustainability. The students identified a challenge and elaborated on its impact through facts and figures for a particular population. For example, a group focused on early child teaching material for water conservation in an average American household through a behavior change strategy. Utilizing the COM-B model (Michie, Van Stralen, & West, 2011), they developed motivational characters called 'Mr. & Miss Dewy' (Figure 10) who appeared as graphic accessories on everyday household products to educate users on when to turn off the tap or how to fend off a section of the bathtub to use less water for bathing infants.

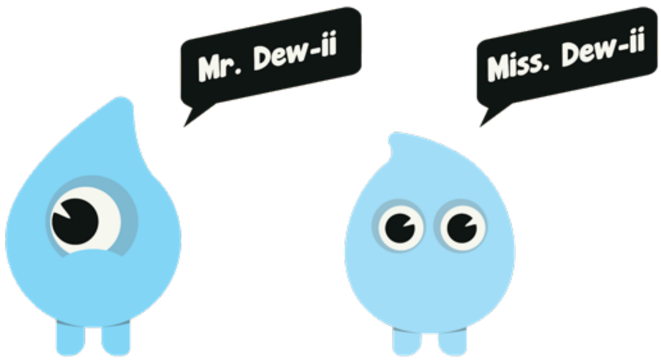


Figure 10 Motivational character illustrations of Mr. & Miss Dewy

Their proposal included the design strategy to achieve the goal along with some product examples based on the strategy (Figure 11).

Figure 11 UN Sustainable Development Goal: Water Conservation and the brand proposal

Another group focused on the same Sustainable Development Goal of Water and Sanitation, but worked on a completely different problem faced by a unique demographic in India. Focusing on a sub-goal, 'By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations', the group devised a DIY origami *Stand to Pee* device for women travelling long distances to defecate because of the lack of hygienic public facilities. Supported by articulation tools they defined their brand strategy as "Our *Stand to* Pee device helps women who want to use public toilets by upcycling hydrophobic materials, eliminating contact with contaminated surfaces and reducing the risk of UTIs."

Divergent concept-generation - Along the process, divergent ideation was promoted by utilizing different tools such as Opportunity Mind Map, Value Hypothesis, Concept-

Generating matrix, prototypes and concept scenarios, etc. all referenced from the book 101 Design Methods (Kumar & LaConte, 2012). Another student group focused on the Affordable and Clean Energy UN goal with a specific focus on the people of Caribia, a small village supported by the cacao industry in Columbia (Figure 12).

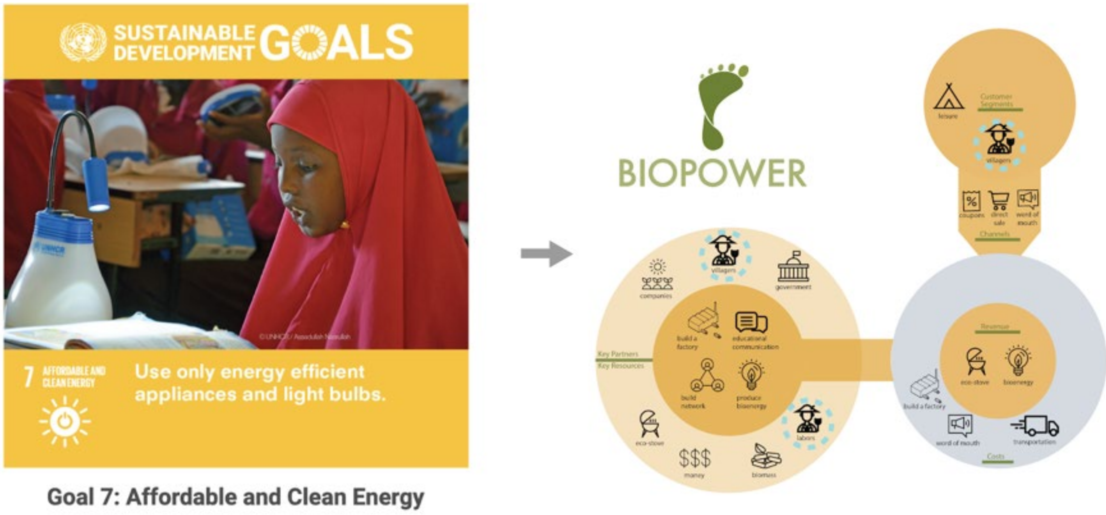


Figure 12 UN Sustainable Development Goal 7: Affordable & clean energy and the brand proposal

Their brand proposition 'Biopower' is an organization offering a system for sustainable clean cooking energy. They researched the negative health outcomes of the current methods of generating cooking energy which majorly comprised of burning wood which causes irreversible respiratory damage. They proposed wood pellets composed of biomass to be burnt instead. In order to develop a self-sustaining business model while still providing these pellets at no cost, the group identified the opportunity to design eco-stoves that could be sold. Although people from Caribia live in poverty and cannot afford their living expenses, they often spend their money on buying satellites TV. This behavior is unique to their target audience and played a major role in designing their brand strategy.

Students further plotted each concept on critical evaluation tools such as the 'who-what-where-when-why matrix' to sift feasible concepts that can be developed further into a strategy (Figure 13).

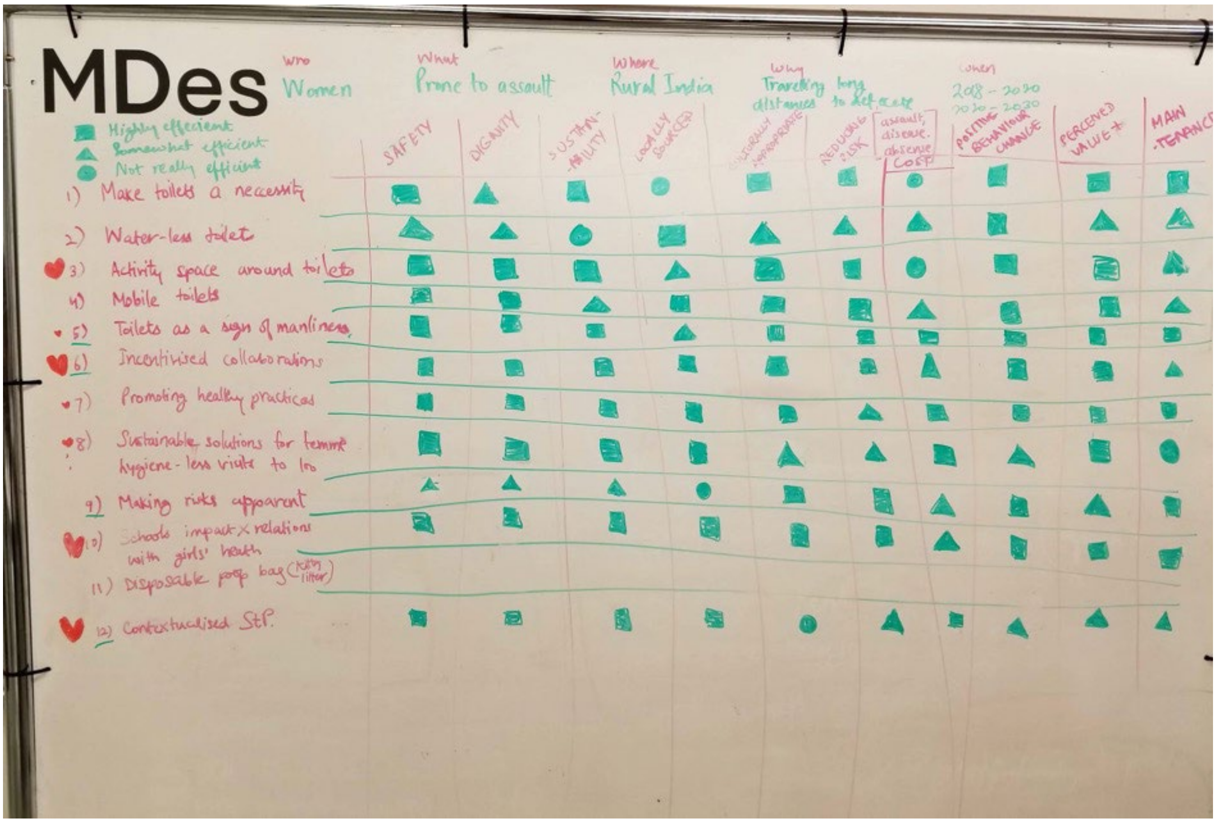


Figure 13 Student group evaluating their concepts on a 'who-what-where-when-how' matrix.

The figure above evaluates strategies for providing equal access to sanitation for women in rural India. The concepts generated in the previous stage varied from large infrastructural investments to individual-level products that can mediate current negative behaviors. The concepts were narrowed down based on a ranking system in the matrix that proved to create substantial impact in safety, dignity, sustainability, cultural appropriateness, positive behavior change and perceived value. This criteria for evaluation was unique to all the groups and their focus audiences.

Other tools such as Strategyzer's Value Proposition Canvas were used to analyze the concepts the students developed (Figure 14). The Value Proposition Canvas provides a set of tools and processes to systematically design and test value propositions and produce results. The visualization of value also helps establish a simple and shared language to discuss value propositions across organizational boundaries (Strategyzer, 2019).

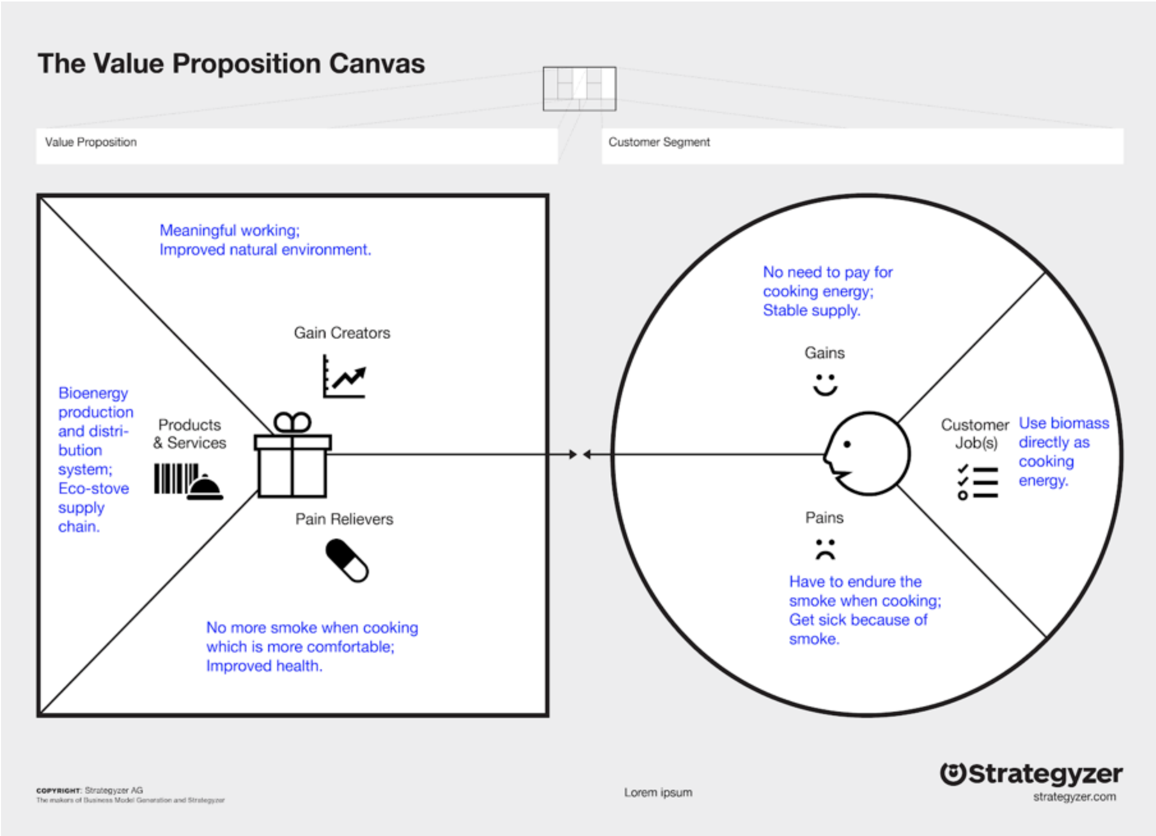


Figure 14 Student group evaluated the value of their clean energy proposal

In addition to the Value Proposition tool, students also used a combination of critical evaluation tools to define how their products and services would create value for our customers.

The final step of the project was a pitch presentation to entrepreneurs and marketing professionals at a local Venture Lab, which activates a high density of rapidly curated startup opportunities. The students prepared a brand strategy presentation, which was followed by a short Q&A session where the students answered questions about implementation, scaling their concepts, extensibility of their strategy, etc. One of the projects was chosen to be accelerated by the Venture Lab where the presentations were held. Overall, brand strategies ranged from individual product concepts to service to systems-level interventions, and utilized the *UN Sustainable Development goals* as their framework for innovation.

4. Discussion

In this course, faculty embraced future-focused yet human-centered approaches as the project frameworks, which were: *Trend as Strategy, Empathy as Strategy, and Vision as Strategy.* Each project was facilitated for a term of five weeks by a team of two design faculty. In teaching the Trend as Strategy project, it was important for faculty to emphasize analogue 'displayed thinking', utilizing post-it notes and visuals to represent the research and mapping techniques. Students responded well to the interactivity and flexibility of this process versus keeping their research in a digital format. Articulation of trend shifts was challenging for the students, so group work and frequent provocation from faculty was needed to aid in the framing of their content. *Trend Forecasting* is a comprehensive course taught at the undergraduate level, so condensing the learning process to 5 weeks was a challenge, given that the Trend process usually requires rigor of several rounds of research, analysis and synthesis. However, enabling students to work in groups alleviated some of the difficulty. Moving forward, it would be interesting to use the trend themes as starting points for strategic translation – that is, to identify the trend DNA, and how that would be leveraged for innovation opportunities for a brand and/or category.

Project 2, Empathy as Strategy, encouraged students to learn and practice primary and secondary design research methods. Being able to select an organization of their interest encouraged students to become more self-directed and curious within the project, while connecting with potential employers. Students appreciated the breadth of tools and frameworks to make sense of their primary research. Furthermore, faculty encouraged students to articulate their research through a variety of frameworks that made sense for their individual projects, yielding creativity and autonomy in their process and output. Finally, students responded positively to the display of their findings in the forms of soft prototypes / visualizations, which was a refreshing alternative to digital presentations.

In Project 3, students identified topics to investigate using the UN Sustainable Goals. Given the importance of involving a multitude of stakeholders early on in the strategic design process as Camillus and Simonarson suggest, students were limited in gaining primary research insight necessary to develop and refine their final concept ideas, often due lack of exposure to the designated population that they were designing for. This made it difficult for students to not only frame their strategy and justify the efficacy of their proposals at the end. To remedy this, each member of a group represented a different stakeholder and together they brainstormed a breadth of possible strategies. These were evaluated through feasibility matrices and one concept was adopted for development. This helped the groups to innovate from multiple perspectives such as product, services, manufacturing and production, branding, etc.

Encouraging students to develop a solution through a business pitch presentation helped them to keep a realistic frame about their concept/solution development. This was released as the minimum viable product towards the end of the course, leaving less time for re-iterating based on new insights. In future courses, faculty suggest that students then spend more time validating, prioritizing and developing a solution in a subsequent course. Faculty would consider limiting the final deliverable to be a visualized systems framework of strategic recommendations.

5. Conclusion

Overall this course framework was successful in providing students with an array of design research methods/tools, ranging from generative to evaluative, for which the students applied them proactively across their projects accordingly. Faculty utilized group work across the projects in order to facilitate communication and comradery amongst this cohort, since this was the first semester of their graduate experience. Most of the students experienced design through research for the first time. Students found the tools, readings and guest lecturers very helpful in the process. They also found their ideation to be catalyzed by the research methods and hence more productive in a shorter amount of time. However, many students wished that there was overlap across the three distinct projects. The shift from three separate project topics, to one topic with three congruent projects/phases, would enable the students to better grasp how these methods are utilized in relation to one another. For example, the trend analysis completed in Project /Phase 1 could be the starting point for strategic foresight and translation, to be explored then in the next two projects. The students felt that they would be more likely to emerge as experts on the subject matter in this case.

The purpose of this paper is to describe a curriculum for teaching design strategy as a core synergistic design research activity. Our collaborative pedagogical approach was complimentary of design strategy as research. It was successful in teaching students the methods and tools necessary to create strategic frameworks and recommendations towards very complex pressing global issues of today.

This course was taught in the following year, so given the analysis of the approach, some refinements made. Faculty re-imagined the sequence and interrelation of the 3 projects. The first project still focused on 'Trends As Strategy', and then to kick off Project 2, students were introduced to the UN Sustainable Development Goals earlier, for which they conducted comprehensive research on a particular goal of interest. Students were still introduced to tools/methods to develop an understanding/functional literacy of the opportunity, and then visualized a framework of that understanding that incorporated all stakeholders and associated issues. Final output was not a business pitch, but rather, students used their framework to generate a strategy to respond to the opportunity. This restructuring was much more attainable, given the complexity of the topics that they were prompted to explore. They presented strategic recommendations that were oriented towards how they might maximize positive results and limit unintended consequences, rather than identifying "solutions".

5. References

Bengtsson, S. (2013) IKEA the Book: Designers, Products and Other Stuff. Stockholm: Arvinius Förlag AB for IKEA FAMILY.

Best, K. (2011). What can Design Bring to Strategy? Design Thinking as a Tool for Innovation and Change. Retrieved from https://tinyurl.com/y9q7na5d

Brown, T. (n.d.). IDEO Design Thinking. Retrieved December 3, 2019, from IDEO | Design Thinking website: https://designthinking.ideo.com/

Brown, T. (2005, June 1). Strategy by Design. Fast Company. https://www.fastcompany.com/52795/strategy-design

Cagan, J., & Vogel, C. (2012). Creating Breakthrough Products, Revealing the Secrets that Drive Global Innovation (2nd ed.).

Camillus, J. C. (2008). Strategy as a Wicked Problem. Harvard Business Review, 86(5), 98–106. https://tinyurl.com/y7d9k9le

Dorst, K. (2008a). Design research: A revolution-waiting-to-happen. Design Studies, 29, 4–11. https://doi.org/10.1016/j.destud.2007.12.001

Dorst, K. (2008b). Shaping The Design Research Revolution. International Conference On Engineering Design.

Empathy. 2019. In Merriam-Webster.com. Retrieved December 14, from https://www.merriam-webster.com/dictionary/empathy

Evans, M. (2004). Trend Forecasting for Design Futures. Paper presented at FUTUREGROUND: Design Research Society International Conference, Monash University, Melbourne, Australia.

Fiorelli, G. (2015). Understand and Harness the Power of Archetypes in Marketing—Moz. Retrieved December 15, 2019, from https://moz.com/blog/the-power-of-archetypes-in-marketing

Gray, D. (2018, July 21). Updated Empathy Map Canvas. Retrieved December 15, 2019, from Medium website: https://tinyurl.com/y9lqqssp

Greenfield, A. (2017). Practices of the Minimum Viable Utopia. Architectural Design, 87(1), 16–25. https://doi.org/10.1002/ad.2127

Kelley, T., & Littman, J. (2005). The Ten Faces of Innovation: Ideo's Strategies For Beating The Devil's Advocate & Driving Creativity Throughout Your Organization. Currency/Doubleday.

Kumar, V., & LaConte, V. (2012). 101 Design Methods: A Structured Approach for Driving Innovation in Your Organization. Retrieved from http://ebookcentral.proquest.com/lib/uc/detail.action?docID=861699

Lester, R. K., Piore, M. J., & Malek, K. M. (1998). Interpretive Management: What General Managers Can Learn from Design. Harvard Business Review, 76(2), 86–96.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Science : IS, 6, 42. https://doi.org/10.1186/1748-5908-6-42

Montgomery, C. (2012). The Strategist: Be the Leader Your Business Needs. Retrieved December 15, 2019 from https://tinyurl.com/yb54aqlg

Muratovski, G. (2016). Research for Designers: A Guide to Methods and Practice. 23-31

Penprase B.E. (2018). The Fourth Industrial Revolution and Higher Education. In: Gleason N. (Eds.), Higher Education in the Era of the Fourth Industrial Revolution (pp. 207-229). Singapore: Palgrave Macmillan.

Personas | Open Design Kit. (n.d.). Retrieved December 14, 2019, from http://opendesignkit.org/methods/personas/

Research and Evaluation in Education and Psychology. (2019, November 14). Retrieved November 14, 2019, from SAGE Publications Inc website: https://tinyurl.com/ybxj7qr3

Raymond, M. (2010). Trend Forecaster's Handbook. London, UNKNOWN: Laurence King Publishing. Retrieved from http://ebookcentral.proquest.com/lib/uc/detail.action?docID=1876097

Sell-your-colleagues-on-value-proposition-design.pdf. (n.d.). Retrieved from https://tinyurl.com/y9gd534b

Service Design Tools | Communication methods supporting design processes (n.d.). Retrieved April 20, 2020, from https://servicedesigntools.org/

Simonarson, M. (2017). How To Set A Company Vision And Get Buy-In From Stakeholders. Forbes. https://tinyurl.com/ya5s3dao

Strategy. 2019. In Merriam-Webster.com. Retrieved December 14, from https://www.merriam-webster.com/dictionary/strategy

What is strategic design? - Helsinki Design Lab. (n.d.). Retrieved December 3, 2019, from http://helsinkidesignlab.org/pages/what-is-strategic-design.html

United Nations General Assembly, Transforming our world : the 2030 Agenda for Sustainable Development, 21 October 2015, A/RES/70/1, available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 15 December 2019].

About the Authors:

Brooke Brandewie is an Assistant Professor at the University of Cincinnati, DAAP. Her research interests focus in strategic foresight and user-centered functional apparel/product design. She is currently engaged in collaborative research on uniforms for first responders, trend/design pedagogy and entrepreneurship.

Neha Mann is a Master of Design student at the University of Cincinnati, DAAP. She has previously contributed to strategies for improving neonatal and maternal health in rural India. In her graduate work, she continues to explore design research in service to strategy.

Dr. Claudia B. Rebola is the Associate Dean for Research, and Associate Professor in Industrial Design at the University of Cincinnati, DAAP. Her work brings together design, science and technology to experiment, design and prototype innovative interactive products in the realm of health and inclusivity.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Designing by frontline tobacco-prevention practitioners: How can Design Thinking workshop affect the development of public health strategies?

Eric Chen-F HSIEH[a]*, Min-yuan MA[a], Fu-Yu LIN[b]

[a] National Cheng Kung University, Taiwan
[b] Arizona State University, United States
*Corresponding author e-mail: chenfhsieh@gmail.com
doi: https://doi.org/10.21606/drs.2020.166

Abstract: Design thinking features a distinct process for probing deep problems and ensuring that the right questions are being addressed and feasible solutions proposed. Recently, Taiwan's Health Promotion Administration took on design thinking as a method for redesigning several health-related public strategies. Although design thinking has been widely applied in several realms, more studies need to be conducted to ascertain its full effect. Therefore, this study attempts to understand how a Design Thinking Workshop could affect the development of public health strategies by using adolescent tobacco prevention as a case for research. The two-phase study included data collection and analysis for exploring the research topic. In conclusion, we found that participating in the process of a design thinking workshop helped establish a human-centred mindset. Further, the workshop resulted in the formation of concrete public policies that addressed fundamental root issues of adolescent tobacco prevention.

Keywords: design thinking; workshop; strategy development; tobacco prevention

1. Introduction

Recently, Taiwan's Health Promotion Administration (HPA) promoted design thinking as a method for redesigning several health-related public strategies. This paper presents one facet of the promotion: a case study of a Design Thinking Workshop that focused on adolescent tobacco prevention (ATP). The workshop was structured around design thinking principles and aimed to enable frontline practitioners to find critical insights and develop creative ideas.

The objective of this study is to understand how design thinking affects the development of public health strategies by using ATP as a case focus: We ask, "how can design thinking affect public strategy development?"

This research collected data from a Design Thinking Workshop for ATP and analysed it through the steps listed below:

1. Generating core factors of ATP
2. Excerpting ATP strategies from proposals
3. Categorising strategies based on core factors of ATP
4. Mapping ideations with ATP strategies

It is hoped that answering the question raised above will contribute to our growing understanding of how and to what extent design thinking affects the development of public strategies.

2. Design Thinking Workshop for ATP

In this section, the author will briefly introduce the Design Thinking and Design Thinking Workshop that addressed adolescent tobacco prevention (ATP), which was hosted by the R&D team from the National Cheng Kung University (NCKU) in collaboration with the Health Promotion Administration (HPA), Ministry of Health and Welfare, Taiwan.

2.1 Design Thinking

Almost three decades ago, design thinking was defined as the cognitive process manifested in design activities that would help us understand how people “do” design (N. Cross, Dorst, & Roozenburg, 1992). The attribute of creativity is widely regarded as an essential element in design thinking (N. Cross, 2001). Research on design thinking attempts to identify the essential mental strategies of a designer instead of universal design methods (Tschimmel, 2012). Design thinking can be seen as a design process that has several connected stages and can be used rapidly and applied to other fields.

2.2 Workshop Setup

The Design Thinking Workshop was held on October 16, 2018. The mission of the workshop was to enable the frontline ATP professionals to gain critical insights and develop creative ideas related to the issue of ATP. The overarching frame for our workshop design was derived from design thinking principles. The workshop setup is depicted in Figure 1.

Figure 1 Design Thinking Workshop: discovering insights for ATP issues

Schedule

The Design Thinking Workshop for ATP was a 5-hour program. First, the host introduced the concepts of design thinking for 30 minutes. Two exercises followed: "Discovering Problem Spaces" and "Defining Insights and Rapid Ideations," each for one-and-one-half hours. In the final hour, all the participants were asked to share their findings and creative ideas. (See Figure 2)

Figure 2 Discovering and defining stages of the Design Thinking Workshop for ATP

Subject and Participants

There were a total of 71 participants in the workshop. Participants were from the HPA (N=8) and local public health bureaus (N=63) in Taiwan, except for Taichung City. The participants were the frontline tobacco-prevention practitioners. They provide smoking cessation counselling and health education services, as well as to conduct regular inspections of tobacco retailers and youth smoking. The complete participant list is shown in Appendix

1. The participants were divided into eight groups, based on the results of ice-breaking activities. Each group was assigned a facilitator to assist the participants during the entire workshop.

Host and Facilitators

The workshop host had over 10 years of multidisciplinary teaching experience. The 10 experienced facilitators included 3 PhD students, 5 MS students, and 2 freelancers in the design field; one facilitator was assigned to each group. All the facilitators had several experiences in facilitating workshops and had been trained beforehand.

2.3 Issue of the Workshop: ATP

The Surgeon General's Report in the United States and myriad other reports have illustrated the problems, including fatal outcomes, attributable to tobacco use. People incur tobacco-related illnesses not only from active smoking but also by inhaling smoke, coming into contact with saliva from smokeless tobacco users, and touching tobacco leaves during farming or manufacturing processes. Smoking is the leading cause of preventable diseases such as chronic obstructive pulmonary disease, cardiocerebrovascular disease, and cancer (U.S. Department of Health and Human Services, 2014).

Prevention of tobacco-related disorders in Taiwan

Creating a smoke-free environment for the next generation is valued across all nations. The goal for decreasing the number of smokers and minimising the impact of tobacco on the national health is to reduce the relative rate of use by 30% by2025, rather than 2010 as stipulated by the World Health Organization. The United Nations Sustainable Development Goals target noncommunicable diseases, including tobacco-related diseases; they were adopted in the 2030 Sustainable Development Agenda by the United Nations General Assembly. The strengthening of tobacco control is, therefore, a pressing challenge worldwide. The Tobacco Hazards Prevention Act proposed by the HPA in Taiwan aims to strengthen tobacco control strategies, respond to hazards posed by novel products, protect the overall population, and help achieve multiple goals associated with global sustainable development.

Adolescent smokers and tobacco hazards

Nowadays, e-cigarettes are used by millions around the world. They first appeared on the Chinese market in 2004 (Yvette Brazier, 2018). The e-cigarettes contain harmful substances, including nicotine. Nicotine exposure during adolescence is harmful to learning, can impair the memory and ability to pay attention, and primes the brain for addiction; these effects can continue into the early to mid-20s. Youth who use e-cigarettes are more likely to go on to smoke conventional cigarettes or become dual users (Chen et al., 2018). Those who use multiple tobacco products when young are at a higher risk for developing nicotine dependence, might be more likely to continue using tobacco into adulthood, and may risk addiction to other drugs in the future (CDC, 2000; U.S. Department of Health and Human

Services, 2016). Future projections for deaths attributable to smoking are high. Virtually all tobacco use begins in adolescence. Starting to smoke cigarettes at an earlier age reinforces the likelihood that a person will continue to smoke and reduces the probability that a person will stop smoking.

3. Methodology

The methodology that contributed to this research will be briefly introduced in this section. It includes two qualitative and two quantitative research methods. Because of the limited time of the workshop, in this study, we applied the focus group technique to collect data from each group. Further, the affinity diagram is applied to break down complex data gathered from the workshop and reassemble them structurally. In the analysis phase, cluster analysis and correspondence analysis were used to mapping strategies and challenges for the tobacco prevention issue together. By illustrating the strategies and challenges, the biplot provided a clear view of the result for further discussion.

3.1 Focus Group

In the 1940s, Robert Merton developed the focus group. Generally speaking, a focus group saves time in investigations because researchers can collect data from a group of participants over the same time span (McQuarrie, Stewart, & Shamdasani, 2014).

Focus groups are currently widely used to (1) collect background information and define the subject of a study as the basis for the formation of research hypotheses, evaluations, or assessments; (2) investigate responses to policies; (3) pretest advertising or marketing efforts; and (4) conduct research on topics that are difficult to measure by one-to-one surveys (Carol Grbich, 1998).

3.2 KJ Method (Affinity Diagram)

The KJ method is a tool used to organise ideas and data that was initially developed by Kawakita Jiro in the 1960s; it is also known as the affinity diagram (Kawakita, 1991). People have been grouping data based on natural relationships for thousands of years. The KJ method does the same thing humans do, which is to break down complex problems and reassemble them structurally. The technique is used to establish hypotheses and theories by ordering facts in new ways and uncovering hidden insights in phenomena.

The KJ method is used to understand facts and find opportunities. Compared with other statistical methods, the KJ method does not quantify a phenomenon; rather, it uses the researcher's point of view as a tool to master questions. There is no specific result in the outcome of the KJ method other than to gain more understanding of a phenomenon. Although the KJ method is a subjective and qualitative research method, it can effectively promote teamwork to clarify priorities of a discussion and reveal observations and ideas in a short time.

3.3 Correspondence Analysis

Correspondence analysis permits visualisation to interpret and reveal relationships among categorical variables. The method determines which category variables are related and correspond with one another for which no specific hypotheses have been formed (Doey & Kurta, 2016). Correspondence analysis technically analyses two-way or multiway tables, with each row and column becoming a point on a multidimensional graphic map called a biplot (Doey & Kurta, 2016). The comparable pattern of counts is a descriptive data-reduction technique.

Correspondence analysis simplifies complex data and adds supplementary data points to better elucidate a model with flexible data requirements. Moreover, the method examines data validity and facilitates the treatment of outliers (Fellenberg et al., 2001; Hoffman & Franke, 2006). The characteristics that facilitate this form of analysis have been applied across numerous domains (Greenacre, 2017), including archaeology, ecology, and epidemiology (Sourial et al., 2010); geology and marketing (Hoffman & Franke, 1986); and sociology and psychology (Doey & Kurta, 2016).

3.4 Cluster Analysis

Cluster analysis identifies explorations and descriptions of data structures rather than hypothesis tests or conformations of theoretical structure (Henry, Tolan, & Gorman-Smith, 2005). Cluster analysis classifies similar variables according to their internal homogeneous and heterogeneous traits (Kaufman & Rousseeuw, 2009; Rousseeuw & Kaufman, 1990). Cluster analysis is a data-reduction technique for analysing interval, ordinal, or categorical datasets (Henry et al., 2005). Moreover, it can analyse data with a mix of categorical and numerical variables. Employing distinct statistical methods (e.g., K-means clustering, agglomerative hierarchical clustering, and density-based spatial clustering of applications of scans with noise) can generate different types of clusters from the same dataset. The concern is in choosing appropriate algorithms to detect, define, and evaluate meaningful clusters (Arabie & Hubert, 2003). Therefore, the validation and interpretation of cluster solutions affect the outcome.

Cluster analysis has played a critical role in a wide variety of fields: psychology and other social sciences, business, biology, statistics, pattern recognition, information retrieval, machine learning, and data mining (Henry et al., 2005).

4. Research Procedure

A two-phase study (i.e., data collection and analysis) was designed to explore our research topic. The research procedure is shown in Figure 3. Further information will be given in the following sections.

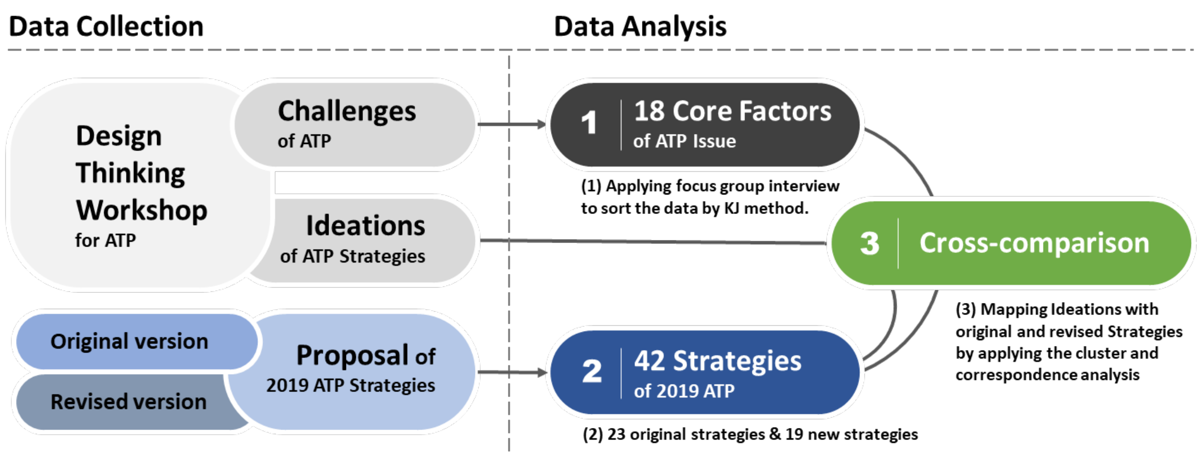


Figure 3 Research procedure

4.1 Data Collection

Our data concerned the challenges and ideations of ATP and a proposal for the 2019 ATP strategy.

Challenges and ideations of ATP

Challenges and ideas were collected from the Design Thinking Workshop. By gathering the issues generated from the session on "Discovering Problem Spaces" of ATP, the research team gathered a total of 213 challenges (problems). In the final presentation of the workshop, 29 creative ideas were put forth by our participants.

Proposal of 2019 ATP strategy

The proposal on the 2019 ATP strategy from the local Department of Health is provided by the HPA, Taiwan, and includes the original version reported before the workshop and the revised version stated after the workshop.

4.2 Data Analysis

Data analysis in this research can be divided into three main parts: (1) generating the core factors of ATP, (2) taking excerpts of ATP strategies from an annual proposal, and (3) adapting a quantitative research approach to make cross-comparisons between strategies (from an annual proposal) and ideas (raised at a workshop).

1. Generating core factors of ATP

In order to group the ATP issues accurately, a focus group was convened and eight R&D members were invited to sort data according to the affinity diagram (KJ method). After the focus group discussion, 213 original data items were sorted into 18 groups (Table 1).

Table 1 Eighteen Core Factors of Adolescent Tobacco Prevention

A	Smoking is attractive to people and fascinates them.
B	Advising underage persons to quit smoking is just inviting trouble.
C	Neglect of and indifference to the issue of underage smoking behaviour are real.
D	Seeing smoking behaviours can cause people to take up the behaviours.
E	Refusing a smoking invitation from others can make a person ashamed.
F	Smoking is an escape from the pressures of reality.
G	Cigarettes (e-cigarettes) are easy to purchase and obtain.
H	The attitude toward smoking is difficult to change.
I	Underage smokers deny that tobacco hazards exist and refuse to face their possible effects.
J	Underage smokers tend to ignore the regulations of the Taiwan Health Promotion Administration.
K	Difficulties in making inspections are caused by limited human resources.
L	Difficulties in inspection because of Insufficient regulations.
M	Verifying the illegality of underage smoking is difficult.
N	Awareness of the harm caused by smoking behaviours is insufficient.
O	Tobacco cessation intervention could not significantly influence young people.
P	Tobacco cessation intervention would be annoying for young smokers.
Q	Resources for and guidelines about tobacco cessation are lacking.
R	It is not easy to quit smoking, but it is easy to continue to smoke.

The core factors of ATP generated in this section reflect the space of the overall problem and reveal the critical issues related to ATP. The 18 core factors of ATP were used for further analysis with the strategies discussed in this study.

2. Excerpting ATP strategies

To reveal the benefits of involving design thinking in tobacco prevention, this research excerpted strategies from the annual proposal of the local Department of Health. Because adolescent smoking behaviour is different from area to area, this research selected two cities and five counties in Taiwan as our target areas. They were comparable to having a high adolescent smoking rate and low rate of decline in smoking behaviours between 2014 and 2016. Based on the Taiwan Tobacco Control Annual Report of 2016, the two cities and five counties selected were Keelung City, Taoyuan City, Hsinchu County, Nantou County, Pingtung County, Taitung County, and Hualien County.

Regarding the topic of the workshop, this research excerpted only the strategies on ATP from the proposal. Similar approaches in the original proposal were combined, so that 23 plans were eventually identified. By comparing the original and revised versions of the proposal, the R&D team identified another 19 strategies that had been added. A total of 42 strategies were excerpted. A more detailed explanation of each strategy can be gained from Appendix 2.

3. Mapping ideations with ATP strategies

After the data were collected and sorted according to the qualitative research approach, this study looked further into the influence of design thinking by applying the cluster and correspondence analyses. Findings of the cross-comparison will be discussed in the next section. The matrix of an evaluated score for the relationship between the ATP factors and strategies is shown in Appendix 3.

5. Results

In this section, we focus on the results of the qualitative analysis. Results of the cluster and correspondence analyses will be presented clearly.

5.1 The Result of Strategy Clustering

A cluster analysis using Ward's method is schematically presented in Figure 4. The core factors from Table 1 were used to classify the strategies in this study, and they were grouped into three categories. By referring to the original data, similarities in group characteristics can be identified.

Each group contained original and newly added strategies. None of the categories had only revised strategies or original strategies. Based on the statistical results, we can see that the new strategies shared similarities with the original ideas (or considered the same ATP factors).

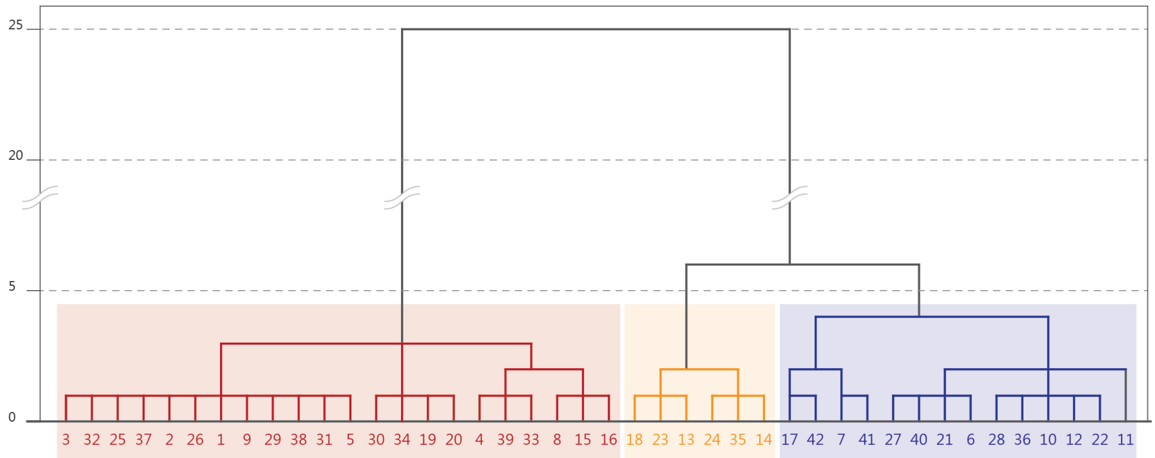


Figure 4 Dendrogram for ATP strategies

5.2 Correspondence Analysis Between Factors and Strategies

In regard to the results of the correspondence analysis (Table 2), we first look at the chi-square test. The value of sig. (or *p*-value) is lower than .001, which indicates that our total inertia value is significantly different from zero. There is a relationship between the ATP factors and strategies. Second, the total inertia is 97.9%, which indicates that for our model, some aspect of the ATP factors explains approximately 97.9% of the strategies. The association is quite strong. In our model, dimension 1 explains approximately 46.1% of the total of 97.9% of the variance shown in the model, whereas dimension 2 explains 16.4%.

Based on the statistical result of the correspondence analysis, we can go deeper into the other factors and strategies.

Table 2 Summary of Correspondence Analysis of ATP Factors, Strategy of 2019

Dimension	Singular Value	Inertia	Chi-square	Singular Value signifies	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Correlation 2
1	.672	.451			.461	.461	.005	.070
2	.400	.160			.164	.625	.008	
3	.301	.091			.093	.717		
4	.246	.060			.062	.779		
5	.216	.047			.048	.826		
6	.193	.037			.038	.864		
7	.178	.032			.033	.897		
8	.149	.022			.023	.920		
9	.141	.020			.020	.940		
10	.125	.016			.016	.956		
11	.107	.011			.012	.968		
12	.101	.010			.010	.978		
13	.096	.009			.009	.988		
14	.070	.005			.005	.993		
15	.057	.003			.003	.996		
16	.050	.003			.003	.999		
17	.038	.001			.001	1.000		
Total		.979	18310.906	.000[a]	1.000	1.000		

a. 697 degrees of freedom

For a visual picture of the correspondence analysis result, see the graphic representation in Figure 5. The yellow-cross marks signify the 18 core factors of ATP, and the blue-triangle and red-circle marks stand for the original and revised strategies, respectively.

6. Discussion

By combining the results of the cluster and correspondence analyses, three main groups are seen in the correspondence analysis biplot (Figure 5). Tracking back to the raw data on the strategies, the groups can be named (1) education and campaign, (2) inspection and training, and (3) smoking cessation services.

Figure 5 Three categories of ATP strategies

6.1 Review of DT Workshop and Public Strategy Development

By mapping the ideas and strategies, the researcher found that 28 of 29 ideas suggested by our workshop participants could be mapped to the list of 42 strategies. Eleven ideas were related to the 23 original strategies and 17 ideas to the 19 newly added strategies.

The 28 strategies related to the workshop ideas are illustrated in Figure 6. The mapping result lends support to the theory that;

- Ideas generated from the workshop were general and seemed to be correlated with new strategies proposed after the workshop.
- The Design Thinking Workshop focused on both past ideas and new ideas.

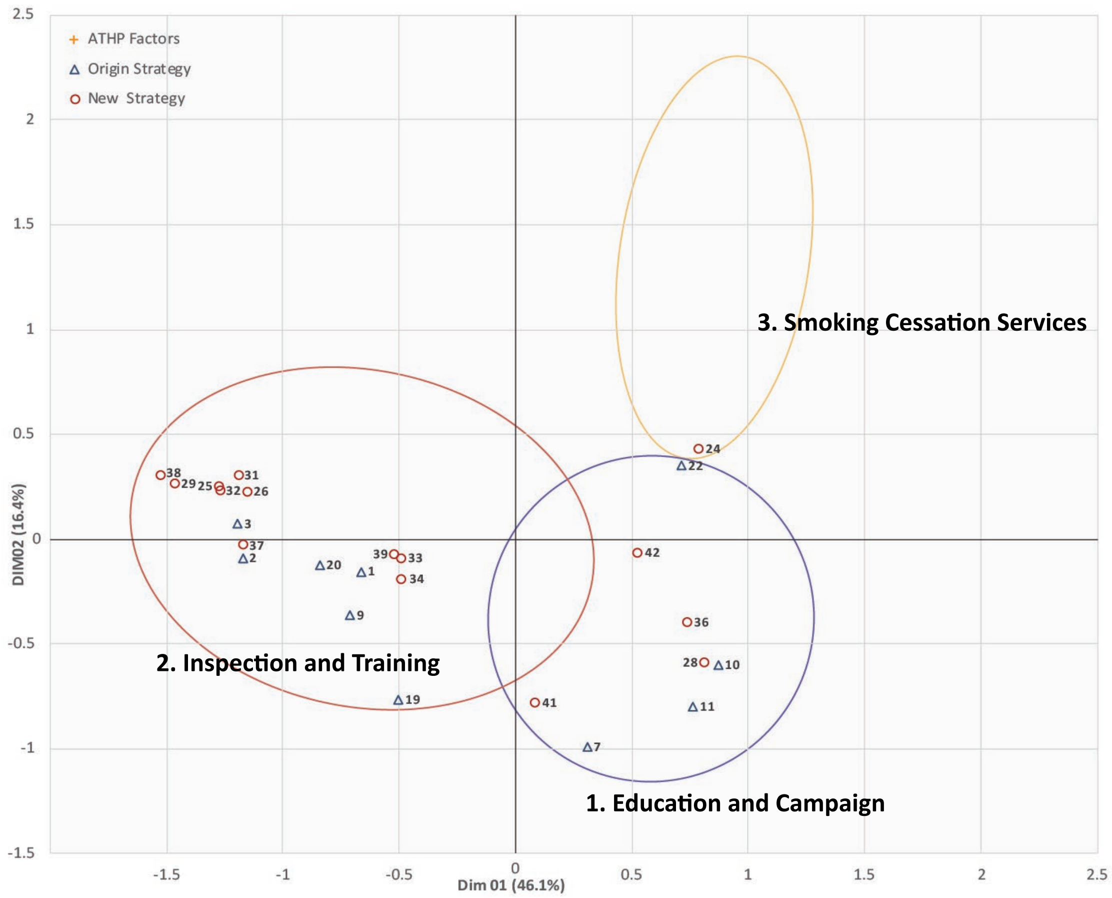


Figure 6 Strategies related to ideas generated in the Design Thinking Workshop for ATP

A quick look at Figure 6 reveals that ideas generated in the workshop were mainly from the education and campaign group and inspection and training group. There was only one new strategy related to new ideas in the smoking cessation services group. The ideas generated by the frontline practitioners usually focused on preventing smoking behaviours in teenagers who had not started to smoke rather than stopping them in teenagers who were already smoking. This finding is in accord with the results of previous studies of the ideations of design thinking workshops, although those studies focused on different issues. Bennett (2016) presented findings from a workshop on designing ways for persons with disabilities to have more options for accessibly. Participants found several access barriers and ideations that prevented disabled persons from contributing on an equal basis (Bennett, Shinohara, Blaser, Davidson, & Steele, 2016, p. 304). The outcome was similar to our research findings, which also focused on prevention. Lindberg et al. (2011) argued that design thinking is limited to fuzzy front-end matters. They found that ideations derived from the process usually did not survive when they came into conflict with established development processes, corporate rewards, and reporting and controlling systems (Lindberg, Meinel, & Wagner, 2011). According to our results, it is likely that issues related to smoking cessation services are too narrow and rigid or generating ideas. Our research results led to the finding that;

- The Design Thinking Workshop tends to lead participants to focus on prevention rather than cessation and is limited to fuzzy front-end matters.

6.2 Review of Seventeen Newly Added Ideas and Strategies

Based on the structure of the three categories, one can explain the insights by comparing the original and revised strategies related to the 17 workshop ideas. The strategies are presented in Appendix 2, and the number appears in brackets for easy checking.

EYE-CATCHING EDUCATION AND CAMPAIGN

Based on the raw data, the original strategies seemed to primarily focus on establishing a smoking-free supportive environment (i.e., family home and school campus). The existing strategies (before the workshop) included board games [10] that included warnings about the effects of tobacco on health, a letter to parents encouraging them to quit smoking [7], smoking cessation courses [11] (courses on quitting smoking for underage smokers), and training for enforcement personnel [22].

After the Design Thinking Workshop, the new strategies on education and campaigning focused more on their targets. For example, some strategies [28] involved using virtual reality antitobacco games to arouse an adolescent's interest. Strategies [36] presented by Pingtung County involved inventing antitobacco board games and other campaigns in indigenous languages because 7.25% of residents were indigenous (Department of Statistics, Ministry of the Interior, 2019).

NOVEL INSPECTION AND TRAINING

The category of inspection and training was the largest of the three categories, and its three main topics were (1) inspection [1, 9, 20]; (2) banning tobacco advertising and marketing, and [3] promoting tobacco control campaigns.

Several strategies were generated in the workshop. One involved addressing the low rate of reporting instances of smoking. It was suggested that paying someone who reports illegal smoking may act as an incentive to the public [26]. If reporting another person's illegal act were rewarded instead of causing trouble, people might be willing to report such an act. Another suggestion involved educating tobacco sellers about teenage smokers. The rate for selling tobacco to teenagers has remained the same over the past 5 years (HPA of Taiwan, 2018). Nantou County tried a new strategy to educate long-time tobacco sellers by posting tobacco-control campaign posters with words in large fonts where they could see them and by offering them one-on-one antitobacco training [34]. To encourage sellers to keep the antitobacco posters, Pingtung County professionals provided "antitobacco promotion cards in the shape of a sycee" [37] for them. The shape of the sycee indicates "great fortune" in Taiwan, and this might impel a tobacco seller to keep the cards.

ENERGETIC SMOKING CESSATION SERVICES

Smoking cessation services in place before the workshop included antitobacco courses

[14] and self-monitoring, progress tracking [13], carbon monoxide monitoring [13], and a smoker's helpline [18, 23].

After the workshop, regular exercise [24] was added to the smoking cessation efforts [24]. A new strategy, health promotion clubs, was provided by Keelung City for underage smokers. Because the impact of peers is much more powerful than that of others, the clubs were set up as friendly societies for helping underage smokers and engage in sports activities that would boost their health and serve as an alternative to smoking.

The review of the insights described above, which were suggested during a Design Thinking Workshop, suggests that there is some benefit in involving design thinking in public strategy development. The result shows that the development of strategies no longer occurs only by professionals. In the findings and insights listed, one can see that the ideas that emerged from the Design Thinking Workshop embraced empathy-based thinking. This finding is in accord with the results of previous studies. Fabrizio and Elena noted that a project-based approach (e.g., workshop) suggested much more emphasis on collaboration and empathy than a traditional approach (Pierandrei & Marengoni, 2017, p. 925).

7. Conclusions

This study proposes that design thinking can affect the development of a public health strategy by focusing on a case study of a Design Thinking Workshop. The researcher remains perfectly aware that the validity of any experimental study is limited to the scope of the experiment. Thus, the generalisation of the result of this study to another field may have limited use. This study has taken a step toward defining the relationship between design thinking and public health strategy development.

In the big picture, this study shows that design thinking contributes to the further consideration of the challenges and problems of people but does not contribute to the expansion of a new domain of strategy. The result of the Design Thinking Workshop for ATP shows that strategy development is no longer only the purview of professionals in the field. Ideas and strategies both arise from the engagement of stakeholders in ATP issues.

To summarise the salient features of the analysis, we look at several findings of interest. The application of design thinking to public strategy development had three main facets. First, based on the characteristics of design thinking, a human-centred design process, participants not only shared new ideas but also considered existing ideas if the ideations were related to stakeholders with whom they empathise. Second, considering the mapping between ideas and strategies, the ideas raised in the Design Thinking Workshop were very similar to the strategies proposed after the workshop. Last, the Design Thinking Workshop tended to lead participants to focus on prevention rather than cessation and limited them to fuzzy front-end matters. We found that participating in the process of a Design Thinking Workshop helped establish a human-centered mindset. Further, the workshop resulted in the formation of concrete public policies that addressed fundamental root issues.

Although this study has its limitations, it is hoped that it can serve as a basis for further studies on strategizing during a Design Thinking Workshop. In the future, we will study whether a Design Thinking Workshop could have the same effect in other realms.

Acknowledgement: We would like to thank the following people for helping with this research project: Chief secretary, YR Wang, and the representatives, CS Chang, SY Luo and YJ Yeh, from Health Promotion Administration, Ministry of Health and Welfare, Taiwan, for their willingness to support and participate the design thinking workshop. Assistant Prof. Wen-Ling Chang for providing practical advice to this research project. Last, all the team members in Lab Ma who have been a great source of support.

8. References

Arabie, P., & Hubert, L. J. (1992). Combinatorial data analysis. *Annual review of psychology*, 43(1), 169-203.

Bennett, C. L., Shinohara, K., Blaser, B., Davidson, A., & Steele, K. M. (2016, October). Using a Design Workshop To Explore Accessible Ideation. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (pp. 303-304).

Grbich, C. (1998). Qualitative research in health: *An introduction*. sage.

Reducing tobacco use: a report of the Surgeon General--executive summary. (2000). *Nicotine & Tobacco Research : Official Journal of the Society for Research on Nicotine and Tobacco*, 2(4), 379–395.

Chen, Y. L., Wu, S. C., Chen, Y. T., Hsiao, P. C., Yu, Y. H., Ting, T. T., ... & Li, C. Y. (2018). E-cigarette use in a country with prevalent tobacco smoking: a population-based study in Taiwan. *Journal of epidemiology*, JE20170300.

Cross, N., Dorst, K., &Roozenburg, N. (1992). Research in design Thinking. *Proceedings of a Workshop meeting held at the Faculty of Industrial Design Engineering*, Delft University of Technology, The Netherlands, May 29-31, 1991.

Cross, N. (2001). Design cognition: Results from protocol and other empirical studies of design activity. In *Design knowing and learning: Cognition in design education* (pp. 79-103). Elsevier Science.

Department of statistic Ministry of the Interior [內政部統計處]. (2019). *108*年第*10*週內政統計通報. Retrieved April 2, 2019, from: https://www.moi.gov.tw/stat/node.aspx?cate_sn=-1&belong_sn=7887&sn=7954

Doey, L., & Kurta, J. (2011). Correspondence analysis applied to psychological research. *Tutorials in quantitative methods for psychology*, 7(1), 5-14.

Fellenberg, K., Hauser, N. C., Brors, B., Neutzner, A., Hoheisel, J. D., &Vingron, M. (2001). Correspondence analysis applied to microarray data. *Proceedings of the National Academy of Sciences*, 98(19), 10781–10786.

Henry, D. B., Tolan, P. H., & Gorman-Smith, D. (2005). Cluster analysis in family psychology research. *Journal of Family Psychology*, 19(1), 121.

Hoffman, D. L., & Franke, G. R. (1986). Correspondence analysis: graphical representation of categorical data in marketing research. *Journal of marketing Research*, 23(3), 213-227.

Health Promotion Administration, Ministry of Health and Welfare of Taiwan [衛生福利部國健康署] (2018). Taiwan Tobacco Control Annual Report 2017 台灣菸害防制年報(英文版). from: https://health99.hpa.gov.tw/educZone/edu_detail.aspx?CatId=22018

Kaufman, L., & Rousseeuw, P. J. (2009). *Finding groups in data: an introduction to cluster analysis* (Vol. 344). John Wiley & Sons. Greenacre, M. (2017). Correspondence analysis in practice. Chapman and Hall/CRC.

Kawakita, J. (1991). The original KJ method. *Tokyo: Kawakita Research Institute*, 5.

Lindberg, T., Meinel, C., & Wagner, R. (2011). Design thinking: A fruitful concept for it development?. In *Design thinking* (pp. 3-18). Springer, Berlin, Heidelberg.

Stewart, D., & Shamdasani, P. (2014). *Focus groups : theory and practice / David W. Stewart, Prem N. Shamdasani*. (Third edition.). Los Angeles: SAGE.

Pierandrei, F., & Marengoni, E. (2017). Design Culture in school. Experiences of design workshops with children. *The Design Journal*, 20(sup1), S915-S926.

Rousseeuw, P. J., &Kaufman, L. (1990). Finding groups in data. *Hoboken: Wiley Online Library*.

Sourial, N., Wolfson, C., Zhu, B., Quail, J., Fletcher, J., Karunananthan, S., …Bergman, H. (2010). Correspondence analysis is a useful tool to uncover the relationships among categorical variables. *Journal of Clinical Epidemiology*, 63(6), 638–646.

Tschimmel, K. (2012). Design Thinking as an effective Toolkit for Innovation. In *ISPIM Conference Proceedings* (p. 1). The International Society for Professional Innovation Management (ISPIM).

U.S. Department of Health and Human Services. (2016). E-Cigarette Use Among Youth and Young Adults: A Report of the Surgeon General. *Atlanta, GA*. Retrieved from www.cdc.gov/tobacco

Yvette Brazier. (2018). Are e-cigarettes a safe alternative to smok

About the Authors:

Eric Chen-F Hsieh is currently a doctoral student at the Industrial Design, National Cheng Kung University (NCKU) in Taiwan. His research interest is focus on Kansei Experience and Evaluation, Design Education and Product innovation & Design.

Min-yuan Ma, Ph.D., is a professor of dept. of Industrial Design of National Cheng Kung University. He is currently the Vice-Dean of College of Design and Planning, NCKU. His research focus on Design Evaluation and Tools development, Innovation Education, Kansei & Miryoku Engineering and Product Innovation & Design.

Fu-yu Lin, is a master student of Arizona State University. Her research interest is focus on the bussiness analytics and data visualization.

Appendix 1

List of Workshop Participants

Employer	Position	Number in Attendance
Health Promotion Administration, Ministry of Health and Welfare	Chief secretary, section chief, director, associate technical specialist, secretary, and contract employee	8
Department of Health for		
Keelung City Government	Section chief	1
Taipei City Government	Section chief, section chief, head, and planner	5
New Taipei City Government	Head, officer	3
Taoyuan City Government	Chief secretary, junior and associate technical specialists	3
Hsinchu City Government	Special assistant	2
Hsinchu County Government	Section chief	2
Miaoli County Government	Section chief, associate technical specialist, and research assistant	5
Changhua County Government	Section chief, associate technical specialist, and case officer	3
Nantou County Government	Associate technical specialist, project specialist, and public health instructor	3
Yunlin County Government	Section chief, junior and associate technical specialists, and special assistant	5
Chiayi City Government	Section chief, associate technical specialist, and special assistant	3
Chiayi County Government	Section chief, project specialist, and head nurse	4
Tainan City Government	Head and associate technical specialist	2
Kaohsiung City Government	Head and project assistant	2
Pingtung County Government	Associate technical specialist and project assistant	4
Taitung County Government	Associate technical specialist, project assistant, and contract employee	3
Hualien County Government	Associate technical specialist and project assistant	4
Ilan County Government	Section chief, associate technical specialist, and public health inspector	3
Penghu County Government	Deputy minister, special assistant, and temporary project assistant	3
Kinmen County Government	Contract employee	1

Lienchiang County Government	Project assistant	2

Appendix 2

Forty-two Strategies for Adolescent Tobacco Prevention from the Annual Proposal of the Local Department of Health

Original Strategies: 23	
1.	Strengthening inspections at the common site of violations (e.g., Convenient store, hospital)
2.	Counseling cigarette sellers to join the “guardian alliance”
3.	Strengthening training for tobacco-store staff (age recognition, etc.)
4.	Informing citizens about the hotline connected with (high) schools and the local Department of Health
5.	Hiring temporary staff for illegal inspections
6.	Using textbooks and other teaching materials to enhance awareness of the effects of second-hand smoke/third-hand smoke and e-cigarette vapors on children
7.	Sending flyers and letters to parents encouraging the quitting of smoking for the building a smoke-free environment effort
8.	Promoting smoke-free environments on campuses and nearby covered walkways
9.	Inspecting smoking hotspots (medical institutions, entertainment venues)
10.	Generating games to be used as teaching materials (e.g., e-cigarette turntable, tobacco prevention board game)
11.	Defining antitobacco activities (e.g., refusing to be around second-hand smoke, refusing offers of cigarettes from peers, being aware of emotional manipulation)
12.	Promoting sports activities and expanding awareness of the harm caused by tobacco
13.	Testing and recording levels of exhaled smoke (e.g., providing education on the addictive properties of nicotine) and providing follow-up counseling (smoking cessation services) to underage smokers
14.	Providing one-on-one health education (smoking cessation services) for dropouts and high-risk students
15.	Providing smoking cessation services in cooperation with the Joint Ministry of Education, external units, and schools
16.	Setting up penalties (payments and smoking cessation services) for students who are violating the Tobacco Hazards Prevention Act
17.	Interviewing and counseling parents of students who smoke
18.	Providing smoking cessation counseling and health education services in combination with community medical resources
19.	Banning tobacco advertising, promotions, and sponsorships
20.	Strengthening inspections of e-cigarettes and monitoring the selling of e-cigarettes on the internet
21.	Providing and renewing health warning campaigns and signs
22.	Training personnel to enforce the smoking cessation services and generate teaching materials

23.	Providing a free smokers' helpline for adolescents
New Strategies (added to the revised version of the proposal)**: 19**	
24.	Setting up health promotion clubs, which are friendly societies for underage smokers that provide a place in which they can build trust and try to quit smoking together through sports activities
25.	Monitoring websites on which tobacco is sold illegally
26.	Setting up payment rewards for the public to serve as incentives for reporting illegal underage smoking and selling
27.	Providing antitobacco board games that can be released on social networks
28.	Providing visual reality experiences for improving teens' abilities to refuse tobacco and strengthen awareness
29.	Posting mystery shopper reports on age verification for tobacco purchases
30.	Counseling tobacco sellers not to promote the sale of tobacco products to teenagers
31.	Investigating sources of tobacco supplied by students using the smoking cessation services
32.	Counseling tobacco traders and strengthening inspections to reduce illegal smoking
33.	Asking schoolteachers to cooperate with the HPA in providing SCSs for underage smokers
34.	Putting up posters with words in large fonts that promote one-on-one health efforts for elderly persons who sell cigarettes
35.	Testing and recording levels of exhaled co-values and providing follow-up counseling (for group /individual smoking cessation services)
36.	Providing unique teaching materials and campaigns in indigenous languages
37.	Providing an "antitobacco-promotion card in the shape of a gold ingot" for tobacco sellers
38.	Posting mystery shopper reports on age verification for tobacco purchases
39.	Informing people about the hotline connected with (high) schools and the local Department of Health
40.	Offering a lecture on campus on a smoke-free environment
41.	Encouraging parents to sign a quit-smoking commitment to build a smoke-free environment
42.	Providing parenting education for the parents of dropouts and high-risk student

Appendix 3

Matrix of Evaluated Relationship between Factors and Strategies

Factors	**18 Core Factors of Underage Tobacco Hazards Prevention**																	
Strategy	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
01	11	11	11	33	33	0	56	11	0	56	56	33	67	22	11	11	0	11
02	0	44	11	11	11	0	100	0	0	33	33	67	56	0	11	0	0	0
03	0	33	22	0	0	0	89	0	0	44	56	44	67	0	11	11	0	0
04	0	56	56	11	0	0	22	11	0	11	89	56	56	11	11	11	22	11
05	0	0	11	0	0	0	44	0	0	11	89	56	89	0	0	0	0	0
06	44	22	67	67	22	0	11	33	33	33	0	0	0	78	33	56	11	0
07	56	33	89	100	0	11	56	22	22	11	11	0	11	56	22	11	0	0

08	11	33	11	33	11	0	22	0	22	56	56	11	33	11	11	11	0	0
09	11	22	11	56	33	11	56	0	11	33	44	67	78	0	11	11	0	0
10	56	11	11	56	22	56	11	33	78	11	0	11	0	100	56	78	0	11
11	44	33	22	67	100	100	11	33	22	22	0	22	0	67	33	22	11	0
12	33	33	22	33	33	67	0	44	33	11	11	11	0	67	44	56	11	22
13	22	0	11	11	11	22	11	22	44	11	22	11	11	44	67	11	78	100
14	11	22	44	22	11	11	11	56	67	11	44	11	11	78	67	56	67	44
15	11	44	33	11	11	11	22	22	33	33	44	11	0	44	33	22	22	11
16	0	0	11	11	0	11	11	33	0	89	22	22	11	0	11	0	0	33
17	0	44	100	22	0	0	11	11	22	33	0	11	11	33	33	33	11	33
18	11	22	11	0	0	11	0	22	33	11	11	22	0	56	44	22	89	33
19	44	11	11	78	0	0	100	0	0	33	11	44	11	22	0	0	0	11
20	22	11	0	33	0	0	100	0	11	67	22	67	44	33	0	0	0	22
21	44	22	22	33	0	11	0	33	44	33	0	11	22	89	22	11	0	0
22	0	11	33	11	11	0	0	22	11	22	11	11	0	44	89	89	22	11
23	0	11	11	0	0	11	0	22	22	11	22	0	0	33	44	22	78	56
24*	33	33	44	56	11	78	0	44	56	22	33	11	0	44	100	67	56	67
25*	0	22	11	0	0	0	78	0	0	56	44	56	67	0	11	0	0	11
26*	0	44	11	0	0	0	78	0	11	89	78	67	67	0	11	0	0	11
27*	56	22	22	56	0	33	11	33	44	11	11	0	0	67	22	44	0	11
28*	33	22	33	44	89	22	0	33	56	11	11	11	0	78	56	67	11	0
29*	0	0	0	0	0	0	89	0	0	22	33	22	67	11	0	0	0	11
30*	22	33	11	22	0	0	89	33	22	44	44	33	22	67	22	22	0	11
31*	0	0	0	0	0	0	89	0	0	44	56	44	89	22	22	11	0	11
32*	0	33	0	0	0	0	100	0	0	56	56	44	78	0	11	11	0	11
33*	11	44	44	11	11	0	67	22	22	56	67	67	22	22	11	22	0	11
34*	11	22	33	11	0	0	100	0	11	56	22	11	33	33	44	22	0	0
35*	11	22	44	44	44	44	0	33	44	11	0	11	0	56	89	56	78	100
36*	22	33	33	33	33	11	11	22	44	11	0	11	0	78	67	67	11	0
37*	0	33	0	11	0	0	100	0	0	78	33	44	67	11	11	11	0	0
38*	0	11	0	0	0	0	78	0	0	33	33	44	89	0	0	0	0	11
39*	0	44	33	11	33	0	56	22	11	11	67	33	44	11	11	11	0	11
40*	44	33	22	44	11	11	0	22	56	11	11	0	11	67	22	44	0	0
41*	11	67	100	56	0	0	44	11	33	11	22	11	0	22	0	11	0	0
42*	11	44	100	22	0	11	11	22	44	33	11	0	11	78	56	22	22	11

* Strategies added after Design Thinking Workshop

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Designing game-inspired narratives for learning

Miranda VERSWIJVELEN[a]*, Ricardo SOSA[a], Nataly MARTINI[b]

[a] Auckland University of Technology, New Zealand
[b] University of Auckland, New Zealand
*Corresponding author e-mail: mverswijvelen@gmail.com
doi: https://doi.org/10.21606/drs.2020.294

Abstract: Digital simulations and scenario-based learning programmes are widely accepted as an effective educational approach where experiential learning is key. However, there is an acknowledged need to improve the narrative design of these educational interventions to make them both engaging for the learner and aligned with learning goals. This study turns for guidance to the expertise of narrative designers for games, where storytelling for interactive narrative has a long history of testing, iterating and perfecting. A collection of proven techniques described by game narrative practitioners will inform creative writing efforts to craft prototypes to test the transferability of those techniques to interactive narratives in a healthcare education context.

Keywords: game design; learning design; creative writing; choice design

1. Introduction

Learning designers use simulations and scenarios to create immersive contexts that reflect the day-to-day realities that are meaningful for learners. In those scenarios, learners face decisions in situations and/or with people in the simulated environment. They experience the consequences of their decisions as immediate feedback. This creates a more meaningful and experiential learning environment that contrasts with the type of right/wrong answer messages in more traditional training materials.

A requirement for this approach to learning design is the creation of a professionally designed narrative, with strong characters, a well-paced storyline, interesting choices and relevant consequences. However, few learning design professionals have a background in creative writing. They often struggle to write narratives that both immerse the learner in a well-crafted story and offer coherent and meaningful choices and consequences that align with the desired learning outcomes.

On the other hand, game writing has advanced significantly faster in the crafting of engaging interactive narratives. Story-based games present their players with appealing dialogues and at the same time provide choices that align player goals with the narrative design.

The research project presented in this paper stems from an ongoing doctoral project that seeks to identify opportunities to improve the interactive scenario writing practice of learning designers with the narrative design techniques developed in games. The design of the study is supported by significant professional experience in digital learning design, with a focus on scenario-based learning and story-based educational games.

This paper describes and reflects on the initial phase of the research project and presents the methods to extract practitioner knowledge about game narrative design techniques from secondary sources. Opportunities and challenges for the development of testing prototypes that apply these techniques to a learning design context are discussed.

2. Background

The role of simulations and scenarios to immerse learners in situations that reflect day-to-day reality has been studied for several decades (J. Biggs, 1996; Kolb & Kolb, 2009; Schank, Fano, Bell, & Jona, 1994). However, it has only recently gained traction in design for work-based learning. High profile practitioners in that industry propose learning design models that shift focus from “knowing about a desired change in behaviour” to “actively changing behaviour”. They champion interactive scenarios as a proven method for successful learning results (Aldrich, 2020; Clark & Mayer, 2012; Moore, 2017). The branching nature of scenario-based learning, with a focus on narrative and decision-making often leads to them being described as serious games in the learning design industry.

Several researchers look at games with a narrative framework as a very productive setting for educational games (Dickey, 2006; Luo, Cai, Zhou, Lees, & Yin, 2015; Shelton & Scoresby, 2011). Within this game genre the adventure game, both in its modern graphical form or its text-based origin (interactive fiction games) is often preferred. This preference is motivated by their high-level narrative framework for problem-solving, specific narrative techniques such as plot hooks that compel the player to find answers, and the emotional proximity between the player and their role (Dickey, 2006).

Looking at the wider context, interactive digital narratives are seen as an opportunity to serve both as entertainment and education. Researchers are particularly interested in how the power of control in a narrative is experienced psychologically by individuals (Green & Jenkins, 2014). While many authors focus on the player role in their definition of interactive narrative, other researchers point out the important role of the narrative or ‘system’ itself. They describe interactivity in storytelling as a cyclic process between agents: each agent (the user and the system) alternately listens, reflects and speaks (Crawford, 2008). This inclusion of the system as an active agent, brings the work of the designer/writer of the interactive narrative into focus.

Since the early days of interactive fiction games (IF), game designers have been perfecting devices and techniques to craft compelling and engaging narratives. They build interesting worlds and characters, write engaging dialogues and player choices and at the same time scaffold the narrative for problem-solving and player insights (Dickey, 2006; Fernández-vara, 2010). However, there are more arguments that make this specific game genre fit with crucial elements for this study. In his seminal work, “Twisty Little Passages”, Montfort (2005) likens IF to the literary genre of the riddle. He explains that IF builds a new world to be unravelled and understood by the reader/player in order to gain new insights and it is built to be solved. An IF game provides a “new perspective on something familiar” (p.60), which aligns with learning design initiatives wanting to achieve a change in how the player views and understands a situation. Narrative design techniques are inherent to the text-based IF genre: the writing must compel to engage the reader/player (Montfort, 2005).

While the IF genre has never really died out and has an active community, the past decade has seen a real “IF renaissance” with smaller independent game studios (“indie”) exploring the possibilities of interactive narrative based on the written word, often with minimal but high intensity graphics (Alexander, 2013). This renewal of the text-based game is aided by our familiarity with reading on tablets and phones as a leisurely activity, which can thus be associated with games (Alexander, 2012). Incidentally, this trend aligns with recent publications within the learning design industry, which advocate for active learning interventions focused on story and choice design with simple graphics (Aldrich, 2020).

While this study ultimately looks at a wider perspective for the improvement of interactive narratives for learning, prototyping applies the findings to healthcare conversations. This choice is motivated by practice experience in the creation of scenario-based healthcare training. More specifically, the prototypes will focus on compassion training, part of training in non-technical skills (NTS), widely seen as essential in the improvement of patient safety and health outcomes (Bauchat, Seropian, & Jeffries, 2016; Riess, 2017). Research in the past two decades looks at narrative approaches to achieve a deep understanding of the patient experience and the facets of clinician-patient relationships (Batt-Rawden, Chisolm, Anton, & Flickinger, 2013). A healthcare provider’s competence in recognising narrative allows a deeper understanding of each patient experience, resulting in more patient-centered care (Barber & Moreno-Leguizamon, 2017). Interactive narratives, in the form of simulations and serious games, have often been discussed as an educational approach to develop empathy and/or empathetic behaviours in patient-healthcare provider situations (Batt-Rawden et al., 2013; Bearman, Palermo, Allen, & Williams, 2015). This aligns with educational approaches that use interactions with virtual patients for healthcare training. In this area, many studies highlight the need for further research into the creation of the interactive narratives that provide learners with the “sense of complexity and unpredictability” that in healthcare replicate experiences with real patients (Peddle, Bearman, & Nestel, 2016).

In conclusion, an application of techniques applied in-game narrative would lead to a higher quality narrative structure that supports the interactive decision-making and dialogues in scenario-based learning and simulations for healthcare and learning design in general. It would support the narrative to approach the behaviour of real people in real situations, and therefore enhance their believability and increase immersion by elevating their intricacy and unpredictability.

3. Methods

Within practice-led research, the approach of the current study aligns with creative writing research, including self-reflexivity, creativity and experimentation as well as scholarship (Kroll, 2009; Skains, 2018). More specifically, it seeks to explore the processes and craft of creative writers in the field of game narrative to inform and lead a professional writing project in the digital learning space. This methodology is iterative and messy by nature, as research and creative writing will alternate, shaped and informed by practice and led by the needs of the project (Kroll, 2009). Additional to the writing project itself, a record of the project iterations of the project and thinking processes involved are part of the research output. The totality of these findings becomes knowledge for wider use in the creative writing field (Harper, 2009).

The creative writing endeavour of this study fits within the wider context of interaction design (IxD) research, which studies the relationship between the artefact, the user and the context or environment (Fallman, 2008). The interactive narratives within this research project compare an interaction design approach that is proven for a specific context - game design - and studies its impact in another context: learning design. Additionally, there is a difference in user. Arguably one could say that a user of an e-learning intervention can be a gamer in another part of their life, but they will approach the artefact with a different mindset and often within a different environment (home vs work). This study finds a place in what Fallman describes as “loops” within his triangle of design practice, design exploration and design studies (Fallman, 2008).

Discussions around the outputs of research through design for IxD call for solutions to address the wide relevance of findings, with the dissemination of both tacit knowledge of experienced practitioners and knowledge acquired through research for the design industry, design researchers and design teachers. (Höök et al., 2015). Within this discussion, active sharing of findings within the learning design and game design community through blogs and presentations at industry events sits alongside academic output throughout the study.

In the initial phase of research, the focus lies on critically gathering best practice narrative design techniques from game writing practitioners to inform the creative writing iterations.

3.1 Practitioner knowledge sharing as data

Game narrative design expertise has been described as a “double secret art”. The knowledge of it is often restricted to the empirical knowledge of the practitioner, or guarded as intellectual property within successful game companies (Roth, Knoller, Koenitz, & Dubbelman, 2018). While some researchers also work on commercial games, and conversely, game designers enter into academic programs, most game designers will never author academic papers (Isbister, Flanagan, & Hash, 2010). This disconnect of knowledge sharing channels between academia and practice is also noted in other practitioner disciplines, such as technical communication, medicine, education and socio-linguistics (Hannah & Lam, 2016). In parallel to these practitioner communities however, game designers are quite prolific in sharing their experiences with fellow practitioners in other ways, thus providing a wide variety of data for the study.

In this initial phase, the study examines blog posts on professional websites of individual designers, game studios and industry sites such as gamasutra.com, and transcripts of talks at industry events about games and interactive narrative. Blogs provide practitioners with a platform for unhindered conversations with colleagues and reflection on their own practice. They are a space where a shared practitioner language is developed (Hannah & Lam, 2016; Schwartz & Schon, 1987). Other sources for future study may be so-called post-mortem reports of games, and critical and authorial comments on narratives that incorporate choices, such as game reviews (Mawhorter, Mateas, Wardrip-Fruin, & Jhala, 2014).

The sheer volume of the materials available online requires strict selection criteria. For the current research, the focus is on texts where the author provides the reader (or listener in the case of industry talks) with practical content that can be applied to personal work immediately: structures, phrases, diagrams, patterns, word choices etc. Words and phrases that highlight texts as relevant for deeper analysis are e.g. “how to…”, “writing…”, “crafting…”, “steps for…” and “tools to…”.

Unfortunately, titles of blog posts and event talks tend to be “catchy” to attract an audience, which makes search actions for this particular content a complex exercise. These types of texts typically also do not have an abstract. However, the background of the practitioner experience that supports this study can take advantage of inside knowledge to commence the search journey. Known names of industry thought leaders on game narrative provide a starting point to select useful texts, from which a snowballing approach uncovers further data through their mention of other authors, praises of well-designed games and related texts.

This is also linked to the selection criteria for retained authors: texts need to be written/expressed by practitioners, possibly in different roles (researchers, critics, players). The authors need to actively write for games, more specifically for interactive fiction games or other story-based games. They need to refer to themselves first and foremost as game writers or narrative designers.

3.2 Prototyping as a research method

In game design, prototypes are often described as thinking tools in what is called a “wicked problem space”. Attempts at producing solutions can change the understanding of the problem and varying the design of a game and studying these iterations is part of game design. Game designers experiment during their design processes: they add and delete components, change the way the game interacts with players, modify mechanics etc. (Lankoski & Björk, 2015).

The interactive fiction prototypes developed for this study can be defined as "research prototypes": the design experimentation process is used as a research method, where the iteration of prototypes is planned starting from the initial research question (Eladhari & Ollila, 2012).

The research questions guide the design process of the prototypes, their development, the testing, the types of data gathered and how to treat those data. In their turn, the prototypes may lead to iteration of the research question, a process well established in IXD research (Fallman, 2008). The goal of the prototyping process is to discover narrative design techniques that can be used for other scenario-based learning pieces that are engaging, challenging and aim to achieve specific learning outcomes.

4. The case of choice design

The case of choice design in games has a multitude of facets. It is not only discussed as part of the craft in creative writing, but also linked to fields of psychology, decision-making theory, player engagement and character development (Mawhorter et al., 2014; Sheldon, 2004). Additionally, a learning designer has the educational goal to consider. Most, if not all of their choices presented to the learner in the course of an interactive narrative need to align with the learning goals (Dickey, 2006; Shelton & Scoresby, 2011).

Mawhorter et al. (2014) are working towards a "theoretical framework choice poetics", which analyses several of the aspects mentioned above, and includes craft advice from practitioners. Their definition of choice structure framed the more focused design of the prototype created in this study. The authors define a choice structure as follows: "A choice structure consists of the framing, options, and outcomes associated with a choice." The "framing" can be described as the context, the situation in which a choice is placed. The "options" are the actual choices the learner can select, and the "outcomes" are the consequence(s) of selecting either of those choices (Mawhorter et al., 2014).

The next sections discuss two examples of how practitioner techniques can inform the prototyping exercises. They both illustrate the varied influences which shape the research, as they are informed by academic writing, a blog post or an industry talk.

4.1 Framing and the use of subtext: an iterative make-over

One of the first texts examined for this study is a talk from AdventureX18 by acclaimed interactive writer Jon Ingold, titled "Sparkling dialogue: a masterclass". Jon Ingold from game studio Inklestudios has co-created and written award-winning narrative games such as 80 Days and Heaven's Vault. He has been active in the interactive fiction community for over 20 years and has created many experimental works exploring the genre and its creative writing aspects. The talk mentioned above uses a crucial scene in the movie "Blade Runner" to demonstrate how it can be turned into an interactive scene. While the talk focuses on many elements of choice structure, for this prototype we focused on the principle of "subtext".

In typical framing text for a scenario, learning designers often err on the side of caution and shower the learner with information. They provide a full framing of the decision presented. While they try to engage with the learner by "creating a story", learning designers often provide too many details and alienate instead of engaging the learner. While this research takes its cue for the 'typical framing' from many examples of colleagues-practitioners, it is important to note that even learning industry thought leaders have acclaimed examples of scenario-based learning that overwhelm learners with details in framing.

The prototype presents a so-called mini-scenario (Moore, 2017), which mostly consists of framing and one set of options. The choice of topic was influenced by practitioner experience in the area of Health and Safety training, and more specifically in hospital settings. A familiar learning challenge in that area was chosen: a slip hazard. The nurse in the prototype story arrives late for work, and will notice a spill in the corridor – will she clean it up or rush on? The paragraphs below are the first version.

> "Laura has worked as a nurse at Starburst hospital for five years. She is on the early shift today, but she is running late. There was so much traffic on the Southern motorway today and her little boy, Jamie, who is 4, decided to protest against the clothes she laid out for him! Definitely no time for a coffee before her shift starts. She speeds to the ward."

Improvement for this piece of creative writing is now sought in the techniques described by the source. In the aforementioned 2018 talk, Jon Ingold tells his listeners to look at subtext. He challenges them to look at "What is actually happening here?" (00:19:39) and reminds them that "This is an opening step." (00:19:39). What is the learning designer trying to do? They try to build rapport with their learner in their workplace context. This paragraph says: "Laura is a nurse, just like you, learner and she's late because of traffic and domestic stuff."

If we, under Jon Ingold's guidance look at what is irrelevant to achieve this goal, we can ask the following questions about the current content: Does it matter how long Laura has worked at the hospital? Or where exactly she was stuck in traffic? Does the learner need to be burdened with an additional name, that of her little boy? Not really. It just adds unnecessary reading effort. Based on those questions, let's rewrite as follows.

> "Laura, a nurse at Starburst hospital, is late for her early morning shift. Her little boy refused to get dressed and she was stuck in traffic.
> Definitely no time for a coffee before her shift starts. She speeds to the ward."

As a first iteration, it can be noted that it is already much shorter, but it still does not engage the learner. Jon Ingold tells us that that is a good step to be at:

> "now that we have a subtext structure, now that we actually know why we're here and what we're doing and who we are, we actually can add value and make things sparkle. We can rewrite the crappy lines and make them a little bit better." (00:43:55)

In line with the title of the talk, we now turn it into dialogue. It provides a change from running text and gives the opportunity to include a glimpse at Laura's emotions.

> "There goes my morning coffee," Laura sighs as she rushes to the ward, late for her shift.

"Ugh! Auckland traffic, and a non-cooperative 4-year old. What a morning.".

Laura is now ushered in as a living person, by making her lateness a personal effusion and using a strong dialogue-like expression that makes her talk to the reader. Reflection about those changes shows that by using the subtext structure, we have written less to write more. The introduction is a lot shorter, and quicker to read for the learner, but it is more engaging at the same time. Also, by making some elements more generic, the paragraph connects with more people. Taking away the details about traffic and the child situation but leaving them in as a reason for the protagonist's lateness, allows more readers to feel connected. The learners may have traffic trouble elsewhere in the city, not on the Southern motorway. They may have a small child in their family, but they are not the Mum, the child may be a little girl, not a boy etc. The child they relate to may have been a fussy eater or a bad sleeper, so the description "non-cooperative" makes that connection with personal experience but does not provide extra details that may not resonate.

From this writing exercise, three questions emerge that learning designers can use to think when they write framing text to introduce a decision: "What is the subtext of this scene?"; "Which details can be generalised so we connect to more learners?"; "Can we draw the learner in by using a bit of dialogue?".

4.2 Writing options: descriptive or action-based

This second example works with one aspect of the 'options' in the choice structure presented by Mawhorter et al. (2014). This part of the choice structure is discussed widely by narrative designers as choices are an inherent part of interactive narratives and games in general. A blog post by narrative designer Bruno Dias on the Choice of Games website, a platform for text-based games, provides advice on writing "good choices" (Dias, 2018). The text stays high level about most aspects of choice design but provides some specific examples for some. Dias touches on the following themes for options: the number of choices provided to the learner/player; the text of the choice: a description or a literal action; the length of the text; balancing choices while considering the hierarchy and relationships of characters; consistency.

The prototype in this discussion provides a testing space for the text of the choice as described by Dias. Choices can feel completely different to a learner/player depending on how they are written, even if the text has the same meaning. Similar to the technique applied in the previous section, the way of writing a choice can affect learner engagement.

Let's look at this simple example of the difference between writing an option as a description of what a player could say to a non-player character (NPC) and writing the choices as the actual speeches.

In this set of three options, the actions presented to the learner are described:

- You tell him he is lying.
- You tell him he is right.

- You say nothing.

Then, the same options are rewritten, but provide the player with actual speeches.

- "You are a liar!"
- "You are right."
- "…".

Bruno Dias warns the game writer that with the action-based options "What you implied (…)" will linger. They help to make up the player's image of the character they are playing, of "what they're capable of" (Dias, 2018). Reflecting on what this means for a learner engaged in a scenario-based learning module, it occurs that direct speeches may alien them. In their work life, with for example clients or colleagues, they may never use such direct speech, it may not fit their personality type. The descriptive version gives room for imagination and allows the learner to envisage a speech that conveys the same meaning but fits their personality and style of conversing.

For a learning design situation, the choice between these two writing styles for options is often linked to the alignment with learning outcomes. As an example, in a scenario-based learning module that is designed to train e.g. call centre employees to handle emotional callers, the literal speeches may be preferable. The module may try to convey the tested and proven use of phrases that can help in such situations, such as "I hear what you are saying…", versus giving the learner a mere description of the speech such as "You acknowledge their story." When learning to use specific phrases in specific situations is one of the learning goals, the learning designer may not want the learner to imagine their own version.

Again, as with the technique discussed in the previous section, we can deduct several questions for the learning designer to ask themselves: what do you want the learner to do or say in a real situation?; Is the viewpoint character the learner, or are they a NPC that the learner makes choices for? How do you want the learner to feel about the viewpoint character if it is a NPC?

Dias (2018) concludes his advice by mentioning the need for consistency: he advises never to mix both styles when writing choices. However, several game examples do combine them with a successful result. In the Titanic interactive story by acclaimed narrative designer Meghan Jayanth, the choices occasionally combine both types, specifically when there is a combination of dialogue options and actions. The player may for example have the choice between two speeches and one action (e.g. walk away). These comparisons of advice by one narrative designer and actual practice in existing games designer by another expert practitioner promise to provide interesting iterations in the prototyping phase of the full study.

5. Conclusion

Narrative techniques used by experienced game designers can help learning designers to reflect on their writing and to improve the engagement of their audience when they create simulations or scenario-based learning. Those techniques can be gathered from practitioner-oriented sources created by game designer such as blogs and talks at industry events.

Next steps in the present study include the development of testing prototypes of interactive stories for compassion training in a patient-healthcare provider relationship setting. Compassion training is a perceived need in healthcare studies and practice, and calls for a better narrative approach to digital training approaches (Kleinsmith, Rivera-Gutierrez, Finney, Cendan, & Lok, 2015). Moreover, the ability of games to elicit empathy and related emotions such as compassion has been the object of different studies (Farber & Schrier, 2018; Isbister, 2016). In this space, it will also be valuable to explore the understanding of compassion as an internal motivation (Perez-Bret, Altisent, & Rocafort, 2016) and how this can be leveraged by the concept of intrinsic motivation in game design (Mallon & Webb, 2006).

Reflections on the creative process to compose the actual stories will be journaled to inform insights in how practitioners can apply the narrative techniques to interactive stories with a training or learning purpose. Ultimately this study can give rise to a set of guidelines or heuristics for creative writing that can be used by learning designers. Additionally, a framework of the effectiveness of particular techniques for specific goals may be derived, which may have applications in both learning design and game design narratives.

6. References

Aldrich, C. (2020). *Short Sims*. Boca Raton: CRC Press. https://doi.org/10.1201/9781003018643

Alexander, L. (2012, May 11). In-depth : Is it time for a text game revival? [Blog post]. Retrieved from https://www.gamasutra.com/view/news/167665/Indepth_Is_it_time_for_a_text_game_revival.php

Alexander, L. (2013). Roundtable : The Interactive Fiction Renaissance. *Game Developer Magazine*, (March), 1–6.

Barber, S., & Moreno-Leguizamon, C. J. (2017). Can narrative medicine education contribute to the delivery of compassionate care? A review of the literature. *Medical Humanities*, *43*(3), 199–203. https://doi.org/10.1136/medhum-2017-011242

Batt-Rawden, S. A., Chisolm, M. S., Anton, B., & Flickinger, T. E. (2013). Teaching empathy to medical students: An updated, systematic review. *Academic Medicine*, *88*(8), 1171–1177. https://doi.org/10.1097/ACM.0b013e318299f3e3

Bauchat, J. R., Seropian, M., & Jeffries, P. R. (2016). Communication and Empathy in the Patient-Centered Care Model—Why Simulation-Based Training Is Not Optional. *Clinical Simulation in Nursing*, *12*(8), 356–359. https://doi.org/10.1016/j.ecns.2016.04.003

Bearman, M., Palermo, C., Allen, L. M., & Williams, B. (2015). Learning empathy through simulation: A systematic literature review. *Simulation in Healthcare*, *10*(5), 308–319. https://doi.org/10.1097/SIH.0000000000000113

Clark, R. C., & Mayer, R. E. (2012). *Scenario-based e-Learning : Evidence-Based Guidelines for Online Workforce Learning*. New York: John Wiley & Sons, Ltd.

Crawford, C. (2008). *Interactive Storytelling*. *Chris Crawford on interactive storytelling* (Vol. 5334). https://doi.org/10.1007/978-3-540-89454-4

Dias, B. (2018, March 13). Making Interactive Fiction: Branching Choices [Blog post]. Retrieved from https://sub-q.com/making-interactive-fiction-branching-choices/

Dickey, M. D. (2006). Game Design Narrative for Learning: Appropriating Adventure Game Design Narrative Devices and Techniques for the Design of Interactive Learning Environments. *Educational Technology Research and Development*, *54*(3), 245–263. https://doi.org/10.1007/s11423-006-8806-y

Eladhari, M. P., & Ollila, E. M. I. (2012). Design for Research Results: Experimental Prototyping and Play Testing. *Simulation & Gaming*, *43*(3), 391–412. https://doi.org/10.1177/1046878111434255

Fallman, D. (2008). The interaction design research triangle of design practice, design studies, and design exploration. *Design Issues*, *24*(3), 4–18. https://doi.org/10.1162/desi.2008.24.3.4

Farber, M., & Schrier, K. (2018). *The Limits and Strengths of using Digital Games as "Empathy Machines"* (No. 2017–05).

Fernández-vara, C., & Osterweil, S. (2010). The Key to Adventure Game Design : Insight and Sense-making. Proceedings of Meaningful Play (October 2010).

Green, M. C., & Jenkins, K. M. (2014). Interactive narratives: Processes and outcomes in user-directed stories. *Journal of Communication*, *64*(3), 479–500. https://doi.org/10.1111/jcom.12093

Hannah, M. A., & Lam, C. (2016). Patterns of dissemination: Examining and documenting practitioner knowledge sharing practices on blogs. *Technical Communication*, *63*(4), 328–345.

Harper, G. (2009). Creative writing: words as practice-led research. *Journal of Visual Art Practice*, *7*(2), 161–171. https://doi.org/10.1386/jvap.7.2.161_1

Höök, K., Bardzell, J., Bowen, S., Dalsgaard, P., Reeves, S., & Waern, A. (2015). Framing IxD knowledge. *Interactions*, *22*(6), 32–36. https://doi.org/10.1145/2824892

Isbister, K. (2016). *How Games Move Us: Emotion by Design*. MIT Press.

Isbister, K., Flanagan, M., & Hash, C. (2010). Designing games for learning: Insights from conversations with designers. *Chi*, 2041–2044. https://doi.org/10.1145/1753326.1753637

J. Biggs. (1996). Enhancing teaching through constructive alignment. *Higher Education*, *32*, 347–364. https://doi.org/10.1007/BF00138871

Kleinsmith, A., Rivera-Gutierrez, D., Finney, G., Cendan, J., & Lok, B. (2015). Understanding empathy training with virtual patients. *Computers in Human Behavior*, *52*, 151–158. https://doi.org/10.1016/j.chb.2015.05.033

Kolb, A. Y., & Kolb, D. A. (2009). The Learning Way. *Simulation & Gaming*, *40*(3), 297–327. https://doi.org/10.1177/1046878108325713

Kroll, J. (2009). The supervisor as practice-led coach and trainer: getting creative writing doctoral candidates across the finish line. *Journal of Writing and Writing Courses*, (6). Retrieved from https://patentimages.storage.googleapis.com/41/b5/ca/69ffeea861af61/US8949899.pdf

Lankoski, P., & Björk, S. (2015). Game Research Methods. (P. Lankoski & S. Bjork, Eds.), *Satisficing Games and Decision Making: With Applications to Engineering and Computer Science*. ETC Press. Retrieved from https://www.diva-portal.org/smash/get/diva2:816775/FULLTEXT01.pdf

Luo, L., Cai, W., Zhou, S., Lees, M., & Yin, H. (2015). A review of interactive narrative systems and technologies: a training perspective. *SIMULATION*, *91*(2), 126–147. https://doi.org/10.1177/0037549714566722

Mallon, B., & Webb, B. (2006). Applying a phenomenological approach to games analysis: A case study. *SIMULATION & GAMING*, *37*(2). https://doi.org/10.1177/1046878106287949

Mawhorter, P., Mateas, M., Wardrip-Fruin, N., & Jhala, A. (2014). Towards a Theory of Choice Poetics. *Foundations of Digital Games*. Ft. Lauderdale, April 3-7 2014.

Montfort, N. (2005). *Twisty Little Passages*. MIT Press.

Moore, C. (2017). *Map it : the hands-on guide to strategic training design*. Montesa Press.

Peddle, M., Bearman, M., & Nestel, D. (2016). Virtual Patients and Nontechnical Skills in Undergraduate Health Professional Education: An Integrative Review. *Clinical Simulation in Nursing*, *12*(9), 400–410. https://doi.org/10.1016/j.ecns.2016.04.004

Perez-Bret, E., Altisent, R., & Rocafort, J. (2016). Definition of compassion in healthcare: A systematic literature review. *International Journal of Palliative Nursing*, *22*(12), 599–606. https://doi.org/10.12968/ijpn.2016.22.12.599

Riess, H. (2017). The Science of Empathy. *Journal of Patient Experience*, *4*(2), 74–77. https://doi.org/10.1177/2374373517699267

Roth, C., Knoller, N., Koenitz, H., & Dubbelman, T. (2018). Interactive Narrative Design Beyond the Secret Art Status: A Method to Verify Design Conventions for Interactive Narrative. *Revista Do Programa de Doutoramento Em Materialidades Da Literatura*, *6*(1), 107–119. https://doi.org/10.14195/2182

Schank, R. C., Fano, A., Bell, B., & Jona, M. (1994). The Design of Goal-Based Scenarios. *Journal of the Learning Sciences*, *3*(4), 305–345. https://doi.org/10.1207/s15327809jls0304_2

Schwartz, H. S., & Schon, D. A. (1987). The Reflective Practitioner: How Professionals Think in Action. *Administrative Science Quarterly*, *32*(4), 614. https://doi.org/10.2307/2392894

Sheldon, L. (2004). *Character development and Storytelling for Games*. Boston, Massachusetts: Thomson Course Technology

Shelton, B. E., & Scoresby, J. (2011). Aligning game activity with educational goals: Following a constrained design approach to instructional computer games. *Educational Technology Research and Development*, *59*, 113–138. https://doi.org/10.1007/s11423-010-9175-0

Skains, R. L. (2018). Creative Practice As Research: Discourse on Methodology. *Media Practice and Education*, *19*(q), 82–98.

About the Authors:

Miranda Verswijvelen is a senior learning designer with a passion for scenario-based learning and game design. She has extensive experience in the digital learning and educational game space, in healthcare, corporate and academic settings. She combines freelance work with PhD study.

Ricardo Sosa is Associate Professor at Auckland University of Technology and holds adjunct positions at Monash University and Nanyang University of Technology Singapore. He teaches and conducts research in design and creative technologies with an emphasis on creativity for social justice.

Nataly Martini is a Senior Lecturer at the School of Pharmacy, University of Auckland. She has a research interest in the use of virtual patient simulations to teach clinical reasoning, collaboration, communication and compassion in health sciences students and professionals.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Reframing in Design: When and how do teams frame and reframe in design projects

Jan AUERNHAMMER[a]*, Max LENZEN[b], Larry LEIFER[a]

[a] Stanford University, United States of America
[b] Stanford University, United States of America; RWTH Aachen, Germany
*Corresponding author e-mail: jan.auernhammer@stanford.edu
doi: https://doi.org/10.21606/drs.2020.280

Abstract: The research presented in this article investigates and discusses the changes in conception throughout twenty-three product innovation projects. Changes in conception in the thinking of the designer that leads to novel design concepts have been investigated mainly in situ through methods such as protocol analysis. However, scholars emphasized that changes in conception happen over longer periods. For this reason, the research examined the changes in conception throughout a nine-month product innovation project. The changes in conception were investigated by identifying the main word-groups used to describe the design concept at different project stages and examining when the word-groups changed over the project period. Design teams produced the reports at specific stages in the project. This consistency allowed comparing twenty-three projects over three consecutive years. The analysis revealed specific conditions that facilitate novel conceptual changes necessary to create an innovative product design concept.

Keywords: reframing; design thinking; engineering design; prototyping

1. Introduction

When do designers have creative leaps that result in new design concepts has been a long interest in design. Many scholars investigated and developed practices and exercises which facilitate creative leaps (e.g., Adams, 2001; Arnold, 1962a, 1962b; Arnold & Arnold, 2016; Dorst, 2015; McKim, 1980; Schön, 1983, 1984). For example, research in design thinking examined the cognitive strategies of problem-solving revealing approaches such as problem and solution framing (e.g., Dorst & Cross, 2001; Lawson, 1979; Schön, 1983, 1984; Valkenburg & Dorst, 1998). These studies examined the thinking and activities through direct observations in situ utilizing methods such as protocol analysis. Protocol analysis is a valuable but highly specific research technique that captures a few aspects of design thinking in detail (Cross, 2001). However, it is failing to encompass many of the broader realities of design (Cross, 2001). A particular broader reality is the emergence and evolution of creative leaps in design throughout a longer period. Psychologist and creativity scholars have long emphasized that creative leaps include a period of incubation of conscious and unconscious processes (e.g., Koestler, 1964; Wallas, 1926). For example, Arnold (1959) described that creativity in design requires a questioning attitude and obsessive observations to recognize patterns in the environment relevant to the solution. These patterns need to be combined and recombined through mental processes of association to create novel or original ideas and require prediction to select the most promising ones (Arnold, 1959). In situ observations examine such activities and thinking of designers in detail. However, they do not observe how, e.g., conceptions in observation relate to conceptualizing the design of the functional product system in a later phase. Investigating creative leaps throughout an entire product innovation project allows identifying the interrelations of changes in the design concept. Therefore, the research presented in this article examines the changes in the design concepts of twenty-three design teams throughout a nine-month program. The study investigates when design teams create and explore changes in the concept of the design within product innovation projects.

2. Background

The challenge for design teams in creating innovative solutions is to produce a novel and tangible outcome that is meaningful, manufacturable, and marketable. Several scholars developed design practices that aim to fulfill people's needs, while generating feasible, manufacturable, and marketable product (e.g., Arnold, 1959; McKim, 1959; Srinivasan, Lovejoy, & Beach, 1997). This creative, experiential, and human-centered design approach has been cultivated and advanced in design firms such as IDEO (e.g., Buchenau & Fulton Suri, 2000; Fulton Suri, 2003; Gilmore et al., 1999; Hargadon & Sutton, 2000; Leonard & Rayport, 1997; Moll-Carrillo, Salomon, Marsh, Fulton Suri, & Spreenberg, 1995; Sutton & Hargadon, 1996). These specific design practices became widespread under the term Design Thinking (e.g., Brown, 2008; Leifer & Steinert, 2011).

2.1 Design Thinking as an innovation practice

Innovative design requires (1) novelty through creativity and (2) meaningfulness for people, feasibility and manufacturability of the technology, and salability of the product system through a sustainable business model.

Scholars investigated and developed several (1) creative practices in design (e.g., Arnold, 1962a, 1962b; Arnold & Arnold, 2016; McKim, 1980; Schön, 1983, 1984). Arnold (1959, 1962a, 1962b) outlined practice and exercises for developing the creative skills and abilities in design. He describes the attitudes of questioning, observing, associating, and predicting in combination with the mental attributes of openness to experience, fluency and flexibility, and originality (1962a, 1962b). These are based on early creativity research by Guilford (1950, 1957) and Rogers (1954). This educational approach by Arnold (1962a) facilitates the development of the inherent creative potential of designers. McKim (1972,

1980) expanded this practice through visual thinking practices to enable seeing, imagining, and idea sketching, while Adam (2001) developed strategies in design to overcome blocks to creativity. Other scholars investigated the problem-solving strategies. For example, Schön (1983, 1984) examined and outlined the reflective practices of framing, moving, and reflecting to create different design concepts to solve complex problems. Based on Schön's (1983) work, Dorst and colleagues expanded the reframing practices (Dorst, 2015; Dorst & Cross, 2001; Valkenburg & Dorst, 1998). These mental activities, such as association and visual imagination, are conducive to creativity. Specific practices and techniques such as brainstorming, Morphological analysis, visualization, and prototyping activities assist these mental activities (e.g., Adams, 2001; Arnold, 1962b; McKim, 1980).

Furthermore, product innovation requires (2) meaningfulness, feasibility and manufacturability, and salability. The above described creative design practices were advanced through practices such as need-finding that aim to fulfill human needs (Faste, 1987; McKim, 1959). This practice enables the design of meaningful concepts for people. Srinivasan et al. (1997) developed practices to generate manufacturable and marketable products based on design activities such as prototyping. These specific design activities aim to enable the (1) creative mental activities (thinking) and the (2) development of human-centric, technologically feasible, and business viable design concepts (outcome). Figure 1 illustrates this interrelation between design outcomes and design activities and thinking.

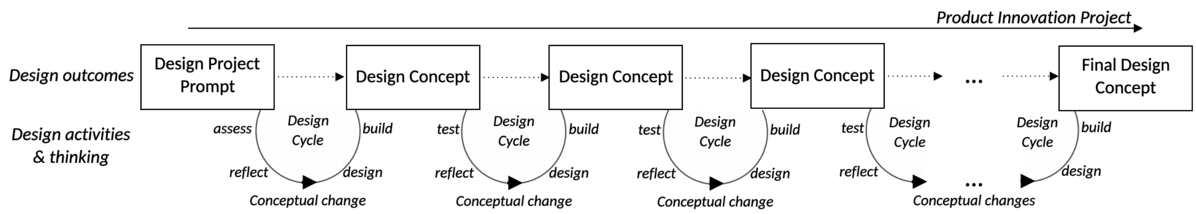


Figure 1 *Illustrates how a design prompt or design concept turns into action, learning, and new outcome. Each cycle aims to generate changes in the design concept. Each conceptual change results from the learning from previous concepts in combination with new learnings based on the design activities.*

Figure 1 illustrates the design cycle as a step process. However, in reality, activities occur simultaneously and represent attitudes of the designer's mind and not step-by-step processes (e.g., Arnold, 1959; Black, Bayley, Burns, Kuuluvainen, & Stoddard, 1994). In the iterative design cycles, creative leaps based on conceptual change in the thinking of the designers are essential to produce a novel design concept. As discussed above, specific creative design activities facilitate changes in conception in design. By facilitating design teams in these specific practices, they experience and learn Design Thinking as an innovation practice while attempting to create innovative products.

2.2 Facilitating Design Thinking

Several scholars developed project-based and experiential learning approaches to facilitate the learning of the creative and human-centered engineering design practice to develop the necessary skills and abilities (Dym, Agogino, Eris, Frey, & Leifer, 2005; Leifer, 1998; Wilde, Faste, & Roth, 1994). As illustrated in Figure 1, this experiential learning follows a learning cycle of design-build-test in a collaborative environment (Leifer & Steinert, 2011). Formal, informal, and experiential knowledge creation facilitates the learning process of the design practice (Eris & Leifer, 2003). Figure 2 illustrates the three learning loops that enable the design team in their experiential learning and innovation challenges.

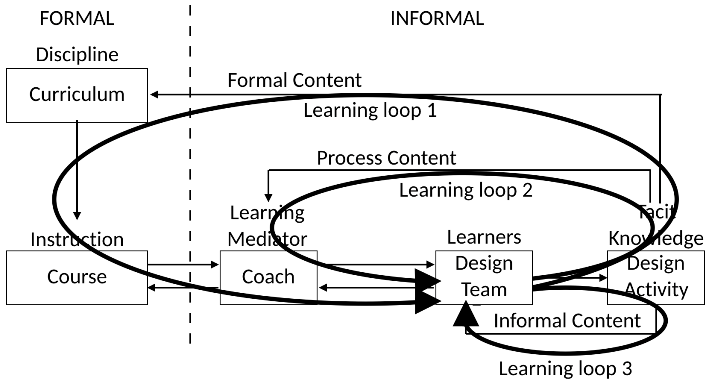


Figure 2 *llustrates the three learning loops of formal, procedural, and experiential knowledge in the education of Design Thinking teams. Based on Eris & Leifer (2003) and Leifer & Steinert (2011).*

In these learning loops, the coaches are the learning mediators for the design teams. They provide formal knowledge such as expert knowledge in the form of conceptual models and codified specific design practices and informal knowledge such as procedural support. The coaches enable the design teams in their design activates and experiential learning. At different points of the innovation project, specific Design Missions support in the facilitation of the design team practices of exploring people's needs, functionality, manufacturability, and marketability. Design Missions aim to enable teams to explore different areas of the design space and encourage them to tackle different design challenges (Bushnell, Steber, Matta, Cutkosky, & Leifer, 2013). Figure 3 shows this facilitation, and Table 1 outlines the Design Missions.

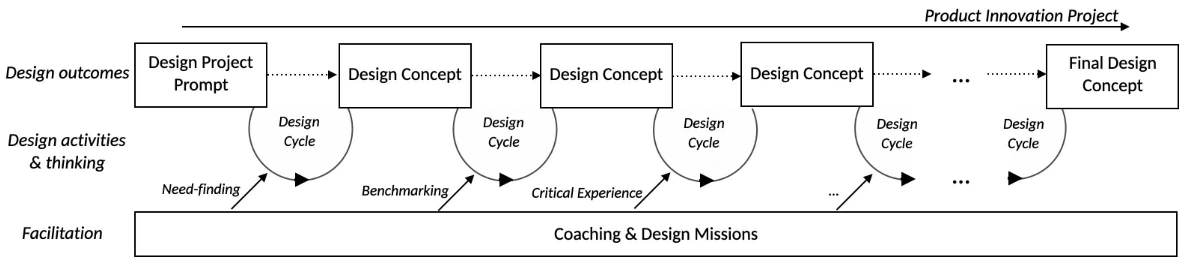


Figure 3 *shows the facilitation of the thinking and activities of the design teams through specific*

Design Missions.

Table 1 Design Missions in the Design Innovation course ME310 (Domingo et al., 2020)

Design Mission	**Challenge**	**Description**
Paper bike (not included in the analysis)	Learning of the design cycle	The paper bike challenge is an initial exercise to provide the student teams with the experience of how designers frame, act, reflect, and reframe to create a design solution for the competitive and fun pre-determined game.
Needfinding (NF)	Identify people's needs	Needfinding reveals needs and explores the context of the person/people for whom to design for by observation, intervening, engaging, and ethnographic interviews.
Benchmarking (BM)	Evaluation of existing solutions	Benchmarking is a physical activity to learn what existing solutions solve the problem and what they do poorly.
Critical Experience (CEP)	Evaluation of experience of users	The critical experience prototype involves creating an experience that answers a particular design question (why) about people's behavior in relation to the aspect of a design. The CEP often utilizes the Wizard of Oz prototyping approach.
Critical Function (CFP)	Evaluation of functionality of the design	The critical function prototype is a physical artifact with the focus on how a design function is needed to deliver the experience.
Dark Horse (DH)	Exploration of risky ideas after design vision has established	Design teams intentionally explore a concept, technology, or idea that would have otherwise not been seriously considered as it is considered unrealistic, too risky, radical, or challenging to implement (Bushnell et al., 2013). It aims to keep the ambiguity high by keeping the conceptual solution space from narrowing down too quickly.
Funky (Funk)	Exploration of a low-fidelity physical system	The funky systems prototype is bringing together parts into a physical system in a manner without making a costly commitment. It is a rapidly assembled concept prototype that allows evaluating and testing of the physical system.
Functional (Func)	Development of product system	The functional systems prototype helps to decide what the system should encompass, the scope, and the joint vision of the design project. It links the human need with major technical issues.
Part X	Development of the critical part	Part X aims to go from a late-stage prototype to a final prototype by getting a vital part of the system done early enough to start undergoing refinements.
Penultimate	Finalizing design concept and story	Penultimate aims to increase the chances to produce a polished final product for the final deadline by "freezing" the design concept.
Final (EXPE)	Presenting the final concept	The EXPE includes presenting the final design to the industry partner.

For each of the different Design Missions, as outlined in Table 1, design teams captured the created design concepts in “Design Mission reports.” These reports are the data basis of this study. The examination of the reports allowed identifying changes in the design concepts throughout the entire product innovation project.

3. Methodology

The study was conducted in the Design Innovation course ME310. ME310 stands for Mechanical Engineering with class number 310. Jim Adams established the course in 1967. Adams started the course as he was unhappy with the no hands-on engineering curriculum (Carleton, 2019). Today, ME310 is a three-quarter engineering design course, in which graduate students need to design and develop breakthrough design concepts for industry partners. They work in collaboration with a student team from other universities, which are located in different countries throughout the globe (Larsson et al., 2003).

Students are facing real-world design challenges sponsored by a corporate partner, which in the past included companies such as SAAB, Microsoft, GM, Volvo, Huawei, AUDI, and Siemens. These design challenges are similar to real-world design projects in the industry as insights are ambiguous, the goals are not clear, and tasks are open-ended (Jung, 2011). The product development is usually performed by three to four students at each university. Teams are self-organized and are supported by Professors and Teaching Assistants of three alumni who have completed the course in one of the previous years (Jung, 2011). The assigned remote partner team is supported by a similar staff set up, although the curriculum and design focus can vary from university to university. The context in which student teams are embedded in is shown in Figure 4. This case allows examining the change in conception as design teams are required to come up with a novel design that fulfills a need or solves a problem within real industry partner projects.

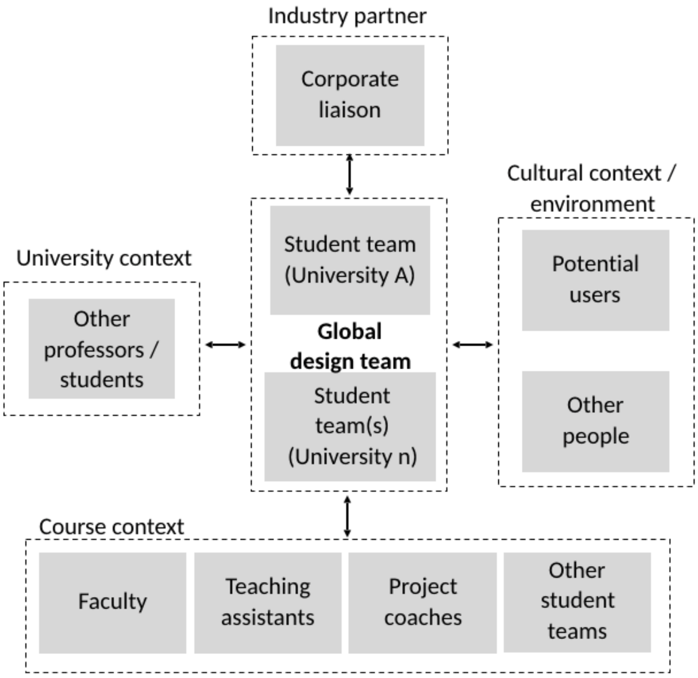


Figure 4 *Shows the wider context in which the graduate student design teams are embedded. It illustrates the support and collaborative environment of ME310.*

3.1 Study design

The research investigates the creative leaps in the thinking of the design teams indirectly by examining the changes in the design concepts described in the Design Mission reports, as illustrated in Figure 5.

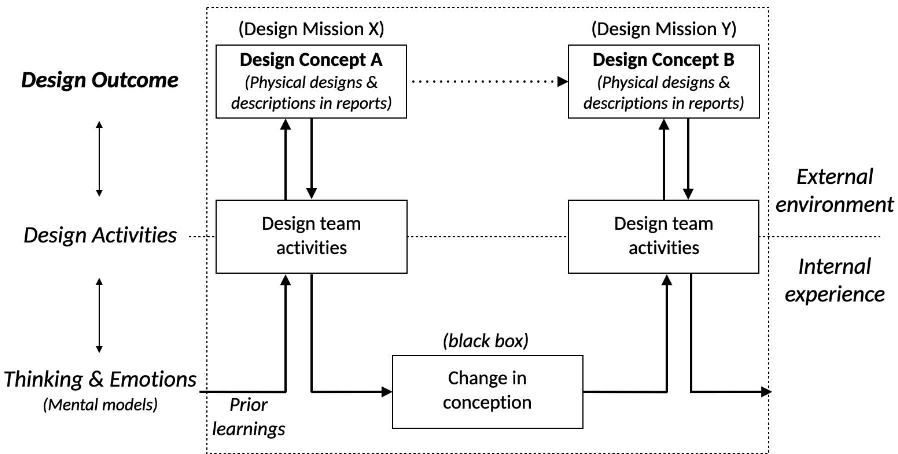


Figure 5 *Illustrates a simplified representation of the change in the design concept. Each conceptual change is facilitated by the learning from past design activities and/or triggered by a specific design practice that leads to new learnings. The model is based on the single and double-loop learning model that incorporates a change in mental models (thinking) or changes in activities (action) to produce a change in outcome (design concept) (Argyris, 1976, 2002; Argyris & Schön, 1989, 1992)*

These changes are triggered through external stimuli such as conversations and produced through internal mental activities such as imagination. For the design teams to explore and create novel design concepts, the design teams have to recognize the information and decide to act on it consciously. Each Design Mission report describes the consciously explored and created design concepts. The study was designed to examine the reports of each Design Mission through a Computer-Aided Text Analysis (CATA), which allowed investigating the changes in conception indirectly throughout the innovation project.

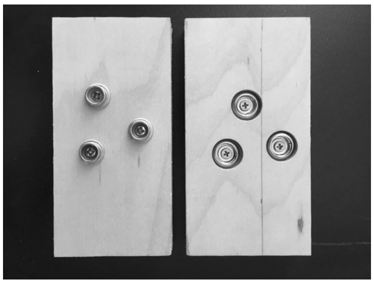
3.2 Sample and secondary data

The study incorporates a sample size of twenty-three design projects representing twenty-three teams of three consecutive years. The study included a total of two hundred thirty reports. The three years were chosen as all relevant reports were available. Design projects from other years were not included due to one or more missing reports.

3.3 Data analysis

The analysis was designed to examine conceptual changes throughout the innovation project. Table 2 shows three design concept examples resulting from three different Design Missions. Each design concept is represented as a physical design (pictures in Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)) and the descriptions in the Design Mission report (“Text in the report” in Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)).

Table 2 Examples of Design Concepts and two types of abstraction (text sample and word-groups)

Design Mission	**Critical Experience Prototype (CEP)**	**Critical Function Prototype (CFP)**	**Dark Horse Prototype (DH)**
Design Concept			
Text in the report	"[…] to create furniture forms, we placed the frame and pellets into vacuum-formable bags and had users sit or otherwise interact with the forms to create personalized vacuum-formed prototypes. […]"	"[…] for our CFP, we explored the concept of artificial elegance as a means of adding perceived value to 'company name' furniture. […] We improved the aesthetic of a 'table name' table by […]."	"[…] while successful, the assembly process company name has developed could be improved greatly. The introduction of a universal fastener, the metal snap, could revolutionize the very definition of assembly. Snaps could mark the end of the […] assembly process that accompanies the majority of Company name's products."
Word-groups	Furniture, Create, Form, Pellets, and Vacuum	Table, Improve, Elegance, 'Company name,' and 'Table name'	Snap, Assembly, 'Company name,' Metal, Process, Fastener, Improve, and Magnet, Prototype

The Design Mission reports were analyzed through a CATA. Firstly, the reports were analyzed independently to identify the main *word-groups* that represent the design concept, as exemplified in Table 2. Representing the design concept through key word-groups identifies the main aspects of the design concept and, at the same time, reduces the information and meaning. This reduction is a limitation of the study. However, it allowed examining conceptual changes through the CATA.

Secondly, changes in word-groups from one design concept to another allowed the identification of the conceptual changes. For example, the design concept in the Design Mission CEP is a furniture that is created easily from pellets and vacuum-formable bags, as outlined in Table 2. The word-groups representing this design concept are Furniture, Create, Form, Pellets, and Vacuum. The next Design Mission of CFP explores the elegance and aesthetics of a table to improve the specific table of the company. The word-groups representing this design concept are Table, Improve, Elegance, 'Company name,' and 'Table name.' The difference in word-groups indicates that the team had a change in conception and explored a different concept in the CFP Design Mission in comparison to the previous concept in the Design Mission CEP. Table 3 outlines the several steps of this data analysis.

Table 3 Data analysis process to identify conceptual changes throughout the innovation process

Steps	Description
1. Determining the preliminary word groups	NVivo performed an automatic grouping of words sharing the same word stem. • Nouns, adjectives & verbs sharing same word stem • Word length > 2 letters • Numbers ("111") and self-defined stop words ("http") not considered
2. Determining uniformed word-groups	Comparison of word-groups across all reports, teams, and years to determine uniformed word-groups. • Visual thesaurus was used to determine the related word-groups
3. Normalizing word-groups	The Weighted Percentage (WP) was calculated (number of the words of a word-group relative to the total number of words in this report).
4. Determining key word-groups	The top five word-groups by WP per report were identified. These word-groups represent the main aspects of the design concept. • A word-group is considered in the top five if its WP is among the five highest in at least one Design Mission report. • When two or more word-groups share the 5th rank due to the same WP, they were all included in the analysis. • The top five word-groups from each report were included in the analysis of all reports.
5. Conceptual changes	Conceptual changes are the top five word-groups that change from one Design Mission report to another Design Mission report • Conceptual changes are presented in percentage (%)
6. Novel conceptual changes	The percentage of novel conceptual changes is identified in each Design Mission as follows: $\frac{Novel\ top\ five\ word\text{-}groups}{Total\ top\ five\ word\text{-}groups}$ • Novel top five word-groups do not occur in the previous Design Missions reports • Results presented in Figure 6
7. Reemerging conceptual changes	The percentage of reemerging conceptual changes is identified in each Design Mission as follows: $\frac{Repeating\ top\ five\ word\text{-}groups}{Total\ top\ five\ word\text{-}groups}$ • The reemerging top five word-groups do not occur in the previous Design Mission report and occur in one of the Design Mission reports before the previous one. • The previous Design Mission report is excluded to identify the conceptual change and not repeating of same/similar concepts • Results presented in Figure 7

8. All conceptual changes	The percentage of all conceptual changes is identified in each Design Mission as follows: $\frac{\text{All top five word-groups representing a conceptual change}}{\text{Total top five word-groups}}$ • All top (novel and reemerging) five word-groups that do not occur in the top five word-groups of the previous Design Mission report and might occur in the top five word-groups of the Design Missions report before the previous one • Results presented in Figure 8

4. Findings

The CATA identified (1) novel conceptual change, (2) reemerging conceptual change, and (3) all conceptual changes throughout the product innovation project.

4.1 Novel conceptual changes in the design

The result of the analysis of the novel conceptual changes is illustrated in Figure 6
Shows the average of novel conceptual changes in all twenty-three design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.. Figure 6 shows the average of the novel conceptual changes of all twenty-three projects.

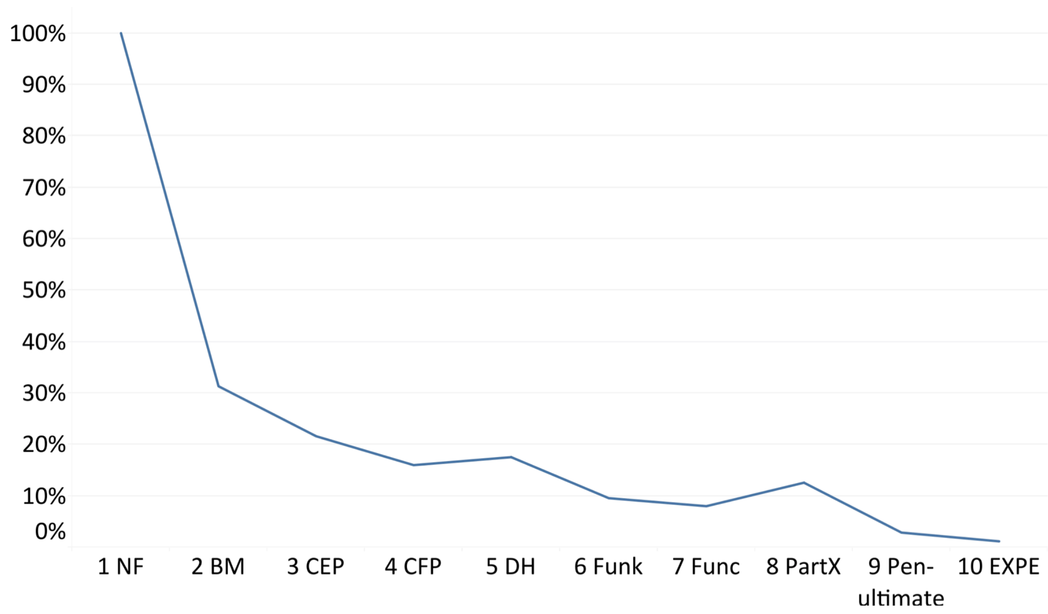


Figure 6 *Shows the average of **novel conceptual changes** in all twenty-three design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.*

Figure 6 indicates that in the first Design Missions of Needfinding (NF), Benchmarking (BM), Critical Experience Prototype (CEP), and Critical Function Prototype (CFP) design teams explore several novel concepts. These missions include identifying people’s needs and their critical experience to define the innovation opportunity. It is an open exploration to define the design vision.

Figure 6 reveals that the Dark Horse and Part X Design Mission is facilitating novel conceptual changes. This finding shows that design teams explore novel concepts when pushed by the Dark Horse into exploring very risky, radical, or challenging ideas. The increase in Part X in Figure 6 indicates that the pressure of finalizing the product concepts facilitated the exploration of novel conceptual changes by the design teams.

4.2 Reemerging conceptual change in the design

The result of the analysis of reemerging conceptual change is illustrated in Figure 7 Shows the average of reemerging conceptual changes in all twenty-three design projects. The analysis identifies the reemerging change by comparing a “Design Mission Z” with the “Design Mission X” that occurs before the predecessor of the “Design Mission Z.” As a result, the first two Design Missions of Needfinding and Benchmarking have the value zero percent (0%).. The figure shows the average of the reemerging conceptual change of all twenty-three projects.

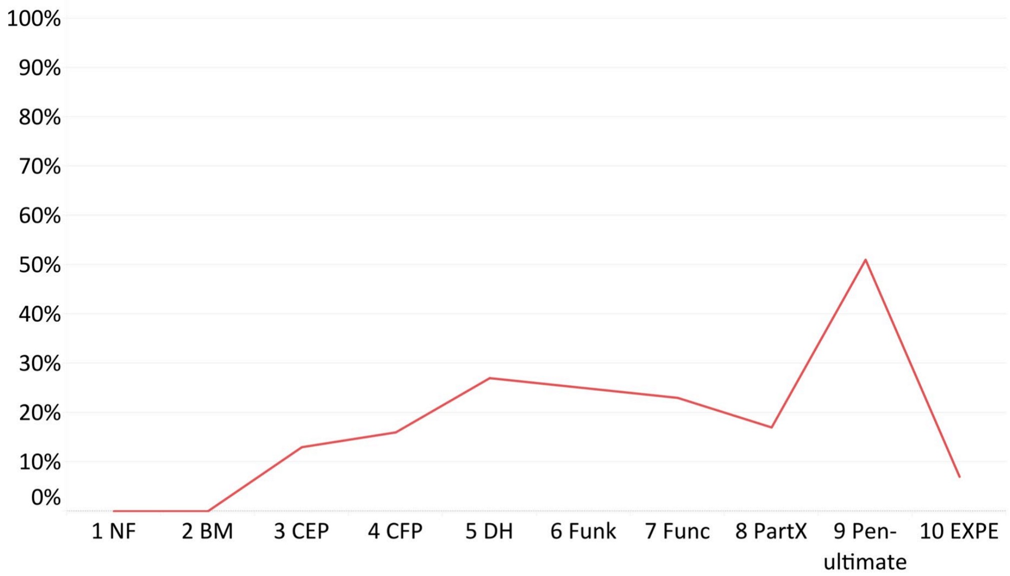


*Figure 7 Shows the average of **reemerging conceptual changes** in all twenty-three design projects. The analysis identifies the reemerging change by comparing a “Design Mission Z” with the “Design Mission X” that occurs before the predecessor of the “Design Mission Z.” As a result, the first two Design Missions of Needfinding and Benchmarking have the value zero percent (0%).*

Figure 7 shows that design teams reconsider previously explored concepts throughout the design project. Design teams reconsider previously explored concepts in particular in the Dark Horse, Funky, and Functional Design Mission. In these Design Missions, teams explore design solutions of previously identified opportunities, problems, and needs of people.

Interestingly, the Penultimate Design Mission reconsiders a large amount of previously considered design concepts. This result occurs as the design teams reflect on the entire project to convey the learnings into a story to communicate the final design concept. Storytelling is essential to communicate the design concept's purpose, meaning, and value successfully by outlining the identified needs of people or problems that the design concepts fulfill or solves.

4.3 All conceptual changes in the design

The result of the analysis of all conceptual changes is illustrated in Figure 8. The figure shows the average of all conceptual changes in all twenty-three projects. Figure 8 illustrates that conceptual changes in the design are not a single or isolated activity of a creative phase that is followed by an implementation phase. Concept changes are interlinked and emerge through every iteration of a design cycle. It also shows that design teams, on average, never abandon all concepts and start from new.

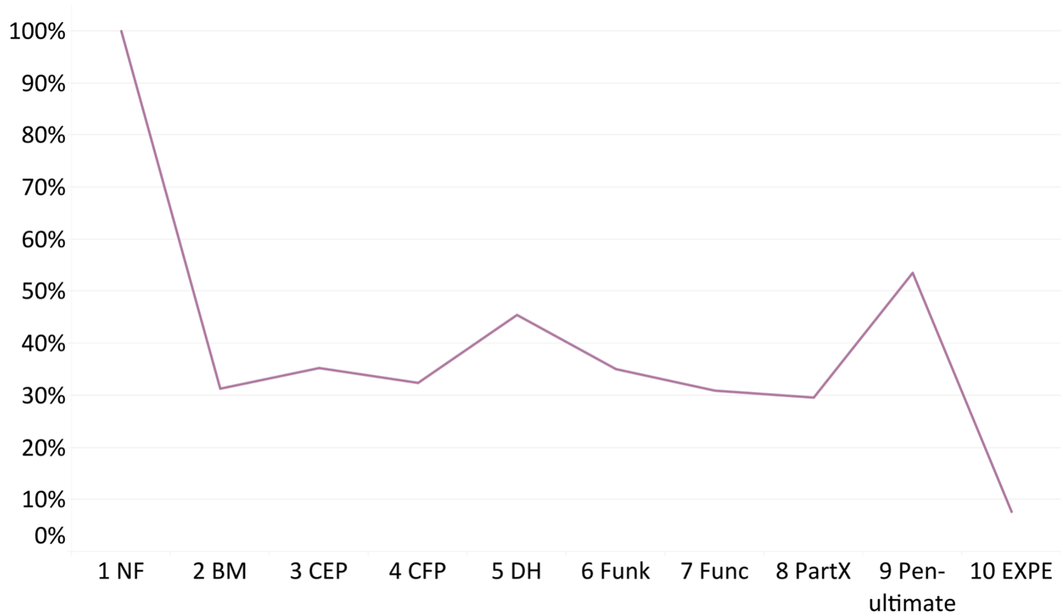


Figure 8 *Shows the average of **all conceptual changes** in all 23 design projects. All word-groups in the Needfinding Design Mission are novel (shown as 100%) as there is no previous Design Mission.*

5. Discussion

In overall, the findings revealed that design teams explore novel concepts in the (I) early phases of a design project, (II) when exploring risky or radical ideas, and (III) before they have to finalize the design concept. The findings revealed that (IV) conceptual changes intertwine throughout the entire innovation project. They are not isolated activities of creativity followed by implementation. The last main finding was that (V) reflecting the entire project allows creating a story to communicate the final design concept. The next paragraphs discuss each main finding in more detail.

5.1 Explore the problem space by questioning the challenge

Arnold (1962a, 1962b) described two essential aspects when creating innovation in design. These are a questioning attitude in combination with thorough observation, and the challenge should be defined as broadly as possible to allow many possibilities. The findings in this study indicate that design teams firstly explore novel concepts in the early phases of the innovation project and, secondly, reconsider these conceptions when exploring solutions. These findings show that design teams utilize the early learnings and conceptions when creating novel solutions. Without these experiences of exploring novel design concepts, teams would not be able to reconsider and recombine these prior learnings. If teams were not able to explore novel concepts in the early phases, they would not have the same amount of novel conceptions to utilize to create novel solution concepts. In ME310, coaches expect and support the design teams in the exploration of the problem space by questioning the given challenge and discovering real-world problems and needs of people. Einstein & Infeld (1967) expressed this questioning attitude as follows:

> "The formation of a problem is often more essential than its solution, which may be merely a matter of mathematics or experimental skill. To raise new questions, new possibilities, to regard old questions from a new angle, requires creative imagination and marks real advance in science." (Einstein & Infeld, 1967)

The same applies when designing innovative products as otherwise, the design activities become merely the execution of a problem-solving task. Design teams reconsider and explore previous concepts during the exploration of solutions. Previously identified and defined conceptions of opportunities, problems, and people's needs are part of the exploration of creating an innovative design concept. An essential condition for exploring the problem space is both the permission and expectation to question and broaden the given challenge through exploring real-world conditions.

5.2 Bet on the Dark Horse

Another interesting finding was the occurrence of conceptual changes through the Dark Horse Design Mission. This mission challenges teams to explore novel concepts after the formation of the design vision. The Dark Horse was created by Prof. Mark Cutkosky in 1999 to explicitly investigate the unlikely or unconsidered ideas to "colonize" the Design Space (Bushnell et al., 2013). Design teams expressed the experience of the Dark Horse Design Mission as follows:

> "The psychology of releasing the expectations while simultaneously pressuring teams to do the impossible pays off in nearly every project. This is even more significant because it occurs after the teams have already developed notions of what the product's potential value may be." (Bushnell et al., 2013)

The Dark Horse is a design practice that pushes design teams to explore the perceived impossible. The conditions of psychological safety and pressure to be able to explore risky ideas enables design teams to explore novel design concepts. Bushnell et al. (2013) outline several Dark Horse case studies that demonstrate the results. The Dark Horse Design Mission can facilitate conceptual changes beyond the obvious ideas, first solution, or blocks such as over-motivation as described by Adams (2001).

5.3 Last-Minute Conceptual Changes

The occurrence of novel conceptual changes in the Part X Design Mission is an interesting finding as it is the last phase in which design teams can explore novel concepts. Team members described that the psychological sensation of the feeling of pressure to finalize the design concept pushed them into exploring novel concepts. Last-minute novel conceptual changes occur under conditions such as the designed solution does not meet the expectation or design teams receive essential insights that need to be incorporated in the design. The finding indicates that time pressure and expectation drive conceptual changes in the design in last-minute situations.

5.4 Hunter-Gatherer

The findings revealed that conceptual changes intertwine throughout the entire innovation project. Design teams utilize learnings and conceptions from previous design cycles in later cycles. This phenomenon has been described by Steinert & Leifer (2012) as a Hunter-Gatherer Metaphor, as illustrated in Figure 9. With each design cycle, design teams make a new conceptual discovery that changes the design concept into a new direction. It requires exploring new directions (concepts) and change direction (act on the change in conception) with each learning. This creative practice requires both the mindset and environment of permission (psychological freedom) and expectation (motivation) to explore and create “the really big idea.”

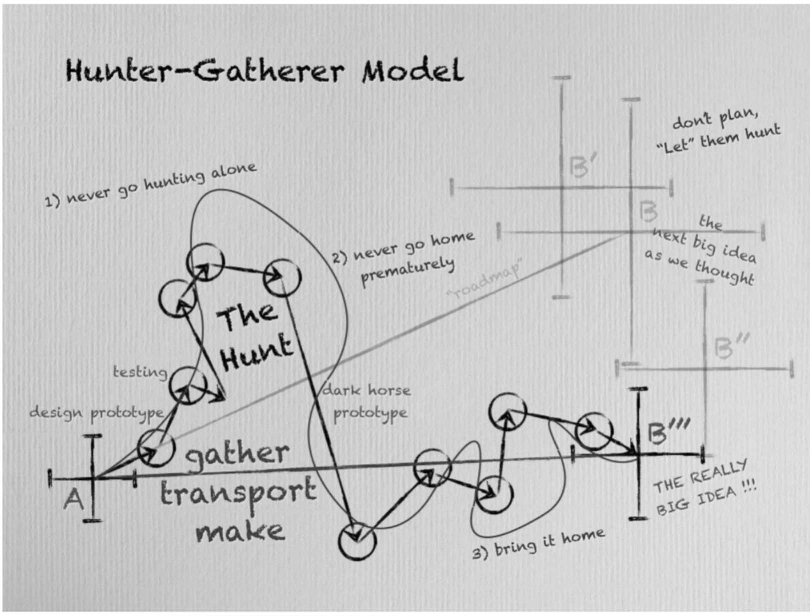


Figure 9 *Illustrates the Hunter-Gatherer Metaphor. The metaphor emphasizes that in education and businesses, there is a need to permit and facilitate people to go hunting to enable innovation (Steinert & Leifer, 2012).*

The following questions and questioning attitude enable the mindset for hunting breakthrough ideas. Firstly, the question of "*why are people doing what they are doing and what is missing in their lives?"* allows exploring unmet human needs. This step follows by asking, "*what are we going to do to fulfill these needs?*" This question allows defining interesting directions to explore them to create a change in conception. "*How are we going to do it?*" enables exploring the concept. Reflecting on "*what have we learned?*" enables externalizing the experience into a concept and new direction. It is a "dance" that requires creativity to explore interesting directions in the design space by creating changes in conception and act on it.

5.5 Storytelling as part of the final design

Reflections and reconsiderations of several conceptions enable designers to tell a meaningful story about and through their design. This storytelling is essential in communicating the purpose, the why of the design. Why is this design useful? Why does it meet a need or solves a problem? Why was it designed this way and not that way? These Why-questions of the design make the conceptions explicit and provide meaning when communicating the final design concept to an audience. Reflection and storytelling reveal the underlying conceptions and allows communicating the meaning of the design.

6. Conclusion

The research presented in this paper indicated the importance of permission (psychological freedom) and challenge (motivation) to create changes in conception in design. In science, Posner, Strike, Hewson, & Gertzog (1982) expressed four main conditions that lead to conceptual changes. These are dissatisfaction with existing conceptions, a new conception is intelligible, a new conception appears initially plausible, and a new conception suggests the possibility of a new area of inquiry. In design, the conditions for changes in conceptions are a questioning and observation attitude to explore real-world conditions, proactive exploration through impulse and motivation, and permission by betting on the Dark Horse, and reactive exploration of last-minute conceptual changes. These interlinked novel conceptions produce the innovative product design concept.

Design education programs in engineering, architecture, business, and other design-related practices that aim to facilitate experiential learning in Design Thinking and the generation of creative design concepts can incorporate the outlined practices that facilitate changes in conception. Enabling these creative design practices requires cultivating the coaching practices that facilitate psychological safety and freedom and encouraging design teams to explore new directions. The coaching includes expecting innovation (motivation), enabling design teams to explore and hunt (psychological freedom) and assist in the design practice (Design Missions). The practices and conditions facilitate the design teams in their dance with creativity. However, there is no guarantee of innovation. The dance with creativity in Design Thinking increases the chance of creating a novel product design concept that is meaningful, manufacturable, and marketable.

Acknowledgments: The authors would like to thank the wider community of the design-lab, Center for Design Research and Design Group.

7. References

Adams, J. L. (2001). *Conceptual Blockbusting: A Guide to Better Ideas, Fourth Edition*: Basic Books.

Argyris, C. (1976). SINGLE-LOOP AND DOUBLE-LOOP MODELS IN RESEARCH ON DECISION-MAKING. *Administrative Science Quarterly, 21*(3), 363-375.

Argyris, C. (2002). Double-Loop Learning, Teaching, and Research. *Academy of Management Learning & Education, 1*(2), 206-218.

Argyris, C., & Schön, D. A. (1989). Participatory Action Research and Action Science Compared - A Commentary. *American Behavioral Scientist, 32*(5), 612-623. doi:10.1177/0002764289032005008

Argyris, C., & Schön, D. A. (1992). *Theory in Practice: Increasing Professional Effectiveness*: Wiley.

Arnold, J. E. (1959). *Creative engineering seminar, 1959*. Stanford, CA: Stanford, University.

Arnold, J. E. (1962a). Education for Innovation. In S. J. Parnes & H. F. Harding (Eds.), *A source book for creative thinking*. New York: Charles Scribner's Sons.

Arnold, J. E. (1962b). Useful Creative Techniques. In S. J. Parnes & H. F. Harding (Eds.), *A source book for creative thinking*: Scribner.

Arnold, J. E., & Arnold, J., Jr. (2016). *Case Study: Arcturus IV*.

Black, A., Bayley, O., Burns, C., Kuuluvainen, I., & Stoddard, J. (1994). *Keeping viewers in the picture: real-world usability procedures in the development of a television control interface*. Boston, Massachusetts, USA: Association for Computing Machinery.

Brown, T. (2008). Design thinking. *Harvard Business Review, 86*(6), 84-+.

Buchenau, M., & Fulton Suri, J. (2000). *Experience prototyping*. Paper presented at the Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques, New York City, New York, USA.

Bushnell, T., Steber, S., Matta, A., Cutkosky, M., & Leifer, L. (2013). *USING A "DARK HORSE" PROTOTYPE TO MANAGE INNOVATIVE TEAMS*.

Carleton, T. (2019). *ME310 at Stanford University 50 Years of REDESIGN (1967-2017)*: Innovation Leadership Publishing.

Cross, N. (2001). Design cognition: results from protocol and other empirical studies of design activity. In C. Eastman, W. Newstatter, & M. McCracken (Eds.), *Design knowing and learning: cognition in design education.* (pp. 79–103). Oxford, UK: Elsevier.

Domingo, L., Moore, D., Sirkin, D., Toye, G., Leifer, L., & Cutkosky, M. (2020). *Strategic Prototyping to Learn in Stanford University's ME310 Design Innovation Course*. Paper presented at the *DESIGN 2020 16th International Design Conference*, Cavtat, Croatia.

Dorst, K. (2015). *Frame Innovation: Create New Thinking by Design*: MIT Press.

Dorst, K., & Cross, N. (2001). Creativity in the Design Process: Co-Evolution of Problem–Solution. *Design Studies, 22*, 425-437. doi:10.1016/S0142-694X(01)00009-6

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94*(1), 103-120. doi:10.1002/j.2168-9830.2005.tb00832.x

Einstein, A., & Infeld, L. (1967). *The Evolution of Physics*: Touchstone.

Eris, O., & Leifer, L. (2003). Facilitating Product Development Knowledge Acquisition: Interaction between the Expert and the Team. *International Journal of Engineering Education, 19*, 142-152.

Faste, R. A. (1987). Perceiving Needs. *SAE Transactions, 96*, 419-423. doi:10.2307/44472796

Fulton Suri, J. (2003). The Experience of Evolution: Developments in Design Practice. *The Design Journal, 6*(2), 39-48. doi:10.2752/146069203789355471

Gilmore, D., Trump, R., Velazquez, V., Coughlan, P., Fulton Suri, J., Prokopoff, I., . . . Saperstein, E. (1999). *User-Centered Design in Practice.* Paper presented at the User Centered Design in Practice - Problems and Possibilities, Stockholm, Sweden.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*(9), 444–454. doi:https://doi-org.stanford.idm.oclc.org/10.1037/h0063487

Guilford, J. P. (1957). Creative abilities in the arts. *Psychological Review, 64*(2), 110–118. doi:https://doi.org/10.1037/h0048280

Hargadon, A., & Sutton, R. I. (2000). Building an Innovation Factory. *Harvard Business Review, May-June*.

Jung, M. F. (2011). Engineering team performance and emotion: Affective interaction dynamics as indicators of design team performance.

Koestler, A. (1964). *The Act of Creation*: Arkana.

Larsson, A., Törlind, P., Karlsson, L., Mabogunje, A., Leifer, L., Larsson, T., & Elfström, B.-O. (2003). *DISTRIBUTED TEAM INNOVATION - A FRAMEWORK FOR DISTRIBUTED PRODUCT DEVELOPMENT*. Paper presented at the ICED 03, the 14th International Conference on Engineering Design, Stockholm.

Lawson, B. R. (1979). Cognitive Strategies in Architectural Design. *Ergonomics, 22*(1), 59-68. doi:10.1080/00140137908924589

Leifer, L. J. (1998). Design-Team Performance: Metrics and the Impact of Technology. In S. M. Brown & C. J. Seidner (Eds.), *Evaluating Corporate Training: Models and Issues* (pp. 297-319). Dordrecht: Springer Netherlands.

Leifer, L. J., & Steinert, M. (2011). Dancing with ambiguity: Causality behavior, design thinking, and triple-loop-learning. *Information.Knowledge.Systems Management, 10*(1-4), 151-173.

Leonard, D. A., & Rayport, J. (1997). Spark Innovation Through Empathic Design. *Harvard Business Review, 75*(6), 102–113.

McKim, R. H. (1959). Designing for the Whole Man. In J. E. Arnold (Ed.), *Creative engineering seminar, 1959*. Stanford, CA: Stanford, University.

McKim, R. H. (1972). *Experiences in Visual Thinking*. Wadsworth Publishing Company Inc.

McKim, R. H. (1980). *Experiences in Visual Thinking*: Brooks/Cole Publishing Company.

Moll-Carrillo, H. J., Salomon, G., Marsh, M., Fulton Suri, J., & Spreenberg, P. (1995). *Articulating a metaphor through user-centered design*. Denver, Colorado, USA: ACM Press/Addison-Wesley Publishing Co.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211-227. doi:10.1002/sce.3730660207

Rogers, C. R. (1954). Toward a Theory of Creativity. *ETC: A Review of General Semantics, 11*(4), 249-260.

Schön, D. A. (1983). *The reflective practitioner: how professionals think in action*. New York: Basic Books.

Schön, D. A. (1984). Problems, frames and perspectives on designing. *Design Studies, 5*(3), 132-136. doi:https://doi.org/10.1016/0142-694X(84)90002-4

Srinivasan, V., Lovejoy, W. S., & Beach, D. (1997). Integrated Product Design for Marketability and Manufacturing. *Journal of Marketing Research, 34*(1), 154-163. doi:10.1177/002224379703400113

Steinert, M., & Leifer, L. (2012). 'Finding One's Way': Re-Discovering a Hunter-Gatherer Model based on Wayfaring. *International Journal of Engineering Education, 28*, 251-252.

Sutton, R. I., & Hargadon, A. (1996). Brainstorming groups in context: Effectiveness in a product design firm. *Administrative Science Quarterly, 41*(4), 685-718. doi:10.2307/2393872

Valkenburg, R., & Dorst, K. (1998). The reflective practice of design teams. *Design Studies, 19*(3), 249–271.

Wallas, G. (1926). *The art of thought*: J. Cape.

Wilde, D. J., Faste, R., & Roth, B. (1994). *Experiental Design Courses in Engineering Education.* Paper presented at the Teaching Science for Technology at Tertiary Level, Stockholm, Sweden.

About the Authors:

Jan Auernhammer is a Research Engineer and Executive Director of the Human-centered Business Design Research and the Leifer NeuroDesignScience Program at the Center for Design Research, Stanford University. His research interest is in the intersection of design, psychology, and management.

Max Lenzen was an M.Sc. Student at RWTH Aachen and a Visiting Research Student at the Center for Design Research, Stanford University. His research interest is in design and behavioral patterns.

Larry Leifer is a Professor of Mechanical Engineering at Stanford University. Founding Director of the Center for Design Research (CDR) and the Hasso Plattner Design-Thinking-Research Program. His research interests are collaboration in engineering design teams, design knowledge capture, and design-for-sustainable-wellbeing.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Nominal Groups? Ok Boomer! A future-oriented agenda for brainstorming studies

Ricardo SOSA[a]*

[a] AUT, New Zealand; Monash University, Australia
*Corresponding author e-mail: rsosa@aut.ac.nz
doi: https://doi.org/10.21606/drs.2020.109

Abstract: This paper critically examines brainstorming going back to the original sources to assess its origins and the origins of its systematic study. It identifies the "nominal groups" fallacy that is often used to discredit this ideation method and reviews evidence that supports the key principles behind group brainstorming. Lessons for a future design-led agenda of universal creative literacy are discussed. Brainstorming appeared eighty years ago, and it is abundantly clear that it works when properly conducted. The substantial challenges that we face in the next eighty years require the power of collective creativity. Properly conducted creative literacy is a strategic priority for the twenty-first century.

Keywords: creativity; ideation; research methods; primary sources; brainstorming

1. Introduction

To brainstorm refers colloquially to the action of generating new ideas by having a group discussion to solve a problem[1]. Canonical definitions depict brainstorming as a mode of problem-solving by means of "a group discussion of spontaneously arising ideas"[2]. Whilst widely used in design practice (Elsbach and Flynn, 2013; Shroyer, Lovins et al., 2018), some critics discredit brainstorming citing studies that claim that, compared to individuals generating ideas in isolation (called *nominal groups*), group brainstorming generates fewer ideas and of lower quality on average in the same length of time. Notwithstanding the conceptual and methodological complexities of defining and evaluating early ideas (Sosa, 2019a), we critically interrogate here the use of so-called nominal groups in studies of group ideation performance. In this paper we go back to the primary sources to critically examine the study of brainstorming and to sketch pedagogical and research paths for future work.

Although everyday definitions of brainstorming tend to characterise it as a spontaneous and

1 Merriam-Webster Dictionary definition https://www.merriam-webster.com/dictionary/brainstorm

2 Oxford Dictionary definition: https://www.oed.com/view/Entry/304150

impromptu activity, in a more rigorous sense the term refers to a well-structured technique for "idea finding" created in the 1930s (Osborn, 1963). Osborn drew on professional practices in advertising to formulate rules and guidelines to plan, prepare, and conduct "brainstorm sessions". A primary recommendation for this technique is to conduct a "triple attack of individual-group-individual ideation" (p. 191) given that both group and individual ideation "can be just as productive" (p. 191). By the 1950s brainstorming had become "too popular too fast" (p. 152), resulting in it being misused and often unable to meet inflated expectations (Osborn, 1963). Around that time the first experimental studies concluding that "group participation when using brainstorming inhibits creative thinking" (Taylor, Berry et al., 1958, p. 23) gained traction and influenced derivative studies over six decades giving brainstorming a bad name (McCaffrey, 2014).

This paper starts by revising the original formulation of brainstorming and the extent to which it has been empirically studied in valid ways. It then delves into brainstorming with three goals in mind: first, it seeks to demystify it and treat it more rigorously as a structured ideation method. It does this by returning to the primary sources to inform a critical review of the related literature. Second, the paper seeks to inform a program of inquiry that addresses open questions on how to aptly conduct brainstorming. These two goals address questions of *whether* group brainstorming works and questions of *how to* do, study, and teach it. In our experience, ideation methods such as brainstorming can enable participants to exercise their creative capacities. Therefore, our third goal here is to reflect that if/once people can become more creative aided by a competent use of methods, then *why, when*, and *what for* could this massive creative power be used in the twenty-first century as we face an existential threat fuelled by a planetary climate emergency and the entrenchment of fascist and patriarchal agendas.

2. The origins of an octogenarian

"Idea-producing conferences" originated in contrast to "conventional conferences" (meetings), and in 1938 participants named them after their value to use "the brain to *storm* a problem" (Osborn, 1963, p. 151). This octogenarian workplace technique has precedents in ancient traditional practices where groups discuss and collectively generate ideas to tackle difficult challenges. *Prai-Barshana* is mentioned as a centuries-old practice in India that explicitly separates generation and evaluation of ideas (p. 151). "Brainstorm sessions" were presented with the aim to formulate the "conscious ways" in which creative people establish a "working mood" to carry out "idea finding efforts" (p. 118). The following principles and rules for brainstorming were postulated (Osborn, 1963):

- Novelty needs to be subject to "the most impartial scrutiny" because new ideas tend to be "worthless or because we shall not know how to elicit their value" (p. 130). All new ideas need, therefore, to be "sceptically entertained… for the thousandth idea may be the one that will change the world" (p. 130).
- Brainstorm sessions are intended to *storm* a problem, i.e., to produce "a checklist

of ideas" that can "serve as leads" to be "subsequently evaluated and *further processed*" (p. 152).

- Group ideation is "relatively fruitless" unless participants understand and "faithfully follow" these rules: rule out criticism; welcome "free-wheeling" (wild ideas); pursue quantity; seek to combine and improve ideas (p. 155). These have become known as the "four rules of brainstorming" (p. 155).
- Associative thinking is singled out as a key group mechanism to trigger a "chain reaction". The resulting ideas, or "*hitch-hikes*", can account for up to one-third of all ideas (p. 154). This process of "re-processing ideas by means of modification and combination" can transform "mediocre ideas into sterling ideas" (p. 158).

Four key guidelines are recommended to prepare creative sessions (Osborn, 1963):

- It is important to adequately formulate the problem to be *stormed* in a session. The problem needs to be specific and narrowed down to "a single target" (p. 158). A brainstorm session can be "successfully devoted solely to breaking down a broad problem" to make it more suitable for a creative session (p. 173).
- Participants are supplied a background memo "at least two days in advance of the session" (p. 175). This memo of "not more than one page in length" serves to orient participants and to let them "sleep on the problem thus allowing incubation to enhance the workings of association" (p. 174).
- The panel leader (facilitator) develops in advance their own list of ideas. If and when a session slows down or gets off the track "the leaders can prime the joint flow of ideas by contributing some of their own" (p. 175).
- Leaders use their own list of ideas to prepare leads that they can suggest during a session "by way of classifications or categories" (p. 172). They also prepare "idea-spurring questions" to move a session forward, such as "Put to Other Uses? Adapt? Magnify? Reverse? Combine?" (p. 175).

Five recommendations are offered to conduct creative sessions (Osborn, 1963):

- Participants only offer "one idea at a time" (p. 176). To achieve this, they are encouraged to "make notes of ideas they plan to offer when their turn comes" (p. 177).
- Turn-taking is expressly recommended to create opportunities for "hitch-hikes" by idea association, thus encouraging ideas that are "directly sparked by a previous idea" (p. 176).
- The leader monitors and incentivises the "spirit of a brainstorm session" (p. 157) for which both self and "mutual encouragement" are crucial (p. 157).
- A secretary captures all the ideas in ways that are "reportorially -not word for word" -brainstorms can also be audio recorded (p. 177).
- In closing, participants are thanked and directed "to keep the problem on their minds until the next day when they will be asked for their afterthoughts" (p. 178). A list of all the ideas is sent to participants asking them to reply with new ideas

formed after the session (p. 179).

To conclude this recount of the primary source where brainstorming was presented (Osborn, 1963), the following key points are noted:

- The *purpose* of brainstorming is manifold: besides generating a check-list of early ideas, these sessions can be “tools for improving morale”, they allow participants to discover “what people think about problems”, they allow them to “gain a better understanding of each other”, they can also produce enjoyment (p. 189), and they can supplement creative training (p. 192).
- Crucially, throughout the book Osborn explicitly indicates that “group brainstorming is recommended solely as a supplement to individual ideation” (pp. 141, 143, 191).
- When properly conducted, group brainstorming “can produce far more good ideas than a conventional conference -and in less time” (p. 152).
- Brainstorming can be directed to produce different types of ideas including “planks for plans”, “check-lists to stimulate further thinking”, and “approaches to solutions” (p. 192).
- To evaluate ideas from a brainstorm as initial leads for further processing, “the surest method of evaluation is to put our ideas to test. And the task of thinking up the best way to test is a creative challenge in itself” (p. 118).

From these steps and suggestions to plan and prepare, lead, and follow-up ideation sessions, it is clear that critical factors for success include participant training and leadership (facilitation) of a session. From its origins, the brainstorming method had a structure derived from practice.

As it became adopted in professional fields during the 1950s, scholars directed their attention to empirically evaluate the claims of brainstorming. Rather than studying the practices of brainstorming, early researchers decomposed and selectively studied some of the underlying mechanisms in isolation (Taylor, Berry et al., 1958; Meadow, Parnes et al., 1959; Parnes and Meadow, 1959; Cohen, Whitmyre et al., 1960; Parnes, 1961; Weisskopf-Joelson and Eliseo, 1961; Gurman Jr, 1962; Dunnette, Campbell et al., 1963). Most of these laboratory studies applied quasi-experimental methods studying undergraduate students randomly assigned to experimental conditions. Researchers instructed brainstormers to generate ideas in response to a brief, assigned them a time limit of five to fifteen minutes, and gave them a compensation. The ideas they produced were counted and judged by a panel for originality, uniqueness, appeal, feasibility, and/or value.

These research efforts misconstrued a brainstorm as an experimental session and selectively focused on some of the rules and guidelines to storm a problem. Specifically, they failed to provide the brief to participants in advance, considered critical for priming and for individuals to prepare for a group session. They also failed to include the strategically important role of facilitation or leadership and instead simply instructed participants to ideate and left them to their own devices. Lastly, the ideation tasks in these studies are fun but inconsequential toy exercises that are either too general and open-ended like the *Tourist* and *Teacher* problems (Taylor, Berry et al., 1958), implausible imagination exercises like the *Thumbs* and *People* problems (Taylor, Berry et al., 1958), or aimless divergent reasoning tasks like the *Hanger* and *Broom* problems (Taylor, Berry et al., 1958). For the last four decades, researchers have pointed that the study of brainstorming has failed to acknowledge and apply the guidelines to properly conduct it (Jablin and Seibold, 1978; Kalargiros, 2014). As a result, these studies ended up testing "quasi-brainstorming procedures" (Jablin and Seibold, 1978, p. 350). Designed with questionable procedures, their findings and conclusions are problematic.

3. The origin of the "nominal group" straw man

The early studies of brainstorming were motivated by a range of goals including: a comparison of individual vs. group performance measured as idea productivity and various criteria of idea quality such as originality (Taylor, Berry et al., 1958); the effects of brainstorming vs. "non-brainstorming" ideation instructions (Meadow, Parnes et al., 1959; Parnes and Meadow, 1959)0022-0663(Print; the effects of group cohesiveness and types of task (Cohen, Whitmyre et al., 1960); the effects of the "rule out criticism" rule (Weisskopf-Joelson and Eliseo, 1961); the effect of time limits (Parnes, 1961); and the effects of homogeneous vs. heterogeneous groups and self, interaction, and task orientation (Gurman Jr, 1962).

Of these, (Taylor, Berry et al., 1958) became by far the most highly cited. That study initially reports that "on each of the three problems the mean total number of ideas produced by the twelve groups was *considerably larger* than the mean number produced by the forty-eight individuals, the difference being highly significant... on all three problems *group performance is clearly superior to individual performance*" (p. 34). Taylor, however, decided to incorporate the construct "nominal groups" from previous work on problem solving (Taylor and McNemar, 1955). Nominal groups are formed after the experiment is completed by adding the responses from the same number of individuals as the size of the real groups. The researchers then score the performance of nominal groups "*by assuming* that if any one in the group solved a particular problem, the group solved it" (Taylor and McNemar, 1955, p. 476). With this setup to compare nominal vs. real groups brainstorming, the study found the performance of the real groups to be "markedly inferior to that of the nominal groups in terms of number of ideas produced" (p. 43). This finding was replicated a few years later (Dunnette, Campbell et al., 1963), and since then nominal groups spread like fire in creativity research (Lewis, Sadosky et al., 1975; Diehl and Stroebe, 1987; Nijstad and Stroebe, 2006).

Here we examine the validity of the assumptions behind the "nominal groups" construct in the context of creative ideation. First, comparing the ideation of groups vs. individuals contradicts Osborn's recommendation for "a triple attack" using individual-group-individual brainstorming. Second, making recommendations based only on fluency and perceived wuality of sketchy ideas reduces brainstorming to "a machine theory view" (Sutton and Hargadon, 1996, p. 688). Third, comparing the outcomes of real vs. nominal groups rises methodological predicaments including time allocation as noted by (Gurman Jr, 1962), since individuals working in groups of size *N* have *1/N* of the time available to share their ideas compared to those working in isolation. Whilst the artifact "nominal groups" is justified on the basis of number of people, their proponents ignore the significant difference in number of minutes between these conditions. Namely, the ideas generated by so-called nominal groups represent *N x t* where *N* is the number of brainstormers and *t* is session time limit, whilst the ideas generated by real groups represent only *t* time. Such direct comparison between parallel and serial ideation is conceptually weak.

Fourth, Osborn indicates that idea association in groups can be superior when the process is *adequately facilitated*. The rationale by Taylor for setting the time limit shows the critical disadvantage of not having adequate (or any) facilitation: "The time limit of twelve minutes for each problem was chosen, on the basis of considerable pretesting, as one which would permit group members to express all ideas occurring to them within the work period and at the same time not result in excessive periods of silence for individual subjects. In the actual experimental sessions, appreciable periods of silence appeared between responses near the end of the twelve minutes." (Taylor, Berry et al., 1958, p. 46). Precisely because ideation slows down, leaders are recommended to "prime the joint flow of ideas by contributing some of their own" and by suggesting "idea-spurring questions" (Osborn, 1963, p. 175).

For these reasons, studies of non-facilitated brainstorming using "nominal groups" engage in a logical fallacy and create an illusory refutation of group ideation. They also show a lack of creative facilitation experience by those studying ideation. The validity of studies that deviate in important ways from brainstorming procedures has been questioned, and studies that do not perform due diligence in implementing Osborn's recommendations are "a futile exercise" (Kalargiros, 2014, p. 15). In the end, scholars who discredit brainstorming on these bases show a "lack of understanding, lack of adherence to critical procedural guidelines, [and a] parochial research agenda" (Kalargiros, 2014, p. 15).

Although many studies of brainstorming cannot be trusted, the last four decades have provided evidence that confirms why it is widely used by professionals (Sutton and Hargadon, 1996; Shih, 2011; Shroyer, Lovins et al., 2018).

3.1 A health check-up of an octogenarian

Several phenomena associated with brainstorming have been studied over the last four decades, providing support for many (but not all, not yet) of the bases of this "idea-finding" method. Namely:

- Creativity is increasingly viewed as a human capacity (Arendt, 2013) which echoes its framing as a universally distributed imaginative faculty: "the fact that war spurred many, many people to think up so many good ideas helps prove that nearly all of us are gifted with creative talent; and it helps prove the part that effort plays in activating this talent." (Osborn, 1963, p. 16).
- Evidence generally supports idea fluency correlates with higher originality and

novelty (Adánez, 2005). This "quantity breeds quality" dictum is explained in probabilistic terms: "the more ideas you think up, the *more likely* you are to arrive at the potentially *best leads* to solution" (Osborn, 1963, p. 124). However, the central role of associative thinking in ideation suggests key combinatorial advantages. In a list of ideas, every new entry causes a significant growth of new connections, meanings, and paths for combining and modifying "leads to solution".

- The associative basis of creative thinking has been established and profusely studied (Mednick, 1962; Goldenberg and Wiley, 2019), giving support to the fourth rule of brainstorming and the observation that "most ideas are by way of combinations" (Osborn, 1963, p. 282). Unfortunately, the standard task for associative reasoning called the "Remote Associates Test (RAT)" employs questions with a single correct answer[3], ignoring the open-endedness of creativity.
- Hierarchy of authority has been shown to be detrimental to idea generation (Keum and See, 2017) confirming the guideline that "a panel should consist of people of substantially the same rank" and to avoid "superior officers" in a brainstorm (Osborn, 1963, p. 170).
- The value of creative sessions beyond producing ideas -as noted by Osborn- has been demonstrated in ethnographic studies of ideation "in the wild" (Sutton and Hargadon, 1996). Measuring ideation sessions solely by number and quality of ideas has been portrayed as a machine view of ideation (Sutton and Hargadon, 1996).
- The documented increased productivity of "hybrid ideation" (Girotra, Terwiesch et al., 2010) supports the "triple attack" strategy recommended to storm problems (Osborn, 1963, p. 191).
- The longitudinal study of creative teams in the workplace has found evidence of two types of contributions from team members: *giving* and *taking* behaviours (Elsbach and Flynn, 2013). This can explain why ideation sessions are appropriate throughout a project (Shroyer, Lovins et al., 2018) as they produce leads to solutions that require further development and imaginative testing (Osborn, 1963).
- Studies of ideation where participants work on design problems rather than toy problems show a comparable performance between individuals and teams, even when brainstorms are not facilitated (Linsey, Clauss et al., 2011). Design ideas that are product of combinations and development of other ideas tend to be of superior quality (Linsey, Clauss et al., 2011), which supports the role of combinatorial processes to transform "mediocre ideas into sterling ideas" (Osborn, 1963, p. 158).
- One of the few studies that compared established (worked together for 10 weeks) vs. non-established groups (only worked together once for the brainstorm session)

3 Remote Associates Test sample questions: https://www.remote-associates-test.com/

found evidence that validates Osborn's claims (Levine, Heuett et al., 2017).
- Evidence suggests that "idea-spurring questions" of the type suggested by Osborn to prepare for a brainstorm do have positive effects in creative ideation (Torrance, 1961).
- Whilst many ideation studies draw conclusions based on average values of fluency and metrics of idea quality, design researchers note that "extremes are what matter, not the average or the norm" (Girotra, Terwiesch et al., 2010) and draw attention to maximum values and variances. This supports Osborn's emphasis on the "thousandth idea" that will pay off (p. 130).
- Studies of ideation that address the effects of how design briefs or tasks are framed are rare, although their likely influence has been mentioned over the years (Meadow, Parnes et al., 1959; Vasconcelos and Crilly, 2016). Osborn warned that failure to adequately frame a problem "can seriously mar the success of any brainstorm session" (Osborn, 1963, p. 173).
- Osborn's reference to the "spirit of brainstorm sessions" strongly resonates with current models for training and practising creative facilitation (Light and Akama, 2012).
- Evidence shows that late stages of ideation sessions tend to be more productive (Parnes, 1961) confirming that "almost always we have to think up a number of *unusable ideas* in order to arrive at one that may work" (Osborn, 1963, p. 126).
- Lastly, studies of design practice show that group ideation that applies many of Osborn's insights continues to be widely used by professionals eighty years later (Shih, 2011; Shroyer, Lovins et al., 2018). Whilst it is clear that *properly conducted* brainstorms work, more research is needed to better understand why and how they do, and how to make them more enjoyable, effective, widespread, and more inclusive.

4. The next eighty years of Brainstorming

The intricacies of group creativity call for research approaches that inform ideation methods in the twenty-first century. Here the following are explored:

- Creative facilitation and creative leadership require more and deeper examination to identify best practices, effective pedagogical approaches, and to identify principles that can be applied across situations, teams, domains, and organisations.
- Attention is required for the conditions originally recommended by Osborn that have been overlooked in the design of empirical studies. These include the effects of briefs given to participants, principles for the appropriate framing of problems, and the information provided to promote incubation and prime associative thinking.
- The contextual and stochastic aspects of ideation need to be considered in the ways brainstorming is studied and how findings are used to inform practitioners.

Osborn explored "the element of luck in creative quests" (Osborn, 1963, p. 331), yet research questions that account for "creative accidents" (Osborn, 1963, p. 332) are largely missing. The choice of research methodologies can expand the current focus on average outcomes and representative samples in the pursuit of generalisation, to pay attention to exceptional conditions and extreme outcomes in the pursuit of qualitative insights and contextualised heuristics.
- The ways in which ideas are defined and evaluated deserve closer attention, especially since they tend to be implicitly and ad-hoc designated across ideation studies (Sosa, 2018; Sosa, 2019a). The effects of evaluation on the nature of findings deserve more careful scrutiny (Weisskopf-Joelson and Eliseo, 1961; Linsey, Clauss et al., 2011).
- Methods like brainstorming suit extroverted individuals and organisational cultures of flat hierarchies where vocal opinions are embraced. Other methods or variations would be valuable to include introverts and collectivist cultures where new ideas can be shared and recombined in less overt ways.
- Technological approaches have so far mainly sought to support or improve brainstorming. In the future, means to automate idea synthesis can be pursued, such as by substantially augmenting the associative basis of creative ideation.
- More studies are needed that target the functions of ideation practices beyond the mechanistic view of ideas as outputs, for example their value to nurture creative organisational cultures, team psychological safety, and individual capabilities.
- Closer attention needs to be put on the "harvesting of afterthoughts" (Osborn, 1963, p. 178) and in general to follow-up practices after an ideation session. The study of individual-group-individual "triple attack" strategies could reveal the ways in which ideation occurs before, between, and after sessions.
- Ideation studies need to differentiate the type of sessions under study. Moving beyond the treatment of all ideation events as one type, researchers could specify what type of problem is studied, what are the ideation goals, what types of ideas are being sought, and where the ideation event is located in the course of a creative project. This would help interpret and connect findings across studies.
- More ethnographic studies of ideation "in the wild" are desirable, as well as laboratory and classroom studies that more faithfully follow brainstorming guidelines (Cohen, Whitmyre et al., 1960; Shroyer, Lovins et al., 2018).

This illustrative list includes ideas aimed at building knowledge about how brainstorming can be better understood, better practised, and better learned. Equipped with more advanced procedural knowledge, designers need to better understand that creativity is needed to tackle the critical global challenges of the twenty-first century. After all, this method originated in advertising and gained popularity in the military and corporate worlds of the Cold War. Brainstorming has mostly been applied to enable a commercial agenda that promotes values and ways of living based on never-ending consumerism that lead to an unsustainable future. How may brainstorming be used to deal with major global challenges in the next decades?

4.1 We can all be more creative! But, what for?

Creativity has traditionally been portrayed as positive and desirable, even having childlike and playful undertones as hinted by the tired dictum that "*creativity is intelligence having fun*". The "dark side" of creativity has been explored to some extent (Cropley, Cropley et al., 2010) ranging from unprecedented ideas for dishonest or criminal purposes, to the negative consequences and side effects of well-intended inventive ideas. The in-depth biographical analysis of creative figures has shown other negative aspects of creativity including the Faustian bargain that some prominent creators accept as the price of their relentless pursuits for originality and fame (Gardner, 2011). Eminent creators also often engage in abuse of power and other unethical behaviours and have suffered mental health problems and addictions (Gardner, 2011). In this context, very little research on brainstorming has included ethical dimensions (Mumford, Waples et al., 2010). To inform an ethical brainstorming practice, the following questions are of relevance:

- How may we foresee and assess the destructive effects of creativity (Schumpeter, 2002) including the loss of existing expertise, practices, and worldviews?
- What are the politics and the ethics of creativity? (Winner, 1980; Sosa, 2019b) Who gets to change things? Whose dreams and visions inform desirable futures? How is the mandate for creative agency adjudicated and asserted?
- How may ownership of new ideas and their effects be negotiated, shared, and transferred? (Ihde, 2006).
- How may creative agency break away from a market economy where large corporations capture most imaginative talent creating a class gap between the haves and have-nots of creativity?
- How may localities transcend the Western version of creativity that is used to colonise other regions through certification on their toolkits and methods? How may local creatives exercise their own version of creative action and constitute their own methods?
- How may creatives attend to the impeding emergencies (climate, social justice, migration) yet avoid tunnel vision that prevents them from imagining a desirable future beyond these crises?
- How may education systems transcend the current disciplinary divides between creatives and non-creatives?
- How may we suspend disbelief to support early ideas and protect their growth based on their potential, yet critically scrutinise them to prevent the high-jacking of innovative ideas by con-artists and fraudulent early investors?[4]
- How may entrepreneurial frameworks like effectuation (Sarasvathy, 2008) explicitly accommodate the type of ethical concerns that come with new

4 The Drop Out documentary about Elizabeth Holmes and Theranos: https://abcaudio.com/podcasts/the-dropout/

ventures?

5. Discussion

This paper started by critically examining brainstorming going back to the original sources to assess its origins and the origins of its systematic study. It then identified the fallacy of using "nominal groups" used to discredit this ideation method and reviewed evidence that supports many of the group brainstorming principles. The paper then framed an agenda for the future study and practice of creative ideation focusing first on questions of "*How*", and questions of "*What for*" later. Brainstorming is turning eighty, and it clearly works when properly conducted to enable the creative capacities of all who make a serious effort. The substantial challenges that we face in the next eighty years can be creatively and collectively tackled to the extent that we support Hannah Arendt's principle of *natality*, i.e., the realisation that "every birth represents a new beginning and the introduction of novelty in the world" (Arendt, 2013, p. 9). Beyond reductive studies that compare group vs. individual ideation, it is time to approach the study and education of creative literacy as a strategic priority for the twenty-first century -a task that designers are well prepared to deliver.

The work presented here suggests a few key ideas that inform future research efforts. The first is that it is critical to return to primary sources. Google Scholar statistics in February 2020, show 7742 papers that cite (Osborn, 1963), of which 594 use the term "nominal groups" and only six include the term "triple attack" -denoting how Osborn's original recommendations remain ignored whilst Taylor's artifice created a big following. Whilst (Taylor, Berry et al., 1958) reports only 856 citations, a Web of Science report in January 2020 shows a total of 11,754 *secondary* citations of the study that introduced the use of "nominal groups". This indicates that the findings of Taylor have been amplified by researchers who may arguably not have even read that paper but learned of its conclusions through secondary sources. As such, one finds statements such as: "There is considerable evidence that group brainstorming is *less productive than individual* brainstorming" (Kohn and Smith, 2011, p. 359) which is precisely the opposite of what the original reports (Taylor, Berry et al., 1958).

Another lesson for designers, design scholars, and design educators is that the myth that group brainstorming does not work is based on research that follows "academic rigour" but ignores "practice rigour". Design research needs to acknowledge the double challenge of being scientifically *and* designerly relevant. Further, as creative methods are increasingly understood and improved, the ethical dimensions of their deployment must be recognised and integrated into our research questions and teaching practices.

The need for creative solutions to tackle the challenges of the twenty-first century seems timely to acknowledge that the creative orientation of design professions has made them instruments to advance corporate agendas that promote a lifestyle of endless consumption and waste. Methods and tools for creativity are urgently needed to address the current global crises and to imagine desirable futures beyond these emergencies. The history of design and invention shows that the best intended innovations have often had disastrous consequences in the long run -this can be viewed as a failure of process and a failure of methods to generate and understand new ideas before it is too late. Innovation in new drug development considers possible consequences and side-effects -likewise, design innovation can and needs to be conducted in more responsible ways.

Lastly, creativity is not exclusive to design, and designers seem ideally positioned to open up *creativity for all* in inclusive ways that are respectful of individual and cultural differences. From a philosophy of natality that underpins rigorous universal creative literacy (Arendt, 2013), it is possible that by the year 2100 we will have resolved the planetary challenges of today and, more so, will have discovered new ways of being creative.

6. References

Adánez, A. M. (2005). "Does quantity generate quality? Testing the fundamental principle of brainstorming." The Spanish journal of psychology 8(2): 215-220.

Arendt, H. (2013). The Human Condition. Chicago University of Chicago Press.

Cohen, D., J. W. Whitmyre and W. H. Funk (1960). "Effect of group cohesiveness and training upon creative thinking." Journal of Applied Psychology 44(5): 319.

Cropley, D. H., A. J. Cropley, J. C. Kaufman and M. A. Runco (2010). The Dark Side of Creativity. Cambridge, UK, Cambridge University Press.

Diehl, M. and W. Stroebe (1987). "Productivity loss in brainstorming groups: Toward the solution of a riddle." Journal of personality and social psychology 53(3): 497.

Dunnette, M. D., J. Campbell and K. Jaastad (1963). "The effect of group participation on brainstorming effectiveness for 2 industrial samples." Journal of applied psychology 47(1): 30.

Elsbach, K. D. and F. J. Flynn (2013). "Creative Collaboration and the Self-Concept: A Study of Toy Designers." Journal of Management Studies 50(4): 515-544.

Gardner, H. (2011). Creating minds: An anatomy of creativity seen through the lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi. New York, Basic Books.

Girotra, K., C. Terwiesch and K. T. Ulrich (2010). "Idea Generation and the Quality of the Best Idea." Management Science 56(4): 591-605.

Goldenberg, O. and J. Wiley (2019). "Individual and Group Brainstorming: Does the Question Matter?" Creativity Research Journal 31(3): 261-271.

Gurman Jr, E. B. (1962). The effect of self, task and interaction orientation on brainstorming. PhD, Louisiana State University.

Ihde, D. (2006). The designer fallacy and technological imagination. Defining Technological Literacy: Towards an Epistemological Framework. J. Dakers, Springer: 121-131.

Jablin, F. M. and D. R. Seibold (1978). "Implications for problem-solving groups of empirical research on 'brainstorming': A critical review of the literature." Southern Speech Communication Journal 43(4): 327-356.

Kalargiros, E. (2014). The effect of inspirational facilitation on brainstorming effectiveness: A test of Osborn's original ideas. 3582312 Ph.D., New Mexico State University.

Keum, D. D. and K. E. See (2017). "The Influence of Hierarchy on Idea Generation and Selection in the Innovation Process." Organization Science 28(4): 653-669.

Kohn, N. W. and S. M. Smith (2011). "Collaborative fixation: Effects of others' ideas on brainstorming." Applied Cognitive Psychology 25(3): 359-371.

Levine, K. J., K. B. Heuett and K. M. Reno (2017). "Re-Operationalizing Established Groups in Brainstorming: Validating Osborn's Claims." The Journal of Creative Behavior 51(3): 252-262.

Lewis, A. C., T. L. Sadosky and T. Connolly (1975). "The effectiveness of group brainstorming in engineering problem solving." IEEE Transactions on Engineering Management(3): 119-124.

Light, A. and Y. Akama (2012). The human touch: participatory practice and the role of facilitation in designing with communities. Participatory Design Conference. Roskilde, Denmark, ACM: 61-70.

Linsey, J. S., E. F. Clauss, T. Kurtoglu, J. T. Murphy, K. L. Wood and A. B. Markman (2011). "An Experimental Study of Group Idea Generation Techniques: Understanding the Roles of Idea Representation and Viewing Methods." Journal of Mechanical Design 133(3).

McCaffrey, T. (2014). Why You Should Stop Brainstorming. Harvard Business Review. Cambridge, Harvard Business Publishing.

Meadow, A., S. J. Parnes and H. Reese (1959). "Influence of brainstorming instructions and problem sequence on a creative problem solving test." Journal of Applied Psychology 43(6): 413.

Mednick, S. (1962). "The associative basis of the creative process." Psychological review 69(3): 220.

Mumford, M. D., E. P. Waples, A. L. Antes, R. P. Brown, S. Connelly, S. T. Murphy and L. D. Devenport (2010). "Creativity and ethics: The relationship of creative and ethical problem-solving." Creativity Research Journal 22(1): 74-89.

Nijstad, B. A. and W. Stroebe (2006). "How the group affects the mind: A cognitive model of idea generation in groups." Personality and social psychology review 10(3): 186-213.

Osborn, A. F. (1963). Applied imagination; principles and procedures of creative problem-solving. New York, Scribner.

Parnes, S. J. (1961). "Effects of extended effort in creative problem solving." Journal of Educational psychology 52(3): 117.

Parnes, S. J. and A. Meadow (1959). "Effects of "brainstorming" instructions on creative problem solving by trained and untrained subjects." Journal of Educational Psychology 50(4): 171-176.

Sarasvathy, S. D. (2008). Effectuation: elements of entrepreneurial expertise. Cheltenham, Glos, UK ; Northampton, MA, Edward Elgar.

Schumpeter, J. A. (2002). The Process of Creative Destruction',in Capitalism, Socialism and Democracy. The foundations of entrepreneurship, Edward Elgar Pub. 1.

Shih, P. C.-P. (2011). Brainstorming Beyond the Laboratory: Idea Generation Practices in Software Development Firms. PhD, University of California, Irvine.

Shroyer, K., T. Lovins, J. Turns, M. E. Cardella and C. J. Atman (2018). "Timescales and ideaspace: An examination of idea generation in design practice." Design Studies 57: 9-36.

Sosa, R. (2018). "Metrics to select design tasks in experimental creativity research." Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science.

--- (2019a). "Accretion theory of ideation: evaluation regimes for ideation stages." Design Science 5(e23).

--- (2019b). Teaching (with) Empathy and Creativity in Design. Proceedings of DRS Learn X Design 2019: Insider Knowledge. N. Börekçi, D. O. Koçyıldırım, F. Korkut and D. Jones. Ankara, Turkey, Design Research Society: 153-160.

Sutton, R., I. and A. Hargadon (1996). "Brainstorming Groups in Context: Effectiveness in a Product Design Firm." Administrative Science Quarterly 41(4): 685-718.

Taylor, D. W., P. C. Berry and C. H. Block (1958). "Does Group Participation When Using Brainstorming Facilitate or Inhibit Creative Thinking?" Administrative Science Quarterly 3(1): 23-47.

Taylor, D. W. and O. W. McNemar (1955). "Problem solving and thinking." Annual review of psychology 6(1): 455-482.

Torrance, E. P. (1961). “Priming Creative Thinking in the Primary Grades.” The Elementary School Journal 62(1): 34-41.

Vasconcelos, L. A. and N. Crilly (2016). “Inspiration and fixation: Questions, methods, findings, and challenges.” Design Studies 42: 1-32.

Weisskopf-Joelson, E. and T. S. Eliseo (1961). “An experimental study of the effectiveness of brainstorming.” Journal of Applied Psychology 45(1): 45.

Winner, L. (1980). “Do artifacts have politics?” Daedalus: 121-136.

About the Authors:

Ricardo Sosa is Associate Professor at Auckland University of Technology and holds adjunct positions at Monash University and Nanyang University of Technology Singapore. He teaches and conducts research in design and creative technologies with an emphasis on creativity for social justice.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

New Design Heuristics Compared with Existing Ones

Xiaoneng JIN[a]*, Hua DONG[b], Mark EVANS[b]

[a] College of Design and Innovation,Tongji University, Shanghai, China
[b] School of Design and Creative Arts, Loughborough University, Leicestershire, UK
*Corresponding author e-mail: jinxn@tongji.edu.cn
doi: https://doi.org/10.21606/drs.2020.256

Abstract: Design Heuristics (DHS) as a tool helps boost designers' creativity in the early design phases. Since the middle of the 20th Century, different DHS have been developed, e.g. general ones such as SCAMPER and 77 DHS; and specific ones such as DHSfX (design for one-handed use) and DHS for additive manufacturing. With rapid technological developments, an increasing number of products now incorporate technological platforms and services. There is a lack of new DHS relating to such service-based information products. Based on RedDot Concept Design Award entries (2013-2017), we have extracted ten DHS that focus on service-based information products. We compared our newly derived DHS with existing design heuristics and discovered that although some of our DHS overlapped with existing ones, the new DHS10 were more specific and useful for digital solutions. The preliminary evaluation of the new DHS suggested its potential in helping generate concepts in the early design phase.

Keywords: design heuristics; methodological review; service-based information products

1. Introduction

Design Heuristics (DHS) are defined as a context-dependent directive, based on intuition, tacit knowledge or experiential understanding which provides design process direction to increase the chance of reaching a satisfactory, but not necessarily optimal, solution (Fu, Yang, & Wood, 2016). Different DHS have been developed for different purposes, such as DHS for additive manufacturing (Bloesch-Paidosh & Shea, 2019), DHS for assistive (one-handed) products (Hwang & Park, 2018), and DHS for technological innovations, e.g. TRIZ (Ilevbare, Probert, & Phaal, 2013).

DHS are evidenced to help generate ideas effectively in the conceptual design phase and play an important role in addressing issues with design fixation. However, existing DHS have some shortcomings: 1) The datasets utilised are not up to date (with the majority originating before 2009); 2) Most of DHS are structural design heuristics for industrial design, with little relevance to service-based information products; 3) Technical advances have triggered an opportunity for design innovation to generate a wealth of new products (Dove, Halskov, Forlizzi, & Zimmerman, 2017), but few DHS are generated for the digital era.

The nature of product design appears to be experiencing significant changes as evidenced by activities in design schools. A comparison of keywords appearing in final year design students' degree show books (based on two UK universities best known for their product design and industrial design student employability) has revealed the changes in the last ten years (Table 1).

Table 1 Keywords in Design Degree Show books compared, 2009 vs 2018

Words appearing 10 or more times in 2009		**Words appearing 10 or more times in 2018**	
Interactive	15	App	40
Experience	12	Environment	27
Portable	12	Personalization	16
Multifunctional	11	Experience/User experience	15
Encourage	11	Smart/Intelligent	15
Environment	10	Modular	14
		Customisable	13
		Interaction/ User interaction	11

With rapid technology changes, DHS have the potential to support designers and this study presents ten new DHS for the digital era. While developing the new DHS, we found there was a lack of comparative evaluation between existing DHS. Our hypothesis is that there are overlaps between different DHS. The objective of this study is to compare existing DHS and then compare them with our new DHS to identify whether there is added value offered by the new DHS.

2. Design Heuristics

'Design heuristics' are defined as cognitive 'shortcuts' that point toward useful design patterns (Daly, Yilmaz, Christian, Seifert, & Gonzalez, 2012; Seda Yilmaz, Daly, Seifert, & Gonzalez, 2016; Seda Yilmaz & Seifert, 2011; S. Yilmaz, Seifert, & Gonzalez, 2010).

2.1 Existing Design Heuristic for Ideation

SCAMPER is an acronym for (S) Substitute, (C) Combine, (A) Adapt, (M)Modify, (P) Put to other uses, (E) Eliminate, and (R) Reverse/Rearrange (Serrat, 2017) which provides a structured method of assisting students to think divergently and enhance their design knowledge (Michalko, 2010). SCAMPER was proposed by Alex Faickney Osborn in 1953 and was further developed by Bob Eberle in 1971 in his book SCAMPER: Games for Imagination Development (Eberle, 1971) .

TRIZ 40 Principles was developed by Altshuller in 1969 through reviewing 40,000 patent abstracts. It provides 40 principles (design heuristics) for helping technological innovations with particular relevance in solving complicated technical problems (Gadd, 2011). TRIZ has been widely utilized to enhance creativity in addressing technical problems. However, there is a degree of confusion with TRIZ on how to approach it and what exactly it embodies, which makes it difficult to fully employ (Ilevbare et al., 2013). Often people need training before using TRIZ.

77 Design Heuristics (77 DHS) was developed by analysing 400 award-winning designs from which 40 DHS were identified (Seda Yilmaz, Seifert, Daly, & Gonzalez, 2016); 218 sequential concepts created by an expert industrial designer over two years for a single design project (a universal access bath within an existing home); and 179 followed by 68 concepts generated via two studies using Think-aloud protocols. The 77 Design Heuristics have proved to associate with effective innovation in both engineering and industrial design domains (Seda Yilmaz, Daly, Seifert, & Gonzalez, 2015). However, the datasets are mainly from 2001 to 2009 (not up-to-date), with most being structural design heuristics for the industrial design area.

Design Heuristics set for X (DHSfX) was developed by analysing a total of 139 products (100 manufactured and 39 patents) by Hwang & Park in 2018. DHSfX provides 13 Design Heuristics as a design aid for assistive product concept generation (Hwang & Park, 2018) focussing on assistive products for one-handed users. An empirical evaluation indicated that DHSfX could enhance the outcome of assistive product concept generation (Hwang & Park, 2018).

Design Heuristics for Additive Manufacturing (DHSfAM) was developed by analysing a total of 275 artefacts (datasets including academic/industry literature, popular media, and industry/hobby websites). DHSfAM provides 29 Design Heuristics for additive manufacturing which were found to positively influence the designs generated and were more effective in communicating DfAM concepts (Bloesch-Paidosh & Shea, 2019).

Table 2 summaries the comparison of the existing DHS.

Table 2 Comparison of the existing DHS.

Reference	DHS Name	Data Source	Purpose	Limitations
(Eberle, 1996)	SCAMPER (1953)	Not specified	A structured way of assisting students to think out of the box and enhance their knowledge.	Can be quite abstract

(Gadd, 2011)	TRIZ 40 Principles (1969)	40,000 patent abstracts	To help technological innovations especially in solving technical contradictions.	Great confusion on how to approach it and what exactly it embodies.
(Seda Yilmaz, Daly, et al., 2016)	77 Design Heuristics (2016)	Study 1: 400 award-winning products. Study 2: 218 sequential concepts created by an expert industrial designer over two years. Study 3: 179 concepts generated from 36 engineers. Study 4: 68 concepts generated from 12 industrial designers.	To help designers to generate more, and more varied, candidate concepts to consider in the early phases of design.	1) The datasets are mainly from 2001 to 2009, and most are structural design heuristics for the industrial design area. 2) service-based products are rarely included.
(Seda Yilmaz, Seifert, et al., 2016)	40 Design Heuristics (2016)	400 award-winning products.	The same as above (77 DHS).	The same as above (77 DHS).
(Hwang & Park, 2018)	DHSfX (13 design heuristics) (2018)	139 examples (100 existing products and 39 patents).	A design aid for assistive product concept generation.	It does not support other phases of the assistive product design process.
(Bloesch-Paidosh & Shea, 2019)	DHS for Additive Manufacturing (29 Design Heuristics) (2019)	275 artefacts (datasets including academic and industry literature, the popular media, and industry and hobby websites).	A design aid for Additive Manufacturing.	The heuristics are meant to represent what is possible at a conceptual level, not what is currently feasible or makes economic sense.

2.2 Research Gaps

Research gaps were identified through analysing existing DHS:

- New technology applications are rarely mentioned and the datasets are not up to date (i.e. lacking data from 2009 onwards), with the exception of DHS for additive manufacturing.
- Most of DHS are structural design heuristics for industrial design, and service-based information products are rarely included. Few studies consider DHS for the digital era.
- Many DHS are difficult to understand, remember and apply, due to extensiveness and abstract descriptions (Ilevbare et al., 2013).

New Design Heuristics are needed for the fast-developing digital era. It becomes necessary to add service-based products and new technology applications to the development of design heuristics. DHS descriptions should also be easy to understand so that designers can remember and utilise them effectively.

2.3 New Design Heuristics for Service-based Information Products (DHS10)

Our DHS, called DHS10, were extracted from 998 award-winning designs covering the period between 2013 and 2017 and aimed to plug the research gap. The data source is RedDot that has been identified as the most credible international design award (Self, 2014). Two researchers (both with masters' degrees in industrial design and winners of RedDot awards) undertook data extraction, following a 5-step process (Figure 1). Details about the extraction of the DHS10 can be found from (Jin & Dong, 2020).

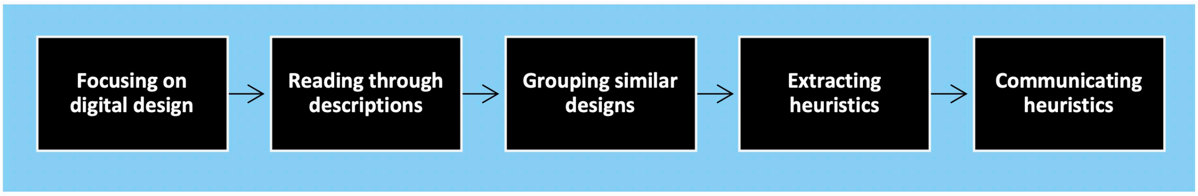


Figure 1 The 5-Step process of extracting design heuristics.

To make the design heuristics easy to understand and easy to remember, we illustrated the new DHS10 not only in textual descriptions but also images. Card-based design tools have been widely utilized (Roy & Warren, 2019) and each design heuristics is presented on one card.

Figure 2 shows the ten cards (Jin & Dong, 2020).

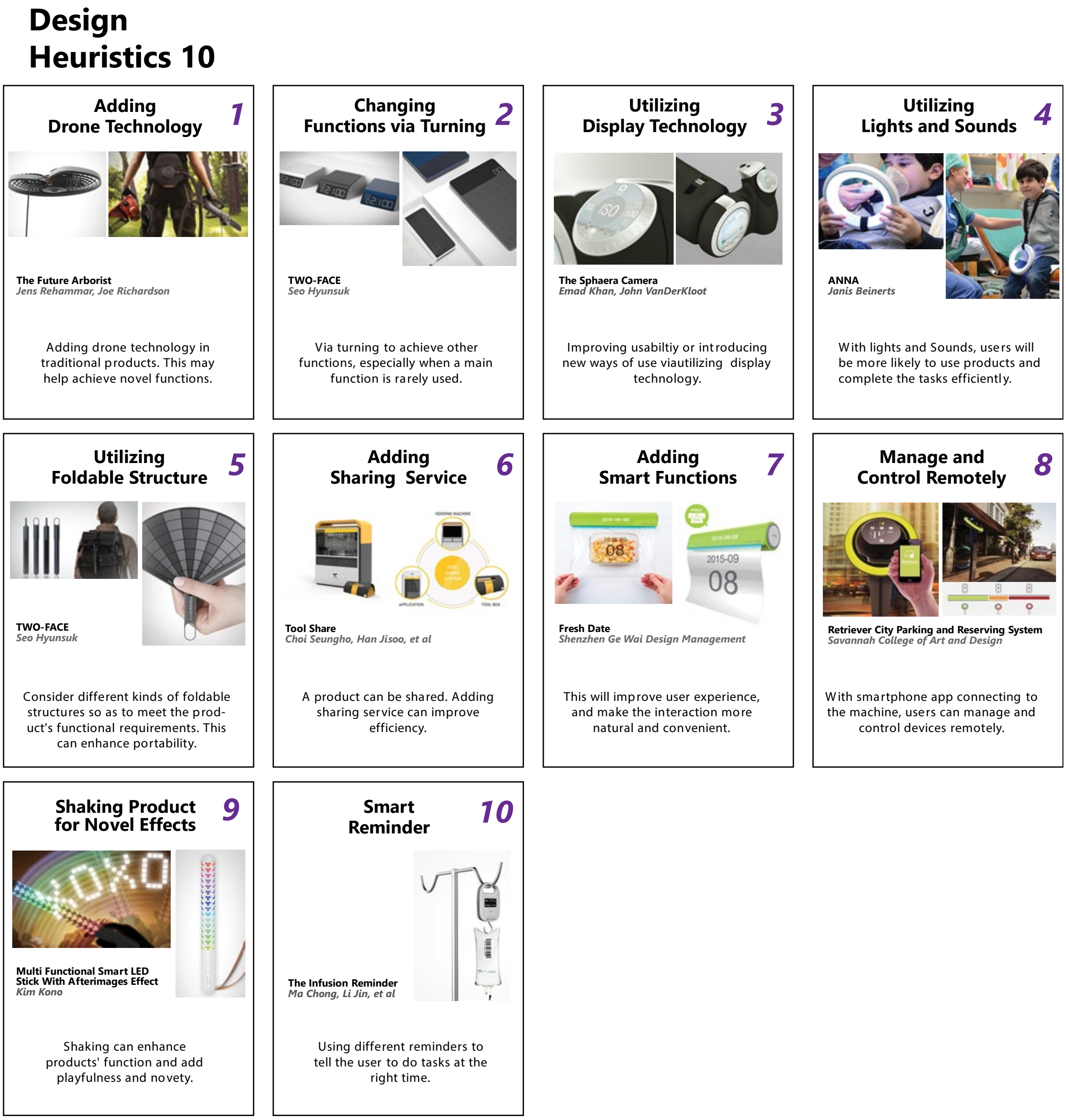


Figure 2 DHS10 for service-based information products.

3. Methods

Four typical DHS were selected for comparison, i.e. SCAMPER, TRIZ, 77DHS and DHSfX. To compare the DHS, two design researchers undertook the role of analysts. One analyst had a bachelor's degree of English and was a postgraduate student in design. The other analyst was a professional designer with bachelor and master degrees in industrial design. The three-step analysis procedure is as follows (illustrated in Figure 3).

Step 1: Familiarising with the design heuristics including SCAMPER, TRIZ 40 Principles, 77DHS, DHSfX, and the DHS10 developed.

Step 2: Analysing the design heuristics independently. Because the 77 Design Heuristics are general and contain the large numbers of DHS, they were used as a datum (shown in capital letters in Table 3) and other DHS were compared with the 77DHS. If the two analysists identified similarity or overlap between different sets of DHS, they made notes independently.

Step 3: Discussing to reach consensus. Once the comparison was completed by each analyst, they compared the results with each other. When they had different opinions, they discussed to achieve agreement.

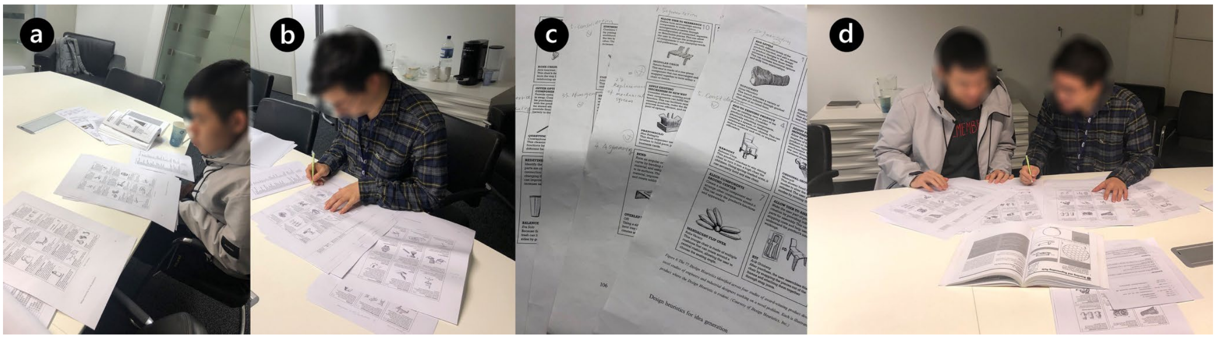


Figure 3a, b Independent review by two analysts; c: comparison; d: discussion

The comparison outcome was further verified by a design professor (Figure 4).

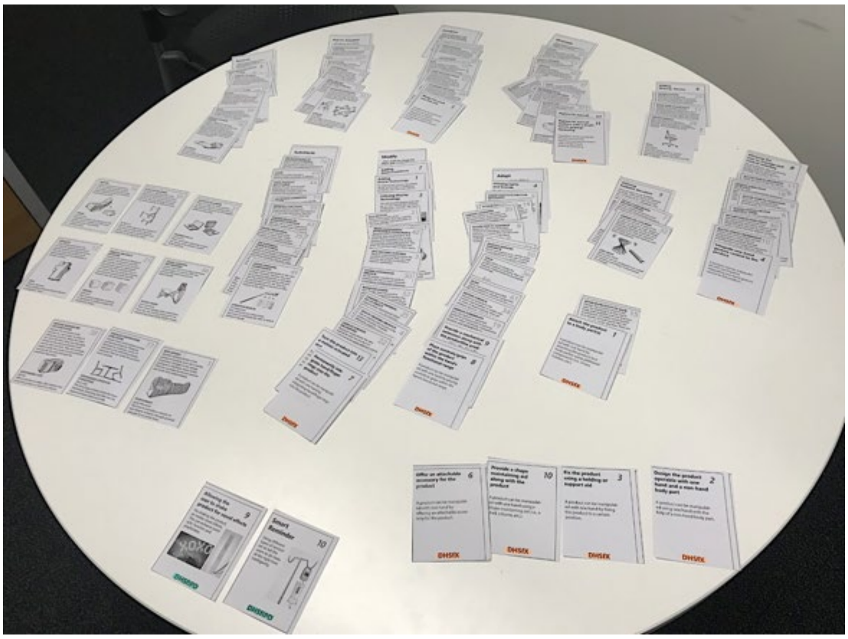


Figure 4 Further verification of the comparison outcome of the DHS.

4. Results

The verified outcome was then visualised (Figures 5-7).

4.1 Overlapping between the Four Sets of Existing DHS

Figure 5 indicates that there is a high overlap between the 77 DHS and TRIZ 40 principles. All the SCAMPER design heuristics are covered by the 77 DHS, and its DHS 'Adapt' and 'Put to other uses' correspond to many DHS in the 77 DHS (Figure 6). In the figures, '0' suggests no matching items.

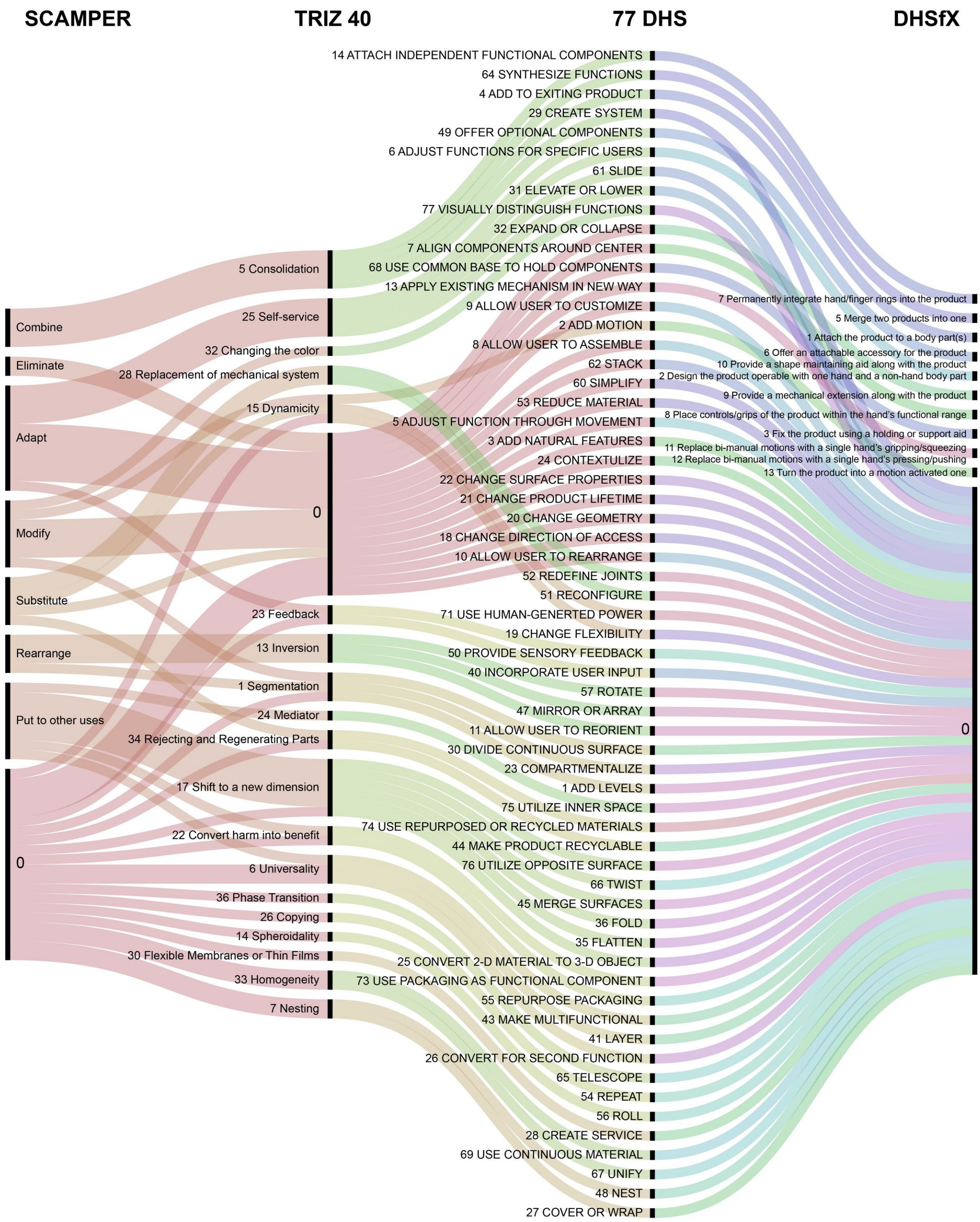


Figure 5 The overlaps of the four selected DHS.

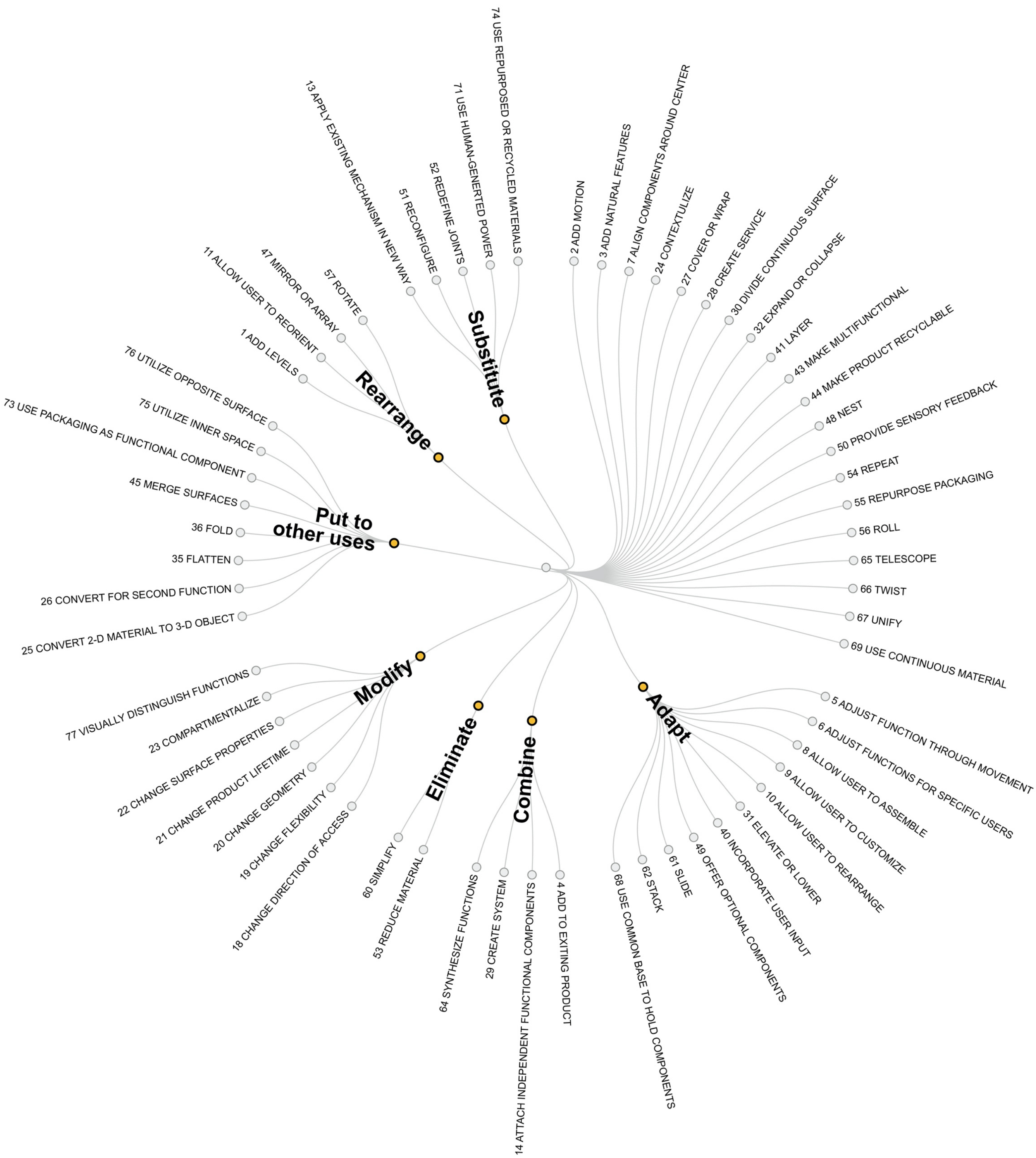


Figure 6 he overlaps between SCAMPER and 77 DHS.

Interestingly, although the DHSfX (Hwang & Park, 2018) is developed specifically for generating designs for one-handed use, it overlaps with the generic design heuristics 77 DHS apart from only one item, i.e. ‘Integrate one-hand gesture control to the product’.

4.2 Comparison between our DHS10 and the Existing DHS

Figure 7 shows the overlap between our DHS10 and the 77 DHS, TRIZ and SCAMPER (DHSfX was excluded as it is specific for one-handed use design, and overlapped a lot with 77 DHS). As show in Figure 7, our DHS10 overlapped one of the TRIZ 40 Principles (i.e. 13. Inversion), two of the 77 DHS (i.e. 11 ALLOW USER TO REORIENT, and 36 FOLD), and five out of the seven 7 SCAMPER DHS (i.e. 'Put to Another Use', 'Adapt', 'Modify', 'Substitute', and 'Combine').

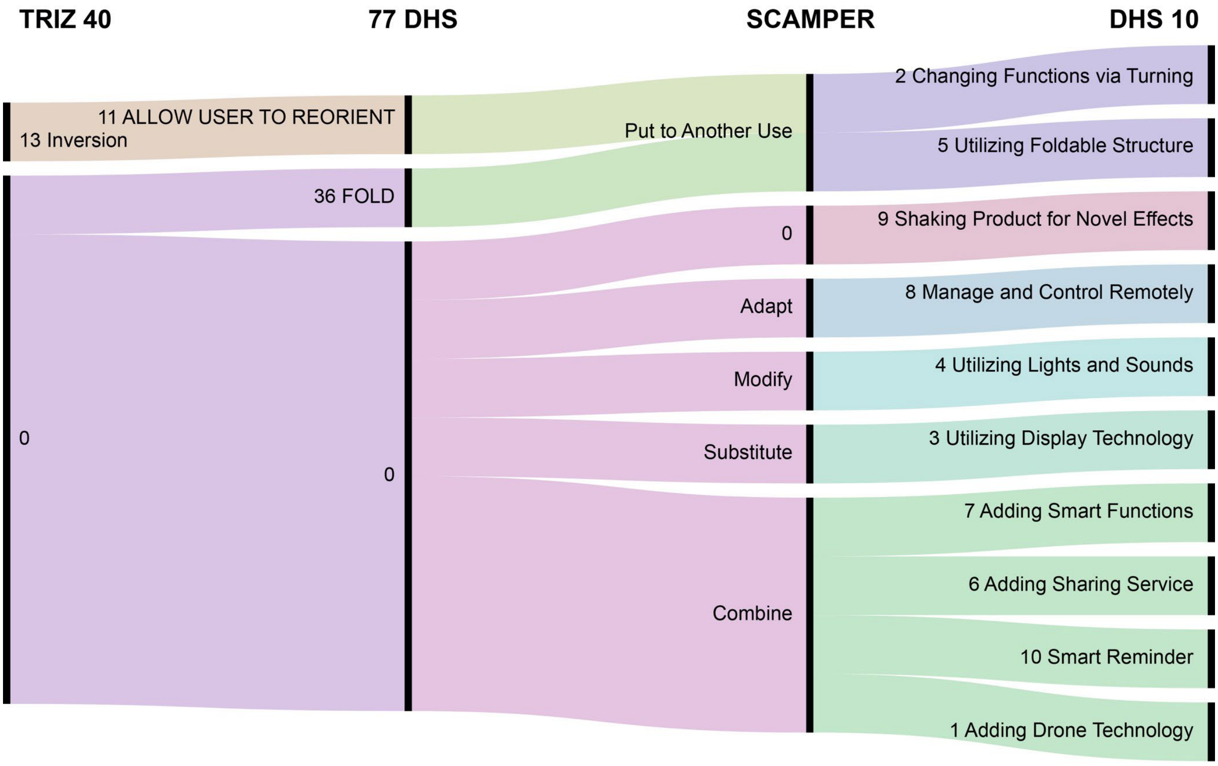


Figure 7 Comparison between DHS10 and 77 DHS, TRIZ and SCAMPER.

Although it appears that there is a high overlap between our DHS10 and SCAMPER, our DHS10 is much more detailed, and specific to the digital design context.

5. Preliminary Evaluation

To assess the usefulness of the DHS10 in helping generate concepts for digital design, we conducted a preliminary evaluation. We asked a volunteer studying for a master's design degree to answer the following brief (Figure 8, adopted from IF 2019): firstly using his existing knowledge and any conceptual design tools he knew; and then using the DHS10. The whole session took 60 minutes in total.

3. SAMSUNG DESIGN PRIZE 2019 by iF: Design for Collaboration –
new concept of collaboration tools and solutions for the augmented workplace

We live in a world where the digital and real life overlap – especially in the workplace. A good communication is needed more than ever to maintain effortless communication and effective collaboration.

Your task: Design a practical smart solution or concept that helps people to communicate and collaborate easily in the daily business – be that digital or physical.

Figure 8 The design brief.

The volunteer was able to develop several concepts within 60 minutes (see sketches in Figure 9) and his feedback was as follows,

> "In the beginning, I saw this design task and I thought it is very hard for me. I use brainstorming to think this design task. Unfortunately, I still can't think of any good ideas. But when I saw these design heuristics, in 10 mins I understood them. Then, I could quickly come out ideas for tackling this design problem."

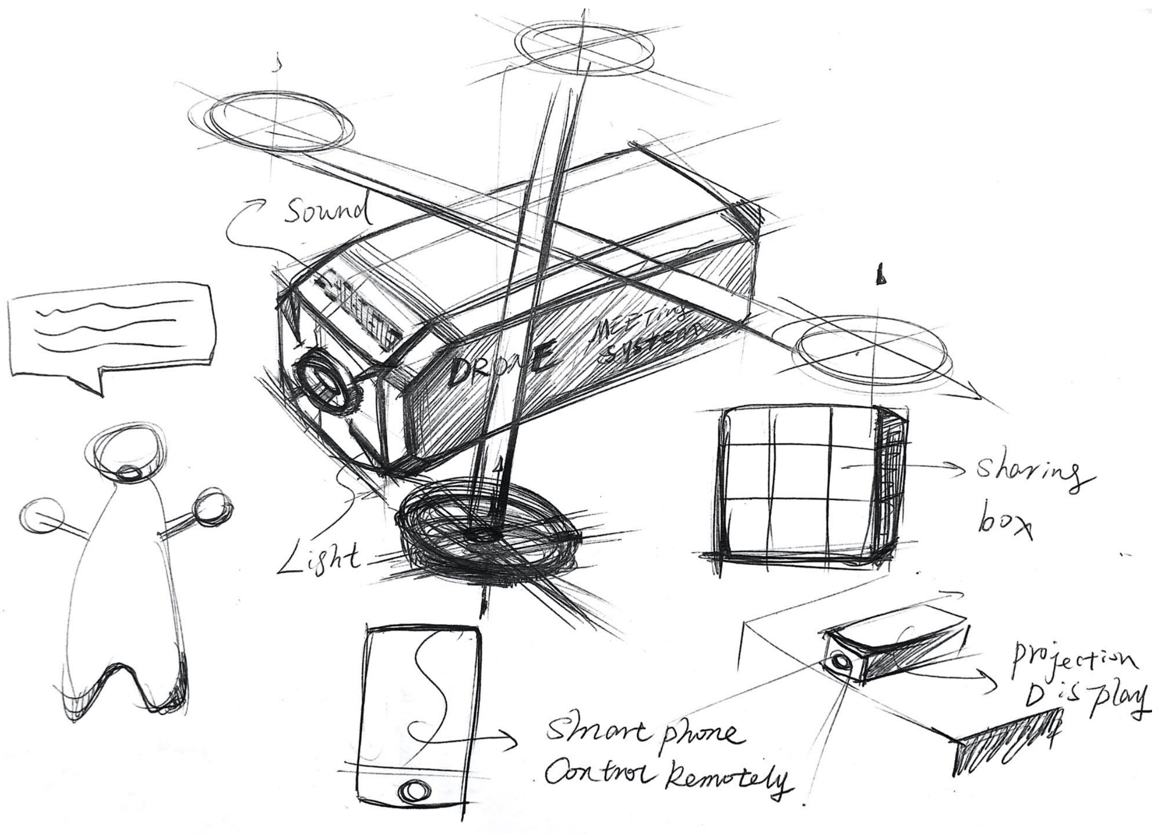


Figure 9 The concept sketches by the volunteer.

The analysis of his design text description suggests that seven out of the 10 DHS10 were effectively applied, as follows (the DHS utilised were numbered in brackets starting with #).

> "The W-Drone is an integrated Drone meeting system (#1 Adding Drone technology), which addresses the teleconference's low efficiency, especially in architecture and industrial design area. The W-Drone can control the Drone remotely and intelligently (#8 Allowing the user to manage and control remotely, #7 Adding smart functions), so as to help stakeholders to watch the whole design and detail design work through different angles and heights. The W-Drone also owns a sound and light system (#4 Utilizing lights and Sounds), which can allow users to send themselves voice to the opposite side. The W-Drone has a foldable structure (#5 Utilizing foldable structure) so that it can be stored in a small space. W-Drone also provides Sharing Function (#6 Adding Sharing Service). Every company's staff can use the W-Drone if it is available. Besides, W-Drone provides projection display technology (#3 Utilizing the display technology), which can display images opposite. For example, stakeholders draw sketches and give reference images to designers. Most importantly, these functions will enhance the experience in collaboration and communication. W-Drone will save costs and time significantly."

This preliminary evaluation suggests DHS10 is effective in supporting conceptual design of service-based information product in the early design stage.

6. Discussion, Conclusions and Future work

In this study, we reviewed existing design heuristics and compared them with our new DHS10, and found some of DHS10 overlapped with existing design heuristics, but our DHS were more specific and relevant to the emerging technological context (i.e. digital design, service-based information product). The preliminary evaluation suggests great potential of DHS10 in helping generate concepts in the early design phase.

The comparison and visualisation of existing DHS is the first study of this kind. In addition, the DHS10 is originally developed by us, and it is the first time that the three 'traditional' DHS (i.e. TRIZ, 77 DHS and SCAMPER) were compared with the DHS10 which was derived from 'digital design' examples.

By analysing the existing DHS, we gain a better understanding of how DHS work and their purpose and limitations. For example, SCAMPER uses the acronyms of the seven design heuristics as its name, which helps the users to remember and recall them easily. TRIZ 40 principles tent to be highly abstract, so detailed description, examples and applications (with images) are often required to help users to grasp the principles. The 77 DHS are comprehensive, but too difficult to remember all. Many design heuristics can be grouped in the same category at a higher level. Although the DHSfX is developed specifically for assistive design, it shares a lot of principles with generic design heuristics (e.g. 77 DHS).

DHSfAM deals with new technology (i.e. additive manufacturing), similar to our DHS10. It is interesting to know that DHSfAM has proved to be very useful in communicating Design for Additive Manufacturing concepts (Bloesch-Paidosh & Shea, 2019). This inspires us to consider whether DHS10 will be effective in communicating digital design and service-based information product design concepts, as an objective for our future evaluation of DHS10. For future work, we are planning an evaluation study which will involve 60+ design students (divided into the control and experimental groups), to test how effective the DHS10 is in helping generate digital design concepts compared with other methods (e.g. Brainstorming). The preliminary evaluation suggests concept sketches and text descriptions can be effective, and these will be incorporated into the future evaluation study.

We also plan to optimise the presentation of the DHS10. The existing DHS take different forms, some are short textual phrases (e.g. TRIZ); some are a combination of texts and images (e.g. 77 DHS), and some are short text followed by a number of probing questions for inspiration (e.g. SCAMPER). Short, abstract text may inspire imagination but sometimes can be difficult to understand; examples and images are effective in explaining the heuristics but might restrain imagination. An optimal form of representing DHS10 will be explored in our future study.

In summary, this study has compared existing DHS sets and the new design heuristics (DHS10). The DHS10 has been extracted from more recent data which address emerging service-based information products in the digital era. We are using the insights gained from the comparison to refine DHS10. The significance of the research is two folds: the visualised comparison of existing DHS has revealed 'unseen' overlaps and gaps, which may give direction of the future development of DHS; and the DHS10's relevance to the contemporary design context, which will make it a useful tool to design students and design professionals.

Acknowledgements: We thank the volunteers who helped analyse existing DHS and evaluating DHS10. The data included in Table 1 has been collected by Giyeun Ma under the supervision of Prof Hua Dong. This PhD study is supported by the Chinese Scholarship Council.

7. References

Bloesch-Paidosh, A., & Shea, K. (2019). Design Heuristics for Additive Manufacturing Validated Through a User Study. *Journal of Mechanical Design, 141*(4). doi:10.1115/1.4041051

Daly, S. R., Yilmaz, S., Christian, J. L., Seifert, C. M., & Gonzalez, R. (2012). Design Heuristics in Engineering Concept Generation. *Journal of Engineering Education, 101*(4), 601-629. doi:DOI 10.1002/j.2168-9830.2012.tb01121.x

Dove, G., Halskov, K., Forlizzi, J., & Zimmerman, J. (2017). UX Design Innovation: Challenges for Working with Machine Learning as a Design Material. *Proceedings of the 2017 Acm Sigchi Conference on Human Factors in Computing Systems (Chi'17)*, 278-288. doi:10.1145/3025453.3025739

Eberle, B. (1996). *Scamper on: Games for imagination development*: Prufrock Press Inc.

Eberle, R. (1971). *Scamper: games for imagination development*. BuffaloN. YDOK.

Fu, K. K., Yang, M. C., & Wood, K. L. (2016). Design Principles: Literature Review, Analysis, and Future Directions. *Journal of Mechanical Design, 138*(10). doi:10.1115/1.4034105

Gadd, K. (2011). *TRIZ for engineers: enabling inventive problem solving*: John wiley & sons.

Hwang, D., & Park, W. (2018). Design heuristics set for X: A design aid for assistive product concept generation. *Design Studies*, 58, 89-126. doi:10.1016/j.destud.2018.04.003

Ilevbare, I. M., Probert, D., & Phaal, R. (2013). A review of TRIZ, and its benefits and challenges in practice. *Technovation*, 33(2-3), 30-37. doi:10.1016/j.technovation.2012.11.003

Jin, X., & Dong, H. (2020). New design heuristics in the digital era. *Proceedings of the Design Society: International Design Conference*, Cavtat, Croatia (in press).

Michalko, M. (2010). *Thinkertoys: A handbook of creative-thinking techniques*: Ten Speed Press.

Roy, R., & Warren, J. P. (2019). Card-based design tools: a review and analysis of 155 card decks for designers and designing. *Design Studies*, 63, 125-154. doi:10.1016/j.destud.2019.04.002

Self, J. A. (2014). Mind the Gap: Perceptions of Design Awards from the Wild. *International Journal of Design, 8*(3), 123-138. Retrieved from <Go to ISI>://WOS:000348573800009

Serrat, O. (2017). The SCAMPER technique. In *Knowledge Solutions* (pp. 311-314): Springer.

Yilmaz, S., Daly, S. R., Seifert, C. M., & Gonzalez, R. (2015). How do designers generate new ideas? Design heuristics across two disciplines. *Design Science, 1*, e4. doi:10.1017/dsj.2015.4

Yilmaz, S., Daly, S. R., Seifert, C. M., & Gonzalez, R. (2016). Evidence-based design heuristics for idea generation. *Design Studies, 46*, 95-124. doi:10.1016/j.destud.2016.05.001

Yilmaz, S., Seifert, C., Daly, S. R., & Gonzalez, R. (2016). Design Heuristics in Innovative Products. *Journal of Mechanical Design, 138*(7). doi:10.1115/1.4032219

Yilmaz, S., & Seifert, C. M. (2011). Creativity through design heuristics: A case study of expert product design. *Design Studies, 32*(4), 384-415. doi:https://doi.org/10.1016/j.destud.2011.01.003

Yilmaz, S., Seifert, C. M., & Gonzalez, R. (2010). Cognitive heuristics in design: Instructional strategies to increase creativity in idea generation. *Ai Edam-Artificial Intelligence for Engineering Design Analysis and Manufacturing, 24*(3), 335-355. doi:10.1017/S0890060410000235

About the Authors:

Xiaoneng Jin A PhD Candidate at Tongji University with visiting study experience at Loughborough University and University of Rome, conducting research on innovative methods for digital design. Prior to joining Tongji, he worked as a UX designer at Microsoft and NetEase Games, and obtained master's degree from Zhejiang University. He is a member of DRS, CHI and IDSA.

Hua Dong Professor in Design at the School of Design and Creative Arts, Loughborough University. Hua has taught industrial design at Brunel University London and Tongji University. She is Fellow of Design Research Society and her research expertise is inclusive design. Hua co-leads the 'Responsible Design Research Group' at Loughborough University.

Mark Evans An award winning industrial designer and educator, as leader of the Design Practice Research Group Mark has received research council, professional society, corporate and government funding to generated over 150 publications and impact through a diverse range of outputs that include website, app, video, product, exhibition and cards.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Leveraging Empathic Strategies: Prototyping for Commercial Space Vehicle Design

Justin LUND[a]*, Jason O'Neill GERMANY[a]*

[a] University of Washington, United States of America
*Corresponding author e-mail: lundjt@uw.edu
doi: https://doi.org/10.21606/drs.2020.203

Abstract: When designers are tasked with the role of future forecaster, they engage in speculative acts that can be aided through prototyping. These tangible analogues act as a platform for building ideas as well as empathy in an effort to approximate the future activities and experiences of end users. The emergence of space tourism as a viable industry in the near future, will require designers to develop prototyping strategies that emulate these future experiences. To that end this paper reports on the development of a modular prototyping system for the design of space vehicle interiors. As a means of evaluating the effectiveness of this experimental prototyping platform it was deployed in a student class studio setting where designers utilized these elements throughout a team project. The results from this experiment indicate that a modular structure has several advantages across multiple phases of the design process that can translate to future space vehicle design.

Keywords: prototyping; empathy; speculative design; space travel

1. Introduction

1.1 Rise of Commercial Space Travel

The rise in interest and new business development surrounding commercial space travel presents a new area that designers will need to increasingly address. Historically space travel was a significant technical endeavour and still is but the potential for tourism flights introduces an increased focus on the user-centered approaches of vehicle design (Tovey, 2012). Early missions into space were large government funded initiatives that supported the efforts of a select few individuals to go into space and report back about their discoveries. Recently, there has been a surge in interest in the private space sector producing such visible players as Virgin Galactic, SpaceX, and Blue Origin (Prosser, 2018). Boeing and Space Adventures have planned to offer a commercial passenger options to the ISS aboard the new CST-100 Starliner capsule (Experiences: Space Station, 2018). These shifts mark the rise of commercial space efforts (Hammond, 1999) and space tourism where humans will be able to stay in space hotels, travel to the moon, and beyond. This also represents a shift towards an area of tourism that has no historic examples to draw from and subjects tourists to environments and experiences that no designer has ever had, nor has the ability to directly reflect upon. The highly technical, scientific, or military nature of past space missions had quite different interior spaces than the new wave of space tourist will expect. Astronauts were trained to deal with more harsh living conditions and experiences than an average tourist will withstand or tolerate. As Mary Roach said in Packing for Mars, "To the rocket scientist, [humans] are a problem. [They] are the most irritating piece of machinery he or she will ever have to deal with." (Roach, 2010). Much like the vehicle design of military equipment and naval architecture, the human is often considered after all other constraints have been met. Ultimately, the facilities for the actual crew are developed to meet the bare minimum of accepted codes and complete the mission. Space missions are no exception. With the added constraint of incredible fuel costs, reducing payload is always a top concern. That being said, tourism operating under these conditions will introduce a need to address comfort as will the overall emotional experience of the trip. Tourists will experience a combination of extreme circumstances such as microgravity and confinement with unfamiliar people while disconnected from the earth. Space travel has been shown to consistently produce many undesirable cognitive and physiological effects (Williams 2002). For, example, even five days in microgravity can lead to a loss of muscle mass (Tischler, et al. 1985). This design endeavour represents challenges as well as opportunities as these experiences are future ones that are tough to replicate on Earth and have limited means for developing a direct or empathetic understanding of.

1.2 Space Travel as Future Scenario

Designers have long embraced uncertainty as a profession. Increasingly, these problems may not be address through new and novel material objects but may result in a myriad of possible designed services, systems or social solutions. These wicked problems (Rittel, 1973) are compounded by planning for current problems as well as future ones. Historically, designers have leveraged lessons from other precedents when developing new concepts but in some cases, these precedents and past best practices are not enough to inform future designs. Iterative approaches to problem solving and a desire to develop these alternatives into a final concept are the underlying structure of the design process. Based on that, designers are increasingly taking on the role of future forecaster. The future of space travel continues to evolve from the visions of the mid-20th century and once again, designers will need to develop concepts that address these futures. Balancing between elements of Design Fiction (Sterling, 2005), and Speculative Design (Dunne A. a., 2013), this activity requires designers to develop scenarios and prototypes that will facilitate concept exploration as a means of making the intangible more accessible. To aid in this process, prototyping strategies need to allow for a range of possible iterations that accommodate potential use cases beyond the traditional government funded space mission.

1.3 Building Empathy through Prototyping

As researchers continue to explore frameworks for empathizing for future scenarios (Evans, 2015), prototyping remains a critical tool for designers. As many of the aspects of the problem space are not completely understood, 'experience prototyping' (Buchenau & Fulton Suri, 2000) has been a proven strategy to "understand, explore or communicate what it (product / interaction) might be like to engage with". By extension this strategy could be leveraged to support designers need to develop empathy around an experience like space travel as most if not all designers are void of directly experiencing this activity. A platform for engaging with the reality of space tourism is needed to facilitate the designer's reflective practice and promote knowing-in-action (Schön, 1983) through analogue experiences. This new prototyping approach not only needs to accommodate some forms of empathic research but needs to address some functional concerns that arise. Habitats being designed for space tourism require flexibility. This is dependent on different factors such as length of travel, tourist type, etc. Additionally, the platform needs to be scalable and modular. Designers will have to be able to easily grow or reduce the size of the platform as well as change its orientation to reflect how one might move between units in space. This will allow the mock-up to accommodate a variety of specific use cases. Additionally, this will allow experimentation by designers that may eventually drive engineering solutions. By allowing the designers to gain some measure of empathy for the experiences future tourists will have and by providing some realistic functional constraints and encouraging designers to prototype early and often within analogue environment, new and unique habitation deigns can arise.

1.4 Approaches to Vehicle Prototyping

Due to the fact that transportation design is such a broad field, this work is limiting its scope of comparison to transportation efforts that deal with similar problems of mobility, specifically the transportation of small groups, for short to medium length durations. The most direct space travel analogue would be the prototyping that NASA has used historically. Most strategic approaches to aerospace transportation design mock-ups can be divided into the same categories defined by the "Design Research Matrix". (Cohen, 2012). These are 1. Concept evaluation 2. Design research 3. Engineering integration 4. Operations simulation and development and 5. Crew Training. Additionally, transportation design often employs mock-ups of an even higher fidelity than those mentioned in the Design Research Matrix. These would fall within a sixth, higher-fidelity category of marketing mock-ups. For the purposes of the research outlined in this paper, most of the speculative prototyping activities centred on categories 1 and 2.

Within the category of 'concept evaluation', the process by which designers have traditionally approached prototyping was to use a full-scale drawing techniques by drawing with tradition media or to use pieces of tape to draw which is heavily relied upon in the auto industry (Starting Out: Car Design Glossary, 2008) (The Language of Tape: Ford Designers and Moders Use Tape to Communicate Throughout The Development Process, 2014) This full-scale drawing technique allowed the designers to work quickly and directly with the actual scale. Small scale sketch models (PEI, 2011) (Starting Out: Car Design Glossary, 2008) have also been utilized in transportation design to quickly validate concepts in 3D before moving to larger and/or full-scale models. Full-scale models are used for both surface validation and interior validation. In those cases, the full scale mock-ups and prototypes are often direct representations of a low or high fidelity but limited to a specific design concept. Whether it is clay modelling as an exterior form or structural modelling, many of these are standard methods don't address the need for a modular and flexible system that can be deployed in a range of configurations. This is particularly important when a designer is exploring a speculative concept such as space tourism and vehicle interior design. To that end, this research reports on a different strategy focused predominately on the interior space of the vehicle and the outer portion was represented for context only. The interior of the new Scaled Section Platform was intended to facilitate low to medium fidelity prototyping with an emphasis placed on iterating concepts, testing human factors, and integrating findings into new prototypes over attempting to achieve a high fidelity look and feel.

2. Prototyping Approach: Scaled Section Platform (S.S.P.)

2.1 Prototyping Strategy

In an effort to address several of the challenges around the future of space vehicle design, this research project developed a prototyping platform aimed at flexibility of use as its primary goal. The prototyping platform needed to allow for a wide variety of designed outcomes, while on providing some constraints to help focus design work in such a speculative area. The largest constraint was the inner diameter representing the inner sidewall, an outer diameter representing the outer structure of the space vehicle, a space reservation for functional systems, and some representative structural elements to introduce the real-world challenge of navigating systems and structure. (see figure 1) Similar to real-world design within large vehicles, these systems and structural "stay out zones" could be compromised if a design solution should require it but would necessitate discussions about how this would be accomplished. Some examples that could be foreseen to arise might be portholes/windows, domes, new doorways, access hatches, or the attachment points of proposed design concepts. To develop the dimensional constraints around this prototype structure, a series of workshop exercises were conducted with the industry sponsor utilizing 1 to 1 taped out floors spaces and a group of seven individuals. These individuals examined common positioning of potential dining, sleeping and group egress between spaces and other individuals. Based on that exercise and combined with secondary research on other transportation spaces such as train sleeper cars and aviation vehicles this information was combined to generate a minimal inner diameter of 2.3m and the outside diameter was the result of structural requirements in addition to studio ceiling height limitations which resulted in an outside diameter of 2.5m. The length of the individual sections was directly impacted by the standard construction material used (plywood) resulting in lengths of 2.43m.

As a result of these constraints, the prototype platform is not a direct reflection of any specific space vehicle but instead a speculative platform developed so design teams could explore early concepts and scenarios. This platform was intended to facilitate open-ended speculative outcomes rather than to produce design solutions for known current scientific missions as a result idealized interior arrangements and specific requirements for necessary equipment were not given. The main objective was to understand how microgravity and being confined in a small space with other people might affect individuals and ultimately their design.

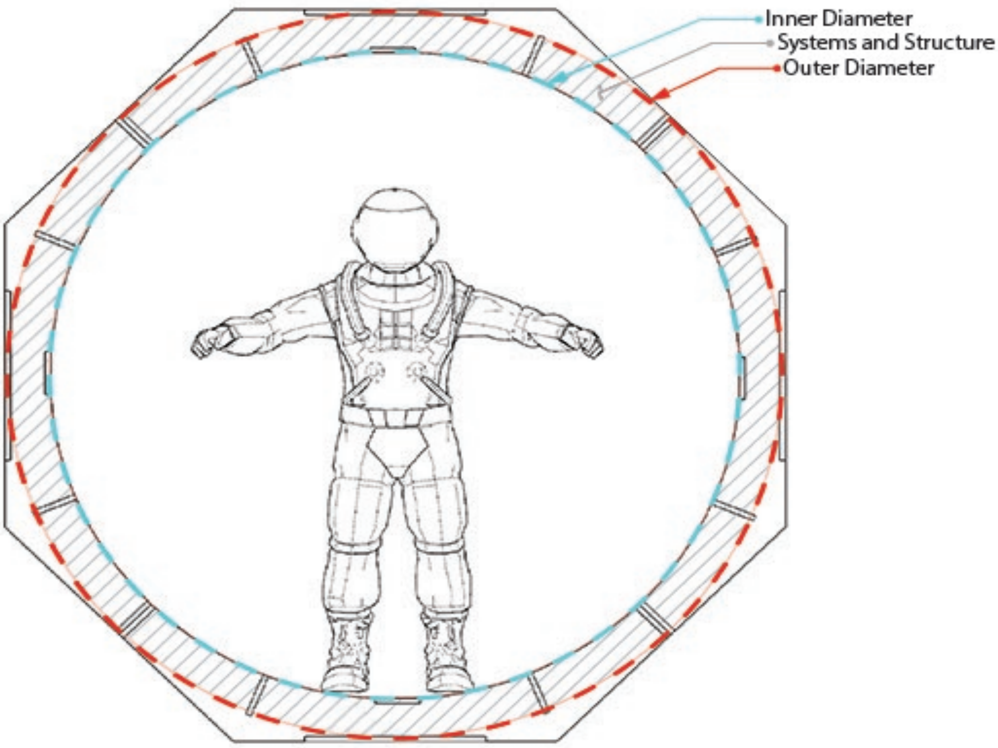


Figure 1 Mock-up cross-section constraints

While a set of functional constraints were introduced, the ultimate configuration and scale was not set. Given that this space vehicle would be operating in a low gravity atmosphere, the orientation, based on our earth directions, as discussed in section 4.2 below, might very well end up as some unknown combination. Designers might decide that modular units could attach end-to-end, at right angles to each other, or some other configuration entirely. In order to facilitate this modular adaptability, and to accommodate the fact that some designers might not be experienced with the fabrication and installation of such a structure, some design considerations were given to the mock-up. Thought was given to hardware, modular adaptability, component complexity, component size, and accessibility.

Hardware was standardized and integrated to reduce complexity. All hardware was utilized the same size bolts for the main structure and the nut portion of the bolted construction was integrated into the structure. This greatly reduced part count and improve the ease of disassembly and reassembly. This also allowed for one size of wrench or socket.

The entire Scaled Section Platform (S.S.P.) could be seen as one main mock-up that was created out of two modules. These modules were in turn comprised of eight components. Each module was designed to be easily separated, rotated, and reattached. The placement of hardware attachment points on the structure was mirrored so that these points would align in any position. This feature was also implemented on the four individual components that make up the modules as well. In this way, even if all eight components were separated, they could be recombined in any order to avoid confusion and add to the ease of adaptability. The individual components were all identical which further reduced complexity and they were designed to be a size that could be easily lifted, manipulated, an attached to the mock-up.

The mock-up was designed to be free standing and structurally sound enough to support the weight of designers walking throughout its interior or, if necessary, support the weight of designers applying forces to the sidewalls, or suspended from the top portion of the mock-up. An outer support lattice (See Figure 2 quadrant D) was designed to facilitate climbing on the outside of the structure should installation of prototypes require it. This lattice was divided into removeable sections should access be necessary (figure 3).

By reducing the number of parts, complexity of components, and creating components in manageable sizes, there were also benefits to project cost and installation. Addressing the part complexity meant that only 1/8th of the parts needed to be programmed by CNC machinists. These initial programmed parts could be copied and re-run, greatly reducing billed hours. Standardized parts allowed for a price break for ordering a larger quantity of one type of hardware rather than small batches of many types. The size of the components allowed for ease of transportation in a small truck, easy movement by two people, fitting within the confines of a standard freight elevator, and could be easily handled by designers. The individual components would be pre-assembled before being delivered to a studio location and were ready to be configured as needed.

2.2 Configurations

Some intended configurations (see figure 2) were A. One full-length, full cross-section longitudinal orientation intended to represent the entire constraints of the habitat module, B. One set of a half-length, full cross-section longitudinal orientation and one half-length, full cross-section vertical orientation, C. Multiple half-height sections and/or, D. Multiple quarter sections. These mock-up design features were all intended to allow a variety of possible experimentation by designers.

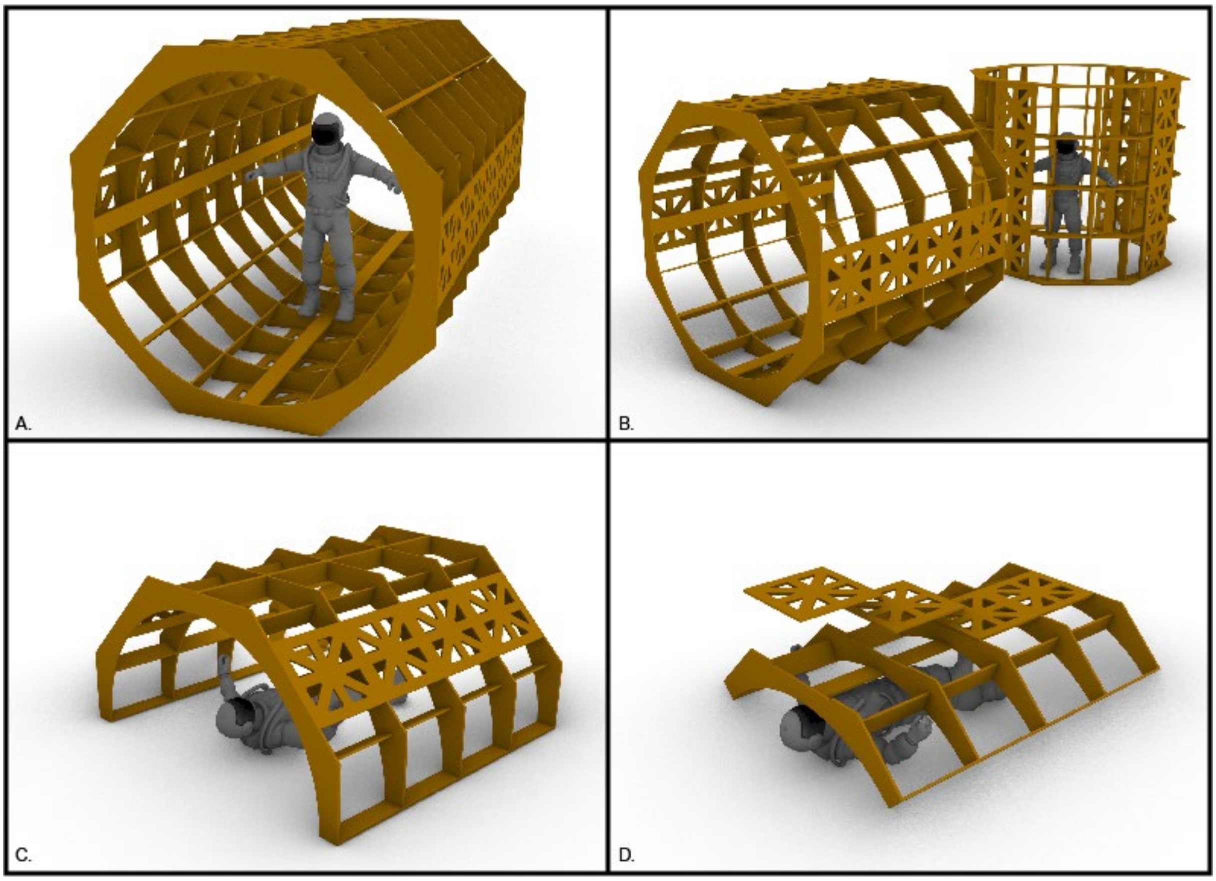


Figure 2 A range of mock-up configurations (CAD model).

Figure 3 SSP individual sections (built platform)

2.3 Empathic Research Platform

Normally, a similar vehicle design project might first progress through several stages before a mock-up is developed. However, being that this project dealt with such an unknown area of transportation design, it was hypothesized that having a realistic representation of the space from the very beginning would provide some context. As well as becoming a platform for prototyping, it was intended to become a platform for research and gaining empathy.

Working within the mock-up would begin to give designers a sense of the confinement and isolation experienced by astronauts (Stuster, 2010) and by using some of the configurations shown in figure 2. Designers could begin to understand some of the human factor challenges imposed by low gravity environments.

3. Scaled Section Platform (S.S.P.) – Course Experiment

3.1 Basic Application

In an effort to explore the implications of a sectioned approach to prototyping, these prototype elements were utilized in a University of Washington Industrial Design studio class setting that was designing for the topic of commercial space travel. Students were asked to utilize these Scaled Section Platform (S.S.P.) prototypes in both the initial research portion of their team projects as well as later in the actual ideation and design refinement phases. The aims of this experiment was to observe and evaluate how students leveraged these platforms throughout the class. A total of eight modular units were deployed in the studio space where four were preassembled and the remaining four were left as independent units. Particular focus was on the use of these prototyping structures as a flexible system of components that might promote a range of applications throughout the entire design process instead of just supporting one portion of the design visualization.

3.2 Course Structure and Implementation

This studio course was unique in that it explored the future of commercial space travel in the year 2030 but was also an industry collaboration between the University of Washington Industrial Design program and aviation industry sponsor, TEAGUE. This collaboration was instrumental in establishing a strong grounding and professional context for designing for transportation needs. With decades of experience in this field, the TEAGUE's contribution helped to guide several of the parameters of the course as well as some of the prototyping platforms that were utilized in this studio class. As a leader in aviation design field, TEAGUE was interested in exploring possibilities in this emergent form of travel. For over 70 years TEAGUE has worked with Boeing to envision the future of flight [9].

The actual class structure was based on a single project and team work spread across the quarter with individual deliverables contributing to the overall performance of the group's work. To best support the various research and design activities over this 11 week term, the 20 industrial design 4th year students in the class were broken into teams of four. The class met in a studio style format twice a week for three hours each meeting. These two meetings were initially split each week between a range of activities including studio tours, lectures, and workshops as a means of accelerating students into the research collection phase. The overall design project was initialized with a secondary data research portion coupled with primary research. This then advanced into a range of generative design activities exploiting various sketching and prototyping methods with the ultimate aim of designing a unique vehicle interior and focused touchpoint (bed, lavatory, galley, etc.). Teams were asked to conceive a seven day space journey within the cislunar area that started from Earth orbit, travelled out and past the Moon and returned to Earth orbit for the year 2030. This journey would be supported by three crew members and four passengers (tourists). Additionally, the envelope of the vehicle interior was defined for teams and the key connection point to the Scaled Section Platform (S.S.P.) prototype elements.

3.3 Prototype Usage in Studio Course

Immersive and Empathic Research

The student teams did not have direct contact with anyone that had spent time in space, which required them to explore other research methods outside of traditional user-centered observations and interviews. A portion of this was supplemented by secondary data but the other main component was a series of student designed immersive and empathic research experiments (Germany and Lund 2019). As many researchers have reported on the importance of introducing empathic methods into design curriculum (Malins & McDonagh, 2008) (Feng, 2017), the goal of these initial experiments was to speculate and ultimately emulate some of the experiences that future space travellers might experience. To that end, students were tasked with examining the effects of isolation and physical constraints on social and emotional wellbeing. To explore these elements, student teams utilized portions of the S.S.P. prototype structures. They positioned these structures in full and partial configurations in that allowed for a set of experiments. Team constrained tasks ranged for group exercises like the ‘human puzzle’ or other games where individuals had to coordinate their efforts to a single goal inside the closed space provided by the S.S.P. structures (figure 4).

Figure 4 Student immersive studies in S.S.P. structures

Ideation and Concept Exploration

After collecting research and synthesizing their findings, teams then moved on to exploring a range of interior design concepts. Initial methods of exploration were done in sketch form but these ideas were then advanced to 1/10th scale section mock-ups (figure 5). These scale mock-ups were constructed from tubular forms and cardboard elements to represent an abstract interior concept. These section pieces of tubular cardboard worked in a conceptual parallel as being analogous to the ½ section pieces (2 unit) of the full scale S.S.P. prototype structures. In starting with this small platform, students could quickly explore and reconfigure their mock-up concepts and couple those design concepts with their direct experience in the full scale S.S.P. structures.

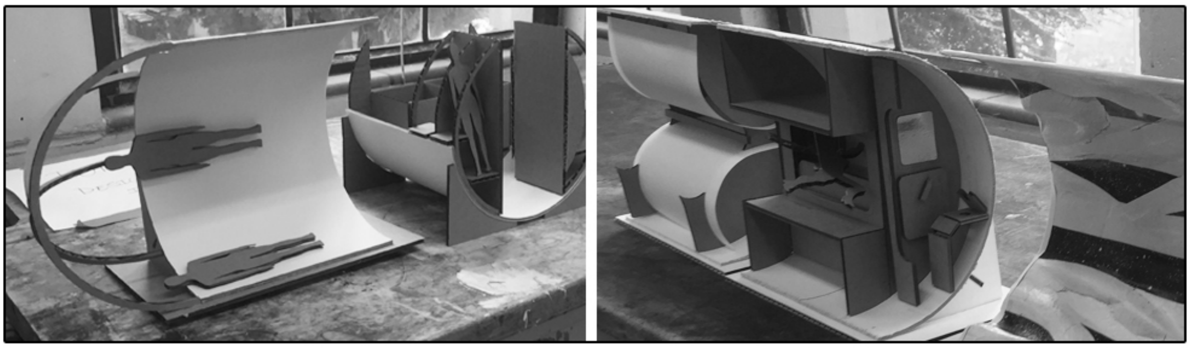


Figure 5 1/10th scale team mock-ups

The 1/10th scale mock-ups were evaluated and a down selection was made. The advancing designs were then enhanced through additional rounds of sketching. The next aim was to begin working at full scale as quickly as possible to explore specific components of their interior designs. To make this transition from reduced scale (1/10th) to sketch to full scale mock-up, teams utilized 2D full scale wall drawings (figure 6) to generate starting templates for their larger mock-ups. Beyond the direct template aspects of this wall drawing approach, these were used to ideate around cross-sectional volume and to build an understanding of the relationships between individual design components within the interior concept.

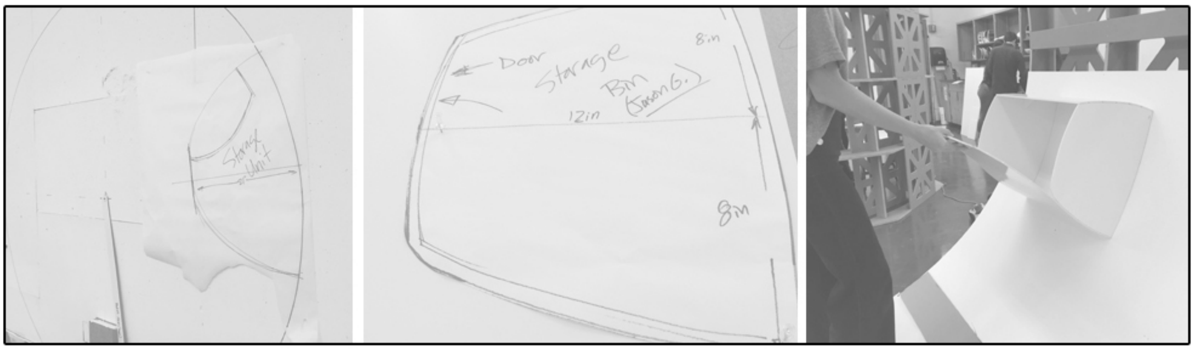


Figure 6 Wall drawings to templates to component mock-ups

From wall drawing to paper template teams then utilized foam core and card board to generate volumetric elements that were positioned within the Scaled Section Platform structures (figure 7). The interior of the S.S.P. was most commonly skinned with a single layer of foam core to act as a smooth wall and doubled as a pinnable surface for quickly moving mock-up pieces in and out.

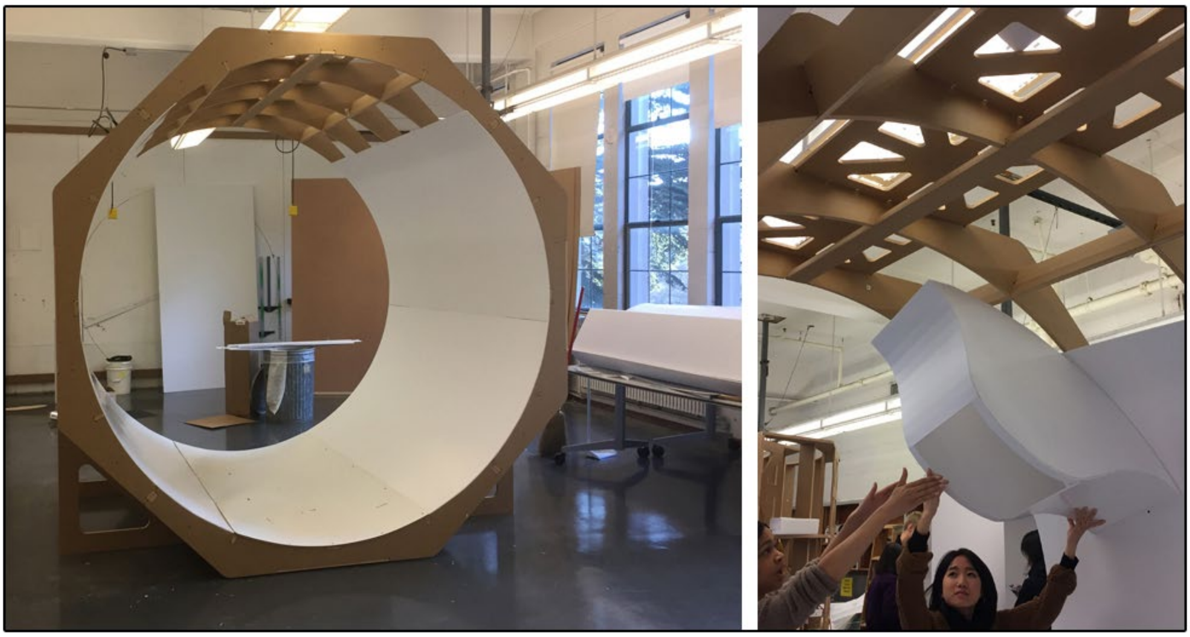


Figure 7 SSP structure and volume mock-ups

Students repositioned these structures as 1/4, 1/2, and full sections in both horizontal and vertical configurations depending on the mock-up elements they were exploring. One team exploring the sleeping units utilized a horizontal configuration where another team that was designing an observation bay positioned the S.S.P. After several rounds of prototyping, each team narrowed down the final elements of their overall concept. Again, teams returned to utilize the S.S.P. structure elements as their platform to display the final interior concept. Using a mixture of foam core, paper, and fabrics, teams assembled their primary interior touchpoints as a final presentation and exhibit (figure 8).

Figure 8   Final interior mock-ups (sleeping pods concept)

Final Concepts Visualizations

The S.S.P. proved to be an affective platform for all phases of the design process and greatly aided the visualization for the final outcomes of this experiment. Each of the student teams advanced the physical prototyping on the S.S.P. by developing a series of renderings and visualizations that combined their speculative scenario with the primary touch point that they focused on. Some teams identified flexibility in sleeping spaces as critical in their design (figure 9) as other teams found that the shared open spaces in the vehicle were the key driver in their concept (figure 10).

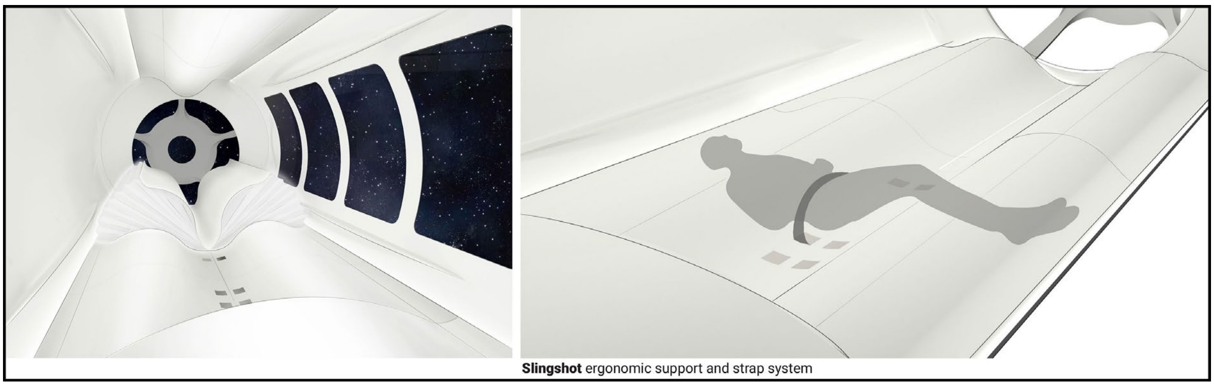


Figure 9   Final concept example 1

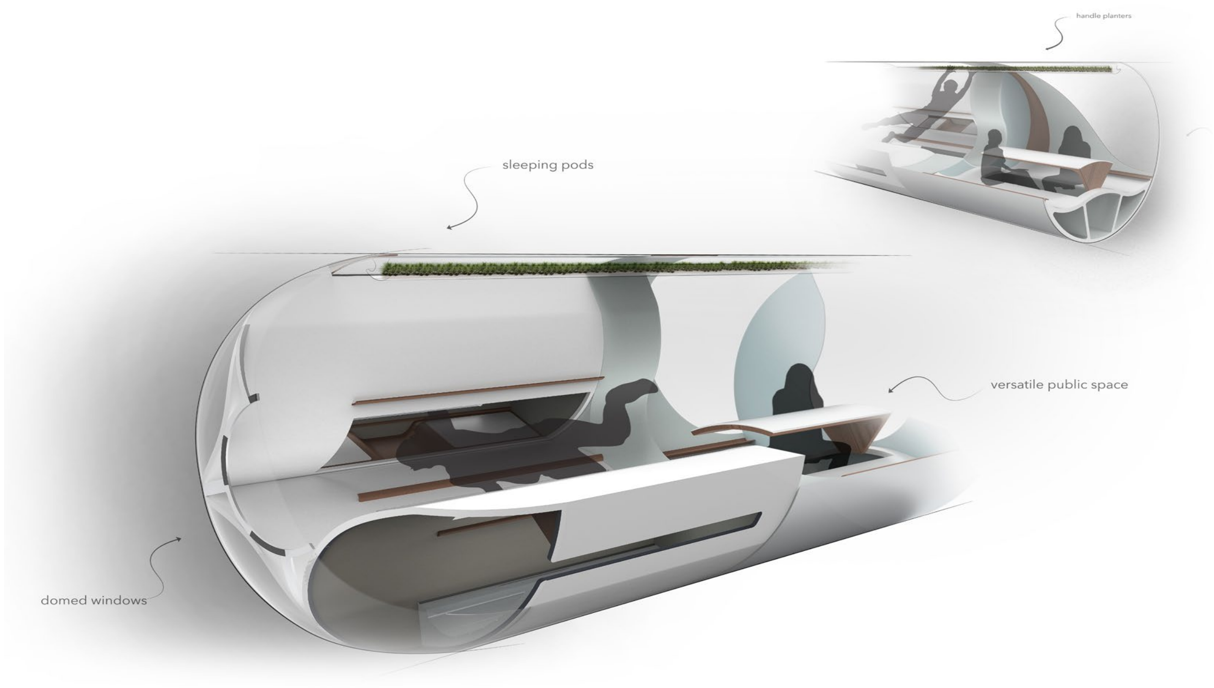


Figure 10 Final concept example 2

4. Discussion

The results of the studio activities were primarily collected by faculty observations as well as input from liaison designers from the industry sponsor, TEAGUE. Observations and interactions occurred during regular class meetings throughout the quarter; specifically, twice a week for three hours each meeting. The primary objectives were to observe how student design teams utilized the Scaled Section Platforms (S.S.P.) from initial research activities through iterative concept development all the way to final visualizations. The main points based on these observations are highlighted in the following section.

4.1 S.S.P. and Research Activities

As previously outline, the premise of the studio was focused on commercial space travel in the year 2030 and the speculative topic presented underlying challenges. One of those challenges was devising a strategy for collecting insights about an activity (space travel) that students could not directly experience and where there were no end users (astronauts) that could be interviewed or observed within the scope of the class time. To that end, teams leveraged the Scaled Section Platforms for several of their initial immersive research studies. In providing an enclosed volume that was a full scale representation of the vehicle, the students began to develop an understanding of some spatial orientation issues, limits on personal space, as well as coordinating team movements inside a confined environment.

4.2 S.S.P. and Design Activities

The rough full scale explorations using the S.S.P. structures provided a direct understanding of the constraints exhibited inside the confined vehicle and allowed teams to empathize with the future space travellers they were designing for. Accelerating their understanding of the challenges and providing a feedback loop to the next round of prototyping. This appeared to be particularly important when they were trying to achieve three main activities in the design process. The first was translating sketch based concepts to full scale volume mock-ups, the second was addressing the 3 axis layout of their design components where there was no defined ceiling and floor and the last activity was the coordination of human movements through the design interior. The last two were of particular importance in the feedback and refinement of the team designs.

Beyond the research and design related activities, the overall performance of the S.S.P. units was accessed throughout the studio course. The key take-away from those observations was that the prototyping platform (S.S.P.) showed significant benefits in that it was a modular, flexible and easy to deploy and redeploy tool that could be utilized not just at the terminal portion of the design project but throughout the class. The modular aspects allowed for design teams to explore interior design sections ranging from 1/4, 1/2 and full tube configurations as well as stacking these full tubes in horizontal modules. This point leads to its flexibility as students utilized the S.S.P. structures in both vertical and horizontal orientations depending on their need. Lastly, because of the ribbed construction, units were light enough that 2-3 students could move them around quickly. The remaining benefits observed in this studio experiment were that the S.S.P. proved to be far more durable than previously thought leading to their reuse over and over throughout the project.

4.3 Limitations

Although Scaled Section Platform prototyping structures appeared to support a range of design activities in addition to their utility applications, there were several areas where improvements could be made to future iterations. The first pain point was related to 1/4 and 1/2 section supports. When deployed in these configurations, the structures had stability issues depending on the volumetric foam core models that were hung on them in the vertical orientation. The work around to this issue proved to be the addition of secondary plywood ground stabilizers or to anchor the section to a wall. The second issue exhibited during the studio was related to the application of skinning materials to the inner ribbed surfaces. The primary skinning material was white 1/4in foam core that required perforation cuts on the back to accommodate the curved interior and mounted with wood screws. This was the least resilient portion of the whole platform and required continued maintenance or replacement as mock-ups were added and removed from the interior space or where foot traffic impacted the surface. Future applications of the S.S.P. would require a more durable surfacing sheet material like styrene or masonite. The last issue to this prototyping platform was that it was modular and scalable but limited to a fixed diameter. For the studio class experiment this was a problem but if applied to a wider range of vehicle applications, this could be a defining constraint.

5. Conclusion

When designers are tasked with the role of future forecaster, they engage in speculative act that is aided by tangible analogues. These analogues can act as a platform for building ideas as well as empathy in an effort to approximate the activities and experiences of end users. The emergence of space tourism as a viable industry in the near future, will require designers to develop concepts for experiences that are not readily replicated. The challenge in developing a prototyping strategy for these experiences is to allow for enough flexibly and adaption to facilitate a range of concept explorations. The Scaled Section Platform (S.S.P.) prototyping structured outlined in this paper aimed to support this range of explorations from initial immersive research to concept iteration to final visualization. This effort is in alignment with other 'experience prototyping' strategies (Buchenau & Fulton Suri, 2000) which focus on user understanding, exploring and communicating as the primary activities. In the context of aerospace design, the S.S.P. prototype structures targeted the first and second columns of Cohen's (Cohen, 2012) "Design Research Matrix", namely concept development and design development but also allowed for primary immersive research which precedes the concept development phase. The primary benefits of the S.S.P. system is that it allows for a modular, flexible and easy to deploy and redeploy set of structures that can accommodate much of the front end prototyping needs of vehicle interior design. Additionally, these structures are reusable thus reducing time and money needed to move to full scale mock-ups. The constraints to this strategy are limited to its fixed diameter and challenges associated with developing a durable and reusable skinning surface. That being said, the underlying strategy of the Scaled Section Platform is one that could prove to be a promising solution to future spatial and space vehicle oriented design efforts. This is particularly true for design teams that are still at the front end exploration phase of a project as this acts as a relatively standardized platform much like a pencil and paper are for other design activities.

Acknowledgements: The prototype platform and studio project highlighted in this paper was made possible with the generous donation of time and expertise from TEAGUE Aviation Studio. The success of this experiment and exploration would not have been possible without their contribution. Additionally acknowledgement goes to the student work examples highlighted in this paper and contributed by Nate Chang, Carly Cheng, Casey Gustafson, Max Werner, Izabella Dadula, Ryan Gilmore, Jazmine Hoyle, Wei Li, Emma Boyle, Jade Granger, Spencer Weglin, and Troy Zhang.

6. References

Buchenau, M., & Fulton Suri, J. (2000). Experience Prototyping. *Designing Interactive Systems Dis'00* (pp. 424-433). Brooklyn: ACM.

Cohen, M. M. (2012). Mockups 101: Code and Standard Research for Space Habitat Analogues.

AIAA SPACE 2012 Conference & Exposition. Pasadena, California: https://doi.org/10.2514/6.2012-5153 .

Dunne, A. a. (2013). *Speculative Everything : Design, Fiction, and Social Dreaming.* Cambridge: MIT Press.

Evans, M. (2015). Empathizing with the Future: Creating Next-Next Generation Products and Services. *The Design Journal*, 231-251.

Experiences: Space Station. (2018). Retrieved from Space Adventures: http://www.spaceadventures.com/experiences/space-station/

Feng, J. (2017). Cultivating Creativity through Empathizing: An Empathy Focused Framework in Design Studio Teaching. IDSA.

Germany, J, and J Lund. 2019. "Form Follows Story: An Approach to Designing for Commercial Space Travel." *International Conference on Engineering and Product Design Education.* Glasgow: Design Society.

Hammond, W. (1999). *Space Transportation: A Systems Approach to Analysis and Design.* Reston: AIAA Education Series.

Malins, J., & McDonagh, D. (2008). A Grand Day Out: Empathic Approaches to Design. *Intl. Conference on Engineering and Product Design Education.* Barcelona: Design Society.

PEI, E. C. (2011). A Taxonomic Classification of Visual Design Representations Used by Industrial Designers and Engineering Designers. *The Design Journal, 14 (1)*, 64-91.

Prosser, M. (2018, May 10). *5 Space Companies Zeroing in on First Launch of Tourists Into Orbit and Beyond*. Retrieved from SigularityHub: https://singularityhub.com/2018/05/10/5-space-companies-zeroing-in-on-first-launch-of-tourists-into-orbit-and-beyond/#sm.0000uh284k666d0ftzl2kncv81879

Rittel, H. W. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences*, 155–69.

Roach, M. (2010). *Packing for Mars: The Curious Science of life in the Void.* New York: W.W. Norton.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action.*

Starting Out: Car Design Glossary. (2008, September 01). Retrieved from Car Design News: https://cardesignnews.com/articles/resources/2008/09/starting-out-car-design-glossary-part-2

Sterling, B. (2005). *Shaping things.* Cambridge, Mass.:: MIT Press.

Stuster, J. (2010). *Behavioral Issues Associated with Long-Duration Space Expeditions: Review and Analysis of Astronaut Journals Experiment 01-E104 (Journals): Final Report.* Houston: NASA.

The Language of Tape: Ford Designers and Moders Use Tape to Communicate Throughout The Development Process. (2014, Feburary 5). Retrieved from Ford Media Center: https://media.ford.com/content/fordmedia/fna/us/en/news/2014/02/05/the-language-of-tape--ford-designers-and-modelers-use-tape-to-co.html

Tischler, M.E., E.J. Henriksen, C.S. Stump, C.R. Woodman, and C.R. Kirby. 1985. "Spaceflight on STS-48 and Earth-Based Unweighting Produce Similar Effects on Skeletal Muscle of Young Rats." *Journal of Applied Physiology.*

Tovey, M. (2012). *Design for Transport: A User-Centred Approach to Vehicle Design and Travel.* London: Routledge.

Williams, D.R. 2002. "Dioastronautics: Optimizing Human Performance through Research and Medical Innovations." *Nutrition.*

About the Authors:

Justin Thoreau Lund is a Master of Design Candidate at the University of Washington, USA. Justin's research interests include; generative industrial design, systems approaches to complex problem spaces, and the intersection of improvisational thinking with the design process.

Jason O. Germany is an Assistant Professor of Industrial Design in the Division of Design at the University of Washington, USA. Professor Germany's particular research interests include; mobile computing, semantics, emergency services, and entrepreneurship.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Designing in virtual environments: The integration of virtual reality tools into industrial design research and education

Sarah ROBERTS[a], Rowan PAGE[a]*, Mark RICHARDSON[a]

[a] Monash University, Australia
*Corresponding author e-mail: rowan.page@monash.edu
doi: https://doi.org/10.21606/drs.2020.284

Abstract: Virtual reality (VR) has become an increasingly common tool in consumer and professional settings. While there are many documented applications of industrial designers using VR in large corporations, there is limited literature detailing applications in studio-based education. This paper shares learnings from three case-studies across undergraduate, postgraduate, and design research projects. These projects share some of the possibilities and limitations of VR tools for future industrial design practitioners. The application of these tools spans across the product development process, from virtual 3D sketching and CAD modelling, visualization, usability testing to co-design workshops with members of the public. VR has moved beyond just a tool for visualization and decision making, and can now play an active role in all stages of the design process. These projects detail the possibilities for VR in industrial design and illuminate some of the challenges in teaching these emerging technologies and tools to design students.

Keywords: virtual-reality; design education; emerging technology

1. Introduction

Virtual Reality (VR) is used to create immersive, three-dimensional (3D) virtual environments, through visual and audio simulations. While VR technology has existed for decades, it has only recently become a reliable, flexible, and affordable tool (Berg & Vance, 2017). With this increased accessibility, VR is moving from a niche design tool used by large industry players – in the well-financed product development contexts of automotive and aerospace – to an affordable design tool that will be integrated into many product design contexts (Berg & Vance, 2017).

These VR product development environments are increasingly desired due to their ability to be used as an immersive test-bed for prototypes of product designs and proposals (Grajewski et al., 2015), particularly in large scale projects. With VR, designers are less restricted to 2D concept visualizations as VR provides a means for designers to 'interact with synthetic object' within a 'rich immersive 3D experiences.' This immersion helps designers to be more creative through a more direct engagement with their designs (Jimeno-Morenilla et al., 2016, Abulrub et al., 2011). VR provides a relatively low-cost platform to quickly iterate, test and prototype concepts within a 1:1 scale 3D environment. With these immersive environments also providing additional communication tools to explain designs to clients and external stakeholders. As VR becomes more common within the industry, sharing concepts and experiences is becoming normalised, allowing for greater immersion and concept understanding to be achieved.

Computer-aided design, digital sketching, and rapid prototyping technologies all had a significant impact on the product development process. Like these technologies, VR offers the potential to not just enhance the quality of the outputs of the industrial design process (Lawson et al., 2016), but to have a significant impact on the design process itself. Industrial design education needs to respond to the challenges of preparing young-designers for the rapid changes that new technologies bring to the design process. Equipping students not just with the skills needed to use these technologies, but with an experimental mindset and openness to trying, learning, and incorporating new technologies in their design practice. VR is an emerging technology highly related to 3D form development and provides a timely and relevant experimental ground for furthering technological exploration with young designers.

This paper presents a series of three case studies that detail the application of VR tools in the industrial design programs at Monash University in Melbourne, Australia. These case studies are grounded within a review of published literature related to applications of VR in industrial product development. Each of these projects demonstrates the possibilities and limitations of virtual reality tools for future industrial design practitioners. The application of these VR tools spans across the product development process, from virtual three-dimensional sketching and CAD modelling to visualization, usability testing and co-design activities in VR. We observe that VR has moved beyond just a tool for visualization and decision making, and is now capable of playing an active role in all stages of the design process. These case-studies illuminate some of the breadths of possibilities in the application of VR tools for industrial design and highlight the challenges in teaching these essential new tools to design students. Figure 1 is an example of a design developed in VR.

Figure 1 *Gravity sketch (Gravity sketch 2019): drink bottle ideation*

2. VR in industrial design and new product development: a review of published literature.

There is limited literature describing the use of virtual reality tools in industrial design education. Yet, in industry and academic publications there is a growing discussion of the use of VR tools in new product development. Due to the previously high cost of VR devices and the computers necessary for high-quality immersive virtual environments, these tools are primarily discussed within high investment product development contexts such as in automotive vehicle design (Lawson et al., 2016). Yet, as these tools become more affordable and accessible they are trickling down to lower-investment product design contexts and educational environments.

In commercial product development, VR tools are documented not just for visualization but to also aid in the layout of manufacturing workflows, optimising assembly, and enhance worker's ergonomic comfort through simulating automotive assembly line production tasks (Caputo et al., 2017). These tools are also used to assist in the visualization of customization options, allowing complex products, with bespoke public transport fit-outs, to be easily customized and visualized in consultation with the client (Gorski et al., 2016). In many cases, these immersive visualizations can replace costly physical mockups and offer greater experiential detail than flat two-dimensional visualizations. These highly realistic immersive environments are allowing users to experience products earlier – and at more frequent stages – throughout the design process. Conducting user observations and interviews in virtual environments has been used to allow people with cognitive and other impairments to describe their knowledge and experiences and evaluate designs (Wallergard et al., 2008) in ways that allow for more controlled testing and evaluation environments than physical mockups. Additionally, this tool enables visualizations to occur in context, virtual environments that reflect where the final design will be used (Grajewski et al., 2015; Rentzos et al., 2014), allowing access to difficult contexts or currently non-existent environments (Wallergård et al., 2008). Within these environments, designs can also be animated and visualized in motion with added sound and other effects, adding realism that can be difficult to achieve with physical properties alone.

Not all design is even intended for the real (physical) world anymore. The prevalence of online, virtual communities, games and 'realities' is necessitating design methods that are oriented exclusively for the virtual (Kohler et al., 2011). VR's use in other aspects of product development, such as manufacturing and training, is championing its use across all aspects of new product development, including design. Utilizing these technologies increases the compatibility of the design processes with these other functions (Lawson et al., 2016) through common experiential access to CAD files. This allows for better collaboration and review, with files able to be easily sent across the world.

In an educational environment, the application of blended learning within design education (incorporating digital learning materials within traditional classes (Chen, Huang, & Chou 2017)) has grown in recent years. Such approaches are said to improve learning effectiveness, content accessibility, deliverability and flexibility, and costs (ibid) as they provide alternative tools to deliver information, through active learning platforms. When user-centred these tools have been identified with encouraging student curiosity and motivations helping to improve their ability to learn (ibid; Herloa 2015). VR offers blended learning opportunities, providing students with tools to learn and engage within realistic real-world simulations, as well as environments to develop and assess their designs within (Kirkley & Kirkley 2015). Digital designs allow files to easily be worked on at home by students on personal computers and then shared in class in virtual reality environments. VR supports a more natural and better intuitive understanding of scale and spatial relationships in an experiential and direct manner (Chang 2017) compared to the abstraction of evaluating CAD on a 2D screen. The directness of these interactions can reduce errors, by allowing real-time editing within a direct 3D experience (Jimeno-Morenilla et al 2016). Overcoming the errors caused by the abstraction of perspective and scale in 2D media (Dorta & Lalande 2014). Barriers to adopting VR as a blended learning tool are the users' ability to learn and engage with the new technologies (Kirkley & Kirkley 2015), as well as accessibility issues. However, if effectively taught, one of the primary drivers of VR prototyping is the reduced design development time and reduced costs when compared to physical prototyping (Caputu et al., 2017; Wallergård, et al., 2008), particularly during the early design stages (Rentzos et al., 2014) when multiple options may need to be explored, drastic changes happen often, and detail may not be sufficient to create physical properties.

These environments allow for greater immersion and real-time interaction with the type of early product design work that is often conducted in sketches and CAD systems. While 3D CAD systems allow us to experience a design's shape, materials, movements etc. they do not allow for real-time interaction and immersion at scale in the way that VR environments do (Rentzos et al., 2014). This allows for more than just visualization but extends to allowing formative testing, experimentation, simulation and evaluation within the early stages of design. Conducting usability testing in VR allows data about users (such as reaction times, or eye-tracking) to be comprehensively captured and analyzed, such as through motion capture (Caputu et al., 2017) enhancing the role of virtual prototypes in design validation. Data can also be captured through video and other data points such as reaction times can easily be quantified in software. This data can also be used to demonstrate compliance with ergonomic and other standards (Caputu et al., 2017).

Beyond the challenges and learning that is always present with new technologies, VR fits easily within product development as it is able to leverage these existing CAD development processes. In this way, VR evaluation can be seen as an extension of conventional CAD tools (Rentzos et al., 2014), with designers able to seamlessly move between these tools while using a common file language. This workflow offers a more direct experience of the object being designed and evaluated than forms of more abstract representation such as engineering drawings, sketches, or 3D models viewed on 2D displays. Allowing designers to have direct experiences with form manipulation analogous to working with a material such as clay, but with the benefits of digital technologies (such as undo, infinite materials, changing scales etc.) (Dorta & Lalande, 1998). This can be compared with analogous trends in digital 2D sketching, which is now a firmly established part of a modern industrial design process and offers similar advantages of the direct experience of sketching, paired with the advantages of infinite brushes, undos, colours and a direct integration between other image editing and image generating software (such as sketching directly over a CAD underlay).

This provides an additional means of exploring, testing, validating, and visualizing designs early in the design process increases the quality of the final design output (Lawson et al., 2016) through increasing opportunities for design validation. At the same time, the integration of these tools with the CAD workflow can speed up the design process and reduce time to market (Lawson et al., 2015). This allows designers to make better product design decisions through overcoming the limits of 2D visualization methods (Jimeno-Morenilla et al., 2016). This is similar to the way 3D printing and digital fabrication allows a more direct connection between design and prototyping. The following diagram (Figure 2) is a representation of how VR tools can be placed to help connect design methods and advance the design process. CAD is the centre of the diagram, with its development being a central anchor for multiple different virtual and physical fabrication techniques.

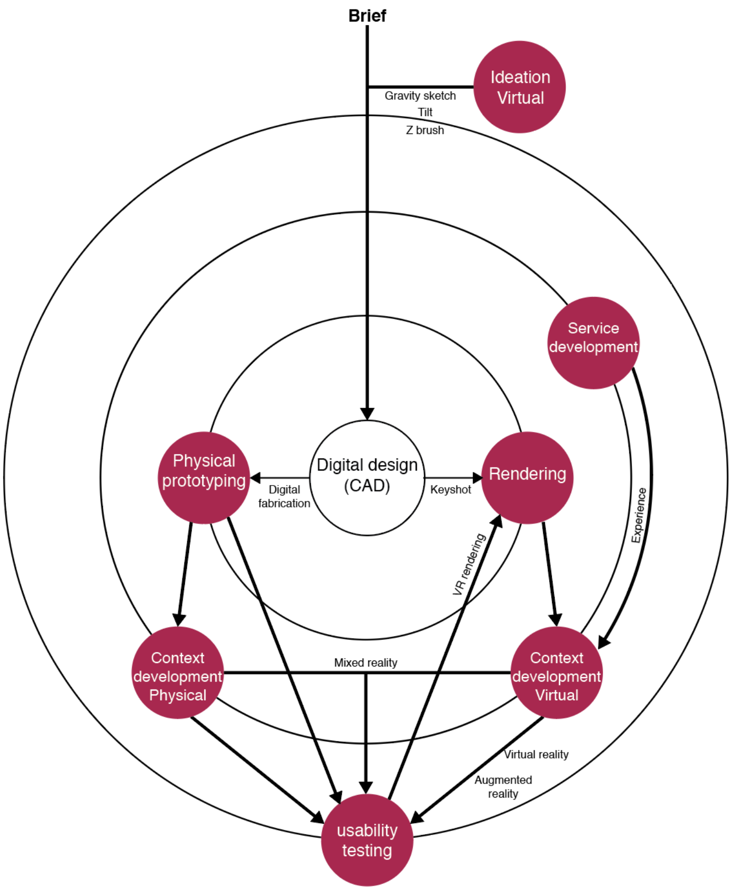


Figure 2 VR design process diagram

The development and application of new technologies is a key factor for success in an increasingly competitive market that requires faster time-to-market and ever-higher quality of products (Choi and Cheung, 2008; Lawson et al., 2016). Design is an iterative process whereby alternatives are constantly created and evaluated against other options/ concepts. This iteration is one of the most expensive and time-consuming aspects of design development with up to 70% of the total cost of a product can occur in this design phase (Lawson et al., 2016). Virtual mockups can replace physical ones, saving time and money (Shao et al., 2012). Additionally, they simplify the review process as virtual models don't need to be modified and rebuilt (Kim et al., 2011 via Lawson et al., 2015) to match changes in digital CAD files, but can be reviewed in VR directly within the CAD environment. Using VR rather than building physical prototypes also allows for quicker iterations between design changes and showing the design to the client – or other stakeholders – between design changes as workflows can go directly from CAD to VR without the complexity and cost of building or editing physical mockups (Gorski et al., 2016). Multiple concepts, changes and modifications can be toggled on and off and reviewed side by side, by both designers and clients. Training can also be enhanced through immersive environments that allow for direct interaction with a product before it is constructed (Grajewski et al., 2015). This allows for better communication with clients ahead of design signoff as they have a better experience of the design, and an increased cooperative understanding (Gorski et al., 2016).

2.1 Current software and hardware technologies for VR in industrial design

Virtual reality technology consists of a spectrum of different configurations and setups, each providing various levels of engagement, cost and ease of use. For simplicity, virtual environments can be divided into two main categories to indicate the level of immersion the technology provides the user. Firstly, full immersion refers to users being fully surrounded by the virtual environment, helping to provide full audio and 1:1 scale visual experiences (Wallergård et al., 2008). Full immersion hardware configurations include Computer Automatic Virtual Environments (CAVE) and virtual reality headset systems. Secondly, semi and non-immersion consist of virtual environments such as desktop computer games or vehicle simulator rigs that allow people to experience the virtual environment whilst still being fully aware of the real world (Wallergård et al., 2008). Other virtual visualisation tools that can be considered within design education include augmented reality and mixed reality configurations, however, they are considered out of scope for this paper.

The virtual reality communication tools used within the following case studies centred around virtual reality headsets which incorporate screens and sounds to place the user within a 360-degree virtual environment. These headsets can be driven by computers with high processing power and a surrounding rig of sensors and controls to provide motion detection (eg. *Oculus Rift, HTC VIVE*). Additional headsets can be powered by mobile or tablet devices, where the device is inserted into the headset providing a screen for use (eg. *Google Cardboard*). The *Oculus Quest*; a computer, cable and sensor free version of the VR headsets, provides portability, accessibility, ease of use and cost-effectiveness to the VR field. The portability of the combined headset and controller arrangement allows increased access to VR software and applications within the classroom and between different site locations, encouraging borrowing, and VR engagement throughout the design process. Additionally, mirroring the viewpoint of the headset grants shared VR experiences and virtual presentations to be made, encouraging collaboration and discussion to take place between others and the headset user.

Programs such a *Gravity Sketch* (2019) allow designers to easily pick up, move and scale their designs during their creation. This provides additional layers to the traditional design process, allowing 3D development to be more of an engagement and a necessity during the designing process. The incorporation of *Unity* (2019) - traditionally gaming software skills - to the designer's toolkit allows designers to go beyond the development of a single product, allowing a means of developing product and service iteration, as well as realistic environments, interactions and digital signage within an overall environment. These environments can provide a more accurate simulation for usability testing and behaviour understanding from a first-person perspective. Allowing designers to use VR to tell, and evaluate, 'stories' about a design (Berg & Vance, 2016), enabling people to 'walk' people through the experience. These tools are particularly important with products that incorporate digital and service components within their designs.

3. Case-studies of VR in industrial design education

As virtual reality continues to gain prominence within the industry, design education has begun to shift, allowing students to gain knowledge surrounding virtual technologies and the opportunities they provide within the traditional design process. Three case studies will be discussed, detailing how VR can be applied within educational settings to help lead the design process.

3.1 VR as a tool for early ideation and exploration

A semester-long industrial design studio based unit was developed that emphasised product development through virtual reality. This unit focused on how virtual tools can be applied throughout the design process to lead ideation and transition concepts towards physical outcomes. To prepare students for changing technological environments, the unit was structured to teach both software skills and independent project development. Independent learning and broad project scope was incorporated to encourage digital technology adaptability, allowing students the freedom to choose and apply appropriate tools based on individual project requirements.

The project focused on the development of smart home devices, with an emphasis of incorporating apps, digital displays and services in relation to the product. Exploring these different components as well as the incorporation of *Gravity Sketch* and *Unity* programs, allows students to learn and test different capabilities of VR within the single project. *Gravity Sketch* and activities such as virtual crazy 8's (Google, 2019) are used at the beginning of the design process to initiate design generation and allow students to become familiar with the hardware and software. As students progress through the unit, students are able to use different VR tools to help design and express different elements of their designs. For example, *Gravity sketch* could be continually used to bridge sketching, CAD, and 3D printing, where scale and correct 3D form could be developed. Alternatively, *Unity* could be incorporated to allow coding and animation to detail product interaction further, providing an additional platform for design iteration, see Figure 3. This structure challenges students to work out how virtual tools fit within their design process and how they can be used to create or inform their work. Similar to Jimeno-Morenilla et al., (2016) findings, these creative and thought-provoking processes which VR possess are believed to encourage active student participation during the design process as well as increased motivation.

Figure 3 VR design process using Unity software

VR application within the design process is believed to strengthen the diverse abilities of students, including enhancing their creativity (Abulrub, Attridge & Williams 2011 as cited in Jimeno-Morenilla et al., 2016) and engages them with autonomous learning environments. These kinds of autonomous learning environments are essential for preparing modern designers to adapt to the constantly changing technology tools and practices of modern design.

3.2 Evaluating usability and user experience in virtual environments

The second case study consisted of an industrial design practice-based PhD project, that used virtual reality as a means of conducting formative usability testing to better understand bus user experiences and validate design outcomes (Roberts 2020). As human research was undertaken Monash University ethical approval was gained - 9513.

As established, VR provides a low cost and time-efficient platform for establishing immersive 3D, context-specific, environments that early stage usability testing can be performed within (Caputu et al., 2017; Rentzos et al. 2014; Wallergård, Eriksson & Johansson 2008). These environments allow ergonomics, usability, aesthetics, scale and many other attributes to be assessed and improved quickly.

During early design stages of product development, formative testing is preferred as it allows concept validation, and feedback to be developed and applied as the project continues to develop (Falcão & Soares 2013; Hannington & Martin 2012; Jerald 2015). By placing the participant within a realistic environment and correct emotional context, more accurate product experiences can be met, resulting in more closely represented responses and real-world comparisons (Cooper & Evans 2006; Jerald 2015; Lindley, Sharma & Potts 2014).

The project's virtual environment was developed using *Unity*, enabling products, services and apps to be developed and tested cohesively. This arrangement allowed alternative scenarios as well as multiple iterations of products and services to be developed, providing a repeatable method to test general use, service failures and other points of difference within. The testing scenarios were set within a 1:1 scale, 360° accessible, low-polygon, highly saturated and cartoon aesthetically styled world (Figure 4). This style was designed to help prevent latency caused by hardware limitations, as well as to elicit a less refined and playful environment encouraging critique and creativity. Multiple alternative activities were undertaken to test environments with altered services, and product installations to determine a variety of interaction scenarios. During the activities, the headset imagery was cast onto a computer screen, visible to the facilitator (Figure 5). This coupled with the think-out-loud approach helped the researcher to gain a first-person view of the scenario and usability being undertaken, helping to build an empathic understanding of the design's value and failures.

Figure 4 Virtual environment

Figure 5 Outside the virtual environment

The VR usability testing was considered a successful way to conduct quick, formative testing, to gain qualitative information that can further inform the concept development process and to be controllable over differing testing environments. This low-cost, but highly complex, research simulation was especially well suited to a PhD research project, as it allowed a single researcher to conduct testing with a moderate budget.

Specific attention was given to user reaction during testing to determine the value of virtual environments during complex scenarios. Even with the low fidelity environment, participants (after the primer activity) interacted with the bus environment as expected, following footpaths, checking bus stop signage etc. Interestingly during one scene where the bus was delayed and unexpectedly missed the stop, the participants gave similar reactions and asked similar questions to what has been observed within similar real-world scenarios, helping to validate the potential worth of the tool. Although VR cannot replace real-world usability testing, it provides a great alternative for collecting qualitative user behaviour early on, helping to shape designs towards more user-centred solutions.

3.3 VR tools for co-designing with non-designers

CoMake Melbourne (MUHREC 19365) was an initiative funded by the Lord Mayor's Charitable Foundation run across 2019 with 15-24 year old students who have fallen outside mainstream education to help prepare them for the future of work. A team of academics from Monash University and RMIT collaborated with partners from Gateway School, Youth Central Broadmeadows, and Hume City Council to deliver a program aimed at fostering intrinsically motivated learner-led learning. Over the year we ran weekly sessions designed to develop participants' 'soft' and 'hard' skills for more adaptive, technologically adept and resilient skills acquisition. The project team worked intensively with the participants to gain a grasp of cutting edge technologies like 3D printing, virtual reality, digital media production and media broadcasting, but also to develop future-of-work personal traits such as curiosity, tenacity, peer-to-peer sharing, and emotional resilience. Our primary motivation was to discover how we might use hands-on making to generate engaged learning of future-of-work-skills for those who do not have access to them through traditional school learning.

As a hands-on future-of-work technical skill, the project team introduced digital modelling in virtual reality using *Oculus Quest* Headsets with the applications *Tiltbrush* and *Gravity Sketch*. As learning facilitators we had very little experience with the tools, having briefly encountered them only a week prior to giving them to participants to use. On the first week of the program, the participants were briefly introduced to the applications then left to their own devices to develop digital models at 1:1 scale in virtual space through unstructured play. Our aim was then to translate these to physical models through 3D printing, laser cutting and CNC routing to replicate what we anticipate future industry processes to be.

Our proposition was that, given the ability to see and 'feel' products at full size using intuitive modelling tools, the tools themselves begin to disappear into the background and imagination can come to the foreground through 'hands-on' digitally mediated making. Both *Tiltbrush* and *Gravity Sketch* allow participants to 'sketch' in 3D using surface-generating brushes controlled by controller handsets. We paired the learning of the modelling applications with other games available on the *Oculus Quest* platform which shared many of the control and interactivity mechanisms as the digital modelling applications. This allowed seamless, fluid intuitive and embodied interaction across the applications providing tacit dexterity shared between the digital modelling applications and games. Like the games, the applications were designed with simple and intuitive interfaces, menu systems and controls that directly relate to coordinated body movement. We found this reduced the abstract thinking required when using a mouse or other controllers in industry-standard CAD programs like Solidworks and Rhino.

Given the user is 'in' the modelling environment and the controllers are represented, the virtual reality process effectively removes the need to translate 2D sketch to 3D form through a CAD program and/or production drawings, modelling directly through sketching in a cartesian environment. This reduces barriers to making sophisticated objects that can be made through digital-physical production tools. Even though we provided very little tuition and relied on the participant's curiosity to drive their learning, those who were interested enough to engage with the technology were able to develop sketch models that were thoughtfully 'designed' within the space of an hour and continue building on this learning at their own pace according to each project's needs moment by moment.

4. Conclusion

This paper expresses the importance of introducing VR to industrial design education, to prepare students for the shifting trend towards virtual design tools. Emerging technologies are increasingly becoming part of industry design teams and are driving shifts in how young designers practice. The development of methodologies to successfully teach technology resilience and adaptability to industrial designers is necessary. Numerous literature was found to discuss the applications and benefits of VR to provide cost-effective design evaluation and development during the early design process. However, limited literature discussed studio-based education practice and methods of teaching VR skills and processes to industrial design students, so that they can be prepared for shifts in industry practice. This paper discussed three case studies that emphasised the benefits, challenges and methods of teaching VR within an industrial design context. This discussion focused on the application of VR to aid the design process at various stages from concept development to usability testing.

The advantage of using VR tools within design education was found to offer additional tools for students to undertake the design process, allowing blended learning opportunities and engagement to take place. Currently, within industrial design education, the application of blended learning and digital software is rapidly expanding, with CAD being a central point of design development, communication, and fabrication (see Figure 2). VR was found during the literature and case studies to offer alternative tools to develop, evaluate and present CAD product designs, within contextual, 1:1, immersive 3D spaces. Whilst encouraging service, interface and environmental relations to be continuously considered and assessed during the product design process. Additionally, VR tools promoted the following:

- Develop and test designs within a realistic 1:1 scale environment.
- Quick generation and modifiable designs, encouraging iterative usability testing and human insights to be gained at early design stages.
- Easy transferral of CAD files, allowing designs to be constructed and evaluated remotely.
- Oculus Quest VR headsets allow for cost-effective and portable headset solutions.
- VR software allows 3D sketch generation and interactive scenario development tools.
- VR challenges students to become adaptive to applying new technologies to the design process. A skill that will encourage greater technology flexibility with emerging technologies during their careers.

Lessons and limitations of VR in industrial design education learnt from the studies and literature are described.

- Objects can be difficult to perceive and interact with due to depth perceptions, especially near scale applications (Lawson et al., 2015) and the lack of haptic feedback including the absence of object weight, tactility and force (Lawson et al., 2015). The lack of fine-grained levels of hand control is limited in most VR systems, this affects physical touch, causing indirect manipulation of the digital product to take place and making design evaluations such as ergonomics and tactile functions difficult to assess (Kuutti at el. 2001; Ran & Wang 2011). Augmented reality and mixed reality (Ran & Wang 2011) can bridge these limitations.
- Limited sensory attributes caused by headset usage, can cause isolating, limiting virtual collaboration amongst students and communication during usability testing. To help encourage communication, think-out-loud approaches, casting VR screens to monitors, limited audio usage and screen projections were used. CAVE like systems are also suggested as an alternative solution to encourage virtual collaborative spaces.
- Motion sickness and latency problems caused by headset usage and hardware limitation can influence usability and can cause attritional biases (Jerald 2015). Low polygon designs and less asset inclusion can help reduce this with designers needing to be aware of their scenes capabilities.
- Students are required to learn additional skills to be able to implement their projects within virtual environments.
- VR hardware is rapidly evolving and can be expensive and tedious to continuously install and uninstall. The Oculus Quest headset featuring minimum cables and inbuilt computer provides a solution.
- The lack of familiarity students have with VR tools, and the lack of industry-standard processes and tutorials.

Despite the above limitations, VR was identified as an important tool to help lead and advance the design process, providing multiple avenues for creativity and iteration to be developed within a 3D context. These case studies identified future work to help teach virtual reality tools consisting of a better understanding and application of mixed reality and augmented reality tools within industrial design education. Adapting mixed reality processes so students can learn to integrate physical and digital products allows ergonomics and tactile usability of a product to be assessed. Figure 6 is an example of how physical objects such as a bus stop, can help mentally and physically prepare users for the environment within the virtual reality headset.

Figure 6 Virtual reality bus stop. Part of Roberts (2020) thesis exhibition.

Further understanding and translating of traditional design methods – from early ideation to usability testing – across to virtual tools is also considered an area of future exploration. Current connections between VR and traditional design methods are currently limited beyond visualization, VR can be implemented across the breadth of activities within the industrial design process and further development in the technology will only open up additional exciting possibilities for industrial design.

5. References

Abulrub, Abdul-Hadi G., Alex N. Attridge, and Mark A. Williams (2017). Virtual reality in engineering education: The future of creative learning. *2011 IEEE global engineering education conference (EDUCON). IEEE*, 2011.

Berg, L. P., & Vance, J. M. (2017). Industry use of virtual reality in product design and manufacturing: a survey. Virtual reality, Vol. 21, pp. 1-17.

Caputo, F., Greco, A., D’Amato, E., Notaro, I., & Spada, S. (2018). On the use of Virtual Reality for a human-centered workplace design. *Procedia Structural Integrity*, Vol. 8, pp. 297-308.

Chang, J. Z. (2017). *Designing in virtual reality: tools with the human field of vision*, Doctoral dissertation, Massachusetts Institute of Technology.

Chen, C.H., Huang, C.Y., & Chou, Y.Y. (2017) Integrating augmented reality into blended learning for elementary science course. *In Proceedings of the 5th International Conference on Information and Education Technology*, pp. 68-72.

Choi, S. H., & Cheung, H. H. (2008). A versatile virtual prototyping system for rapid product development. *Computers in Industry*, Vol. 59, pp. 477-488.

Cooper, R., & Evans, M. (2006). Breaking from tradition: Market research, consumer needs, and design futures. *Design Management Review*, Vol. *17*, p. 68.

Dorta, T., & LaLande, P. (1998). The impact of virtual reality on the design process. *Digital Design Studios: Do Computers Make a Difference in Design Studio*, pp. 138-160.

Falcão, C. S., & Soares, M. M. (2013, July). Application of virtual reality technologies in consumer product usability. In *International Conference of Design, User Experience, and Usability*. Springer, Berlin, Heidelberg, pp. 342-351.

Google. (2019). Design Sprints: Crazy 8's core methods. Retrieved from https://designsprintkit.withgoogle.com/methodology/phase3-sketch/crazy-eights (Accessed 1 November 2019)

Górski, F., Buń, P., Wichniarek, R., Zawadzki, P., & Hamrol, A. (2015). Immersive city bus configuration system for marketing and sales education. *Procedia Computer Science*, Vol. 75, pp. 137-146.

Grajewski, D., Diakun, J., Wichniarek, R., Dostatni, E., Buń, P., Górski, F., & Karwasz, A. (2015). Improving the skills and knowledge of future designers in the field of ecodesign using virtual reality technologies. *Procedia Computer Science*, Vol. 75, pp. 348-358.

Gravity sketch. (2019). Gravity Sketch. Retrieved from https://www.gravitysketch.com/ (Accessed 1 November 2019)

Hanington, B., & Martin, B. (2012). *Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions*. Rockport Publishers.

Herloa, D. (2015). Improving efficiency of learning in education master programs, by blended learning. *Procedia-Social and Behavioral Sciences*, Vol. 191, pp. 1304-1309.

Jerald, J. (2015). *The VR book: Human-centered design for virtual reality*. ACM books, New York City

Jimeno-Morenilla, A., Sánchez-Romero, J. L., Mora-Mora, H., & Coll-Miralles, R. (2016). Using virtual reality for industrial design learning: a methodological proposal. *Behaviour & Information Technology*, Vol. 35, pp. 897-906.

Kim, C., Lee, C., Lehto, M.R. & Yun, M.H. (2011). Affective evaluation of user impressions using virtual product prototyping. *Human Factors and Ergonomics in Manufacturing & Service Industries*, Vol. 21, pp. 1-13.

Kirkley, S.E. & Kirkley, J.R. (2005). Creating next generation blended learning environments using mixed reality, video games and simulations. *TechTrends*, Vol 49 (3), pp. 42-53.

Kohler, T., Fueller, J., Matzler, K., Stieger, D., & Füller, J. (2011). Co-creation in virtual worlds: The design of the user experience. *MIS quarterly*, pp. 773-788.

Kuutti, K, Battarbee, K, Sade, S, Mattelmaki, T, Keinonen, T, Teirikko, T & Tornberg, AM. (2001). Virtual prototypes in usability testing, *paper presented at the 34th Annual Hawaii International Conference on System Sciences*, 6 January, Maui, viewed 7 July 2018.

Lawson, G., Salanitri, D., & Waterfield, B. (2016). Future directions for the development of virtual reality within an automotive manufacturer. *Applied ergonomics*, Vol. 53, pp. 323-330.

Lindley, J., Sharma, D., & Potts, R. (2014, October). Anticipatory Ethnography: Design fiction as an input to design ethnography. In *Ethnographic Praxis in Industry Conference Proceedings*, Vol. 2014, pp. 237-253.

Ran, Y & Wang, Z. (2011). 'Virtual and augmented reality applications in industrial design', *paper presented at the 3rd International Conference on Machine Learning and Computing*, 26–26 February, Singapore, viewed 7 July 2018.

Rentzos, L., Vourtsis, C., Mavrikios, D., & Chryssolouris, G. (2014, Juxne). Using VR for complex product design. In International conference on virtual, augmented and mixed reality (pp. 455-464). Springer, Cham.

Roberts, Sarah. (2020). Feeling in control: Designing the Melbourne bus user experience. *figshare. Thesis.* https://doi.org/10.26180/5e7046bfcf940

Unity. (2019). Unity Retrieved from https://unity.com/ (Accessed 1 November 2019)

Wallergård, M., & Johansson, G. (2008). A suggested virtual reality methodology allowing people with cognitive disabilities to communicate their knowledge and experiences of public transport systems. *Technology and Disability*, Vol. 20, pp. 9-24.

About the Authors:

Dr Sarah Roberts' current interests are in designing human centred design outcomes through physical, digital and service applications. She has a particular focus in mobility design, exploring how product service systems can be developed to create improved human mobility opportunities.

Dr Rowan Page explores the role of design research and practice in the translation of fundamental research into commercial outcomes. His research interests include co-design, speculative design, digital fabrication and the function of designed artefacts as boundary objects within collaborative and interdisciplinary projects.

Dr Mark Richardson Through Open Design, upcycling and modularity I believe we can generate low-cost enabling tools-for-living that can be made by anyone, anywhere in a sustainable way. Further, physical acts of making and co-designing can impact wellbeing, inclusiveness and attachment to objects, people, space, place and environment.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Optimizing sources of inspiration for innovation: a case study in concept generation process

Jeff FENG[a]*

[a] University of Houston, United States of America
*Corresponding author e-mail: ffeng@uh.edu
doi: https://doi.org/10.21606/drs.2020.298

Abstract: The conceptual distance between the inspiration source and the design subject affects the performance of idea generation. Despite many studies about the significance of distant or near sources of inspiration to boost design creativity, which source of inspiration plays a greater role remains unclear. This paper explores the benefit of incorporating both distant and near sources of inspiration in concept generation in a design studio context. An idea-generation process is implemented in a third-year industrial design studio for three years. The project outcome indicates a potential advantage in guiding students to collect and organize diverse inspirational sources to improve their design productivity and quality. While the distant source of inspiration advocates the ideas' novelty and originality, the near source of inspiration supports design quality and details in further development.

Keywords: passion; inspiration; concept generation; creativity

1. Introduction

The designer's creative process of generating ideas is a domain filled with research studies in the design community. In the process of ideation, designers usually do not generate new designs completely from scratch. Instead, they learn from existing designs, integrate and transform multiple elements into something new (Jasson & Smith, 1991) (Marsh, Ward, & Landau, 1999). As an effective way to spark innovation, "different sources of inspiration have been a focus on the study for years about the relevance between the inspiration source and the productivity of idea generation" (Eckert & Stacey, 1998). Researchers try to identify which type of sources that impact the idea generation process in a greater positive way (Chan, Dow, & Schunn, 2015). Inspirations are generally categorized into two sources: "incidental knowledge from daily experiences, and intentional learning in a particular domain" (Purcell & Gero, 1996). Both sources of inspiration play a role in the designers' creative process. Forms of inspiration is another matter being investigated. While inspirations can take many forms such as texts, audios, tactile senses, sketches, diagrams, works of art, designers tend to work better with visual forms (Keller, Pasman, & Stappers, 2006) (Cheng, Megge, & Schoormans, 2014). While research has shown that rich visual inspirations enable designers to create more original designs than lacking supplementary sources of inspiration (Goldschmidt & Smolkov, 2006), "inspirational texts also improve the quality of design solutions in terms of originality" (Goldschmidt & Sever, Inspiring design ideas with texts, 2011).

1.1 Near and Distant Sources of Inspiration

Conceptual distance is a term to describe how different the inspirational stimuli or analogy is from the design subject or the problem domain (Chan, Dow, & Schunn, 2015). Most sources of inspiration can be characterized as a near or distant source of inspiration. "Near or distant sources of inspiration influence the idea generation process in different ways" (Chan, Dow, & Schunn, 2015). So, which type of inspiration will likely play a greater role in the creative process? What are the best sources of inspiration for the design? Current studies show a mixed view of both sources in supporting the creative design process. Many researchers, mostly studying the role of analogy in creative problem solving, proposed that far sources of inspiration are likely to be the best source for aiding creative breakthroughs (Gentner & Markman, 1997); (Ward, 1998). Specifically, a process called" Conceptual Leap Hypothesis" is established by consistently identifying creative discoveries such as George Mestral's invention of Velcro by analogy to burdock root seeds (Freeman & Golden, 1997). However, other recent studies show "an equivalent benefit from near and distant sources of inspiration" (Enkel & Gassmann, 2010). While distant sources were more impactful in the middle of the ideation process, "distant sources not always led to more novel ideas" (Tseng, Moss, Cagan, & Kotovsky, 2008). In some cases, research revealed that "distant sources of stimuli even caused lower novelty and quality of ideas than near sources" (Fu, et al., 2013). Other studies also propose that "conceptual distance of the inspiration sometimes does not matter, but the within-domain expertise is a primary driver of creative cognition.". The study indicates that creative design ideas are more likely to come from relying on a predominant source (Chan, Dow, & Schunn, 2015).

Due to methodological limitations (Chan, et al., 2011), a lack of statistical power (Chiu & Shu, 2012), and substantial problem variation in different studies (Goldschmidt & Smolkov, 2006) (Liikkanen & Perttula, 2008), more empirical work is called to investigate "the functional factors of inspiration sources" (Chan, Dow, & Schunn, 2015). On the other side, for design concept generation, the supporting role of both distant and near sources of inspiration have been validated explicitly in all studies. In design education, a more relevant question is how to utilize both sources of inspirations to support and enhance students' idea generation.

1.2 Inspiration versus Fixation

While stimuli are widely exploited as inspirational sources in the idea generation with positive outcomes, studies have also revealed that consulting existing designs may instead negatively impact the quality of the design solution. When individuals are given a solution example as a reference, they often tend to produce solutions similar to the example provided. This effect is called “Design Fixation” (Crilly, 2015). Since Jansson and Smith’s first study, the idea of design fixation has fascinated researchers from different fields. “The interpretation of design fixation has been narrowed or broadened from its original meaning” (Youmans & Arciszewski, 2014). While narrower interpretations focus on designers’ tendency to build new concepts that conform to a shown example (Finke, 1996), “broader interpretations consider any cognitive or process interference that affects the design work” (Perttula & Sipilä, 2007).

To be more relevant to the ideation generation process in this study, fixation in design refers to “the phenomenon that designers adhere to a couple of existing ideas or concepts unconsciously” (Jasson & Smith, 1991). It is a broad phenomenon commonly seen in engineering, industrial, and architecture designs (Jasson & Smith, 1991) (Purcell & Gero, 1996). Experiments demonstrated that participants without being exposed to a solution example, tend to generate more novel ideas. The more individuals learn from the referencing examples, the smaller the number of ideas they can generate. On the other side, through studying existing examples, participants will likely improve their designs in terms of quality (Sio, Kotovsky, & Cagan, 2015). Studies also show that expert designers will likely be aware of and recognize their fixation episodes. They learn about causes and indicators of fixation which can help them to be more sensitive and “guard them against such fixation episodes in the future” (Crilly, 2015). With a respect to the fixation risk discussed in the literature, the ideation process in this study was designed to avoid or minimize the chances of fixation by delaying the introduction of near sources of inspiration to students.

1.3 Sketching Abstraction

Sketching is an essential step in the designers’ creative process. Studies approve that sketching plays a critical role not just in documenting and communicating ideas but affecting a designer’s creativity in idea generation. “In sketching, two mental processes revealed themselves as critical in the creative process: Restructuring and Combining.” (Verstijnen, Hennessey, Leeuwen, Hamel, & Goldschmidt, 1998). These two processes are imperative in the idea generation process. Design experts consciously combine and restructure their ideas to achieve high productivity and quality. In terms of sketching behavior, some expert designers tend to create simple sketches and rapidly generate a high number of sketches in the early stage of ideation. To avoid distracting designers from focusing on a few ideas, sketch rendering, perspective drawing, and high-level details should be delayed in the early stage of sketching (Linsey, et al., 2011) (Booth, Elkin, Karthik, & Tahira, 2016).

A sketching process in capturing certain characteristics of objects in an abstractive way is understood as a generic abstraction (Zhang & Norman, 1994). The study shows “generic abstraction through sketching is an effective exploration strategy that fosters creativity in design” (Dogan & Nersessiam, 2010). With an intent to enhance students’ creativity in ideation, a generic abstraction process through sketching was integrated into the ideation process in this study.

2. Method: an individual passion-driven process

With an intent to take advantage of both near and distant sources of inspiration, an idea generation process is devised to incorporate activities exploiting both sources. The course framework is shown in figure 1. Both distant and near sources of inspiration were integrated into a parallel process.

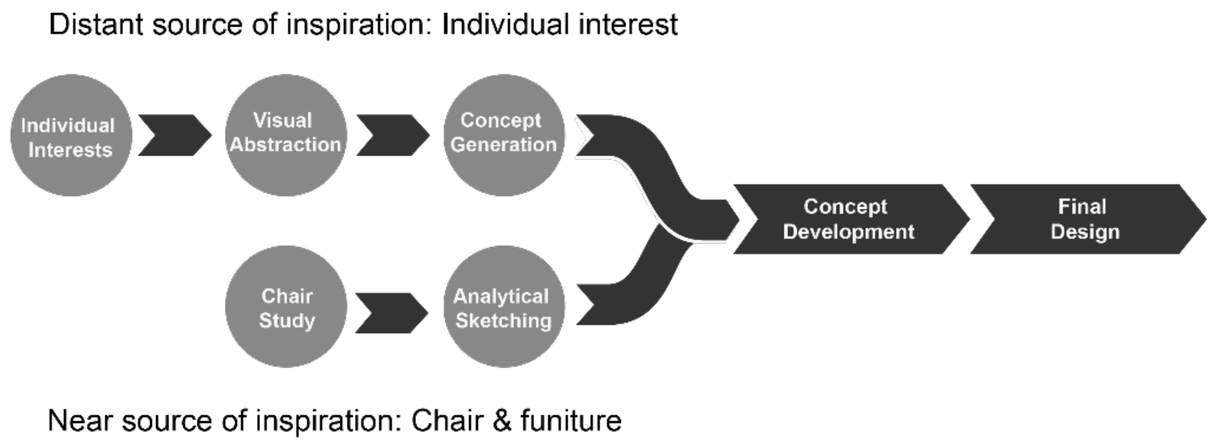


Figure 1 A concept generation process is driven by distant and near sources of inspiration.

Intentionally, the research activity was designed to tap into students' passion for design as a distant source of inspiration. Specifically, students were asked to search for things that interest them the most in design including man-made products or natural objects. These things were represented by images. Through comparing and grouping, these objects were summarized into several key attributes with visual representations. The outcome was developed into one imageboard. Then through a visual-abstraction drawing exercise, these attributes and visuals were simplified into basic sets of lines, shapes, and symbols. Based on these abstract drawings, students started their initial idea generation with an attempt to transform them into a surface or form for sitting. In terms of utilizing near sources of inspiration, a study on the same or similar product samples was included on a parallel but delayed path. Students were given opportunities to examine good design products in person. In addition to a general exploration, students were required to conduct a focused examination of products through a sketching process including perspective drawings of the whole piece as well as detailed drawings of parts of the product. Based on the learning from the literature, near sources of inspiration were planned mainly to support students in further design development. After the concept generation, both sources of inspiration were integrated into the concept development and final design execution.

To manage a project through this process with clear and visible indicators in each step, a tangible and straightforward simple product is selected as the design challenge for the experimentation. It is to design a chair with a set of criteria as following:

- A chair of the original design should be aesthetically pleasing.

- Create an offering that can be marketed to the context of residential and/or contract trade.
- Any material or combination of materials will be accepted.
- The chair should be appropriate for manufacturing, fiscally feasible, and suitable for mass production.

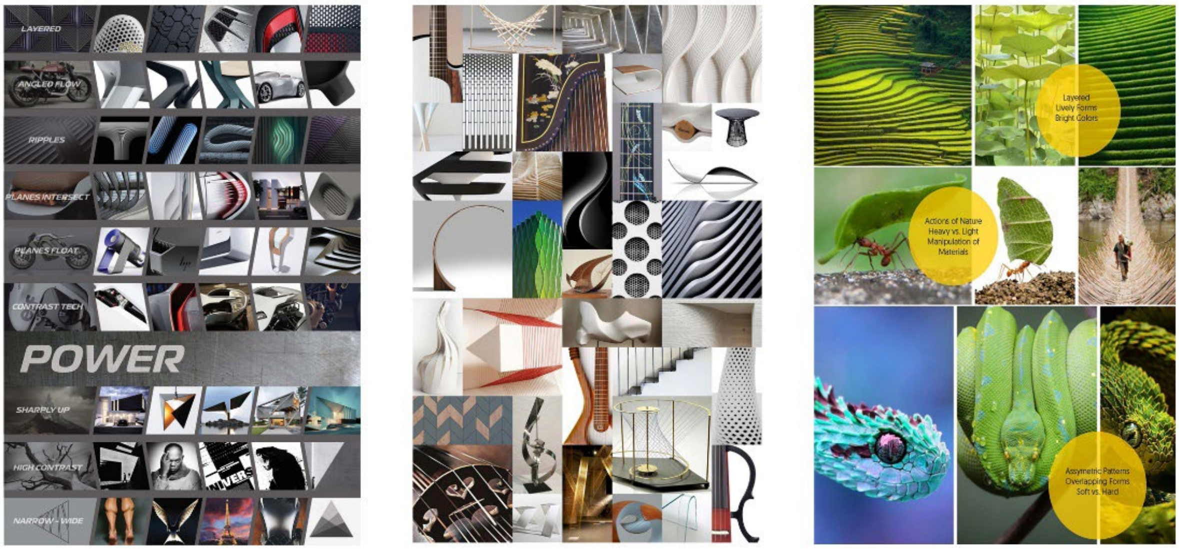
The generally open design requirement provided a wide space for students' ideation exercise.

3. Case study

This method was applied to the same project in an industrial design junior studio in the fall of 2017, 2018, and 2019. The class size ranges from 14 to 16 students. Since the detailed project description, learning process, and requirement remains virtually the same in three studios, the detailed narrative of the case study will not hinge on by years, but be treated as one case.

STEP 1. PERSONAL INTEREST EXPLORATION.

Students were instructed to search for their interests in design and reflect on subjects they are most passionate about. The subject is open to everything including objects, memorable experiences, enjoyed activities, and so on. Students had a week to conduct this activity. They were tasked to identify three to five key attributes in adjectives representing their interests. Then they would collect a set of visual images embodying these attributes, compile them onto an imageboard. Their board should be structured by the attributes. Figure 2 shows three samples of students' exercise. The theme of the board a. is power. Primary attributes are sharply rising, high contrast, aggressive and angular. The image collection covers a wide range of things from movie characters to architectures. The theme of the board b. is music. This student plays drums in a band and loves music. His board is filled with flowing music notes in all forms. The theme of board c. is nature. Primary attributes are layered lively forms, heavy vs. light, manipulation of materials, soft vs. hard, asymmetric patterns. The board is occupied by striking natural landscapes and creatures.

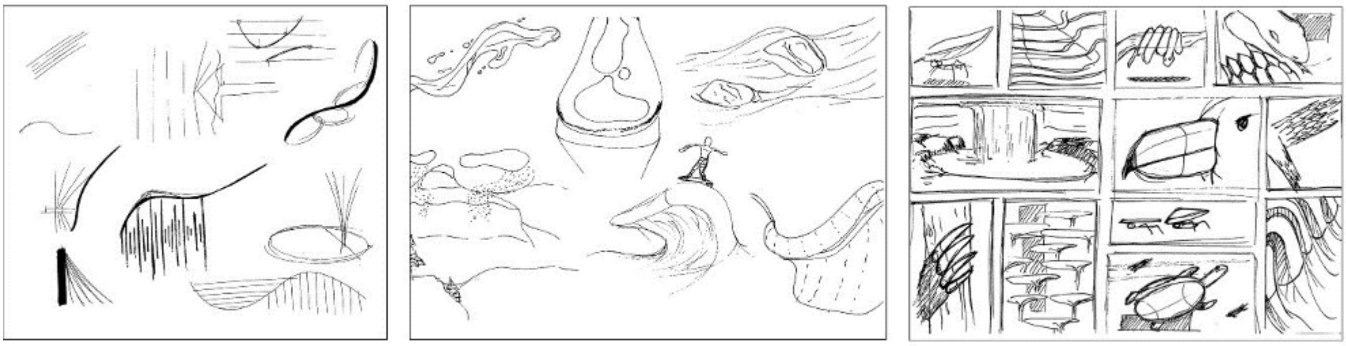


a. b. c.

Figure 2 A collection of individual's interests visualized as a distant source of inspiration.

Step 2. Visual abstraction

When the board was completed, students were advised to transform the essence of their visual interests on the board into simplified abstractive forms composed of dots, lines, planes, and surfaces. This drawing exercise was limited in 15 minutes. Students were instructed to focus on the quantity but not the quality of ideas. They did not have much time to draw more details but go through a brief visual reduction process to translate visual elements into simple lines and forms. Although their drawings were minimal and abstract, most of them captured the essence of visual elements successfully. As shown in figure 3, simple lines and curves were mostly seen in drawings. Figure 3 shows two sample drawing collections. Drawings on board a. are done by the student inspired by music as shown in figure 2. Drawings on board b. are done by the student inspired by nature. While most of the students learned and mastered this abstraction process, a few students had trouble to simplify their visuals to abstract representations. They tend to draw more detailed forms shown on their image boards. Board c. is such an example. The students' original inspirations are many animals. Images of specific animal heads, overall body, and body parts were noted in detailed sketches.



a. b. c.

Figure 3 Examples of visual abstraction.

Step 3. Concept generation

Based on their abstractive drawings, students started sketching their chair concepts. To avoid inhabitation in concept generation by a confined concept of chair analogy, the established concept of 'Chair' was replaced by 'a sitting surface' in this exercise. This exercise was also timed within 15 minutes. Again, they were instructed to focus on the quantity but not the quality of drawings. Under the influence of their inspirational drawings, in simple lines and forms, students tried to draw as many concepts as possible, but not spend much time in drawing details.

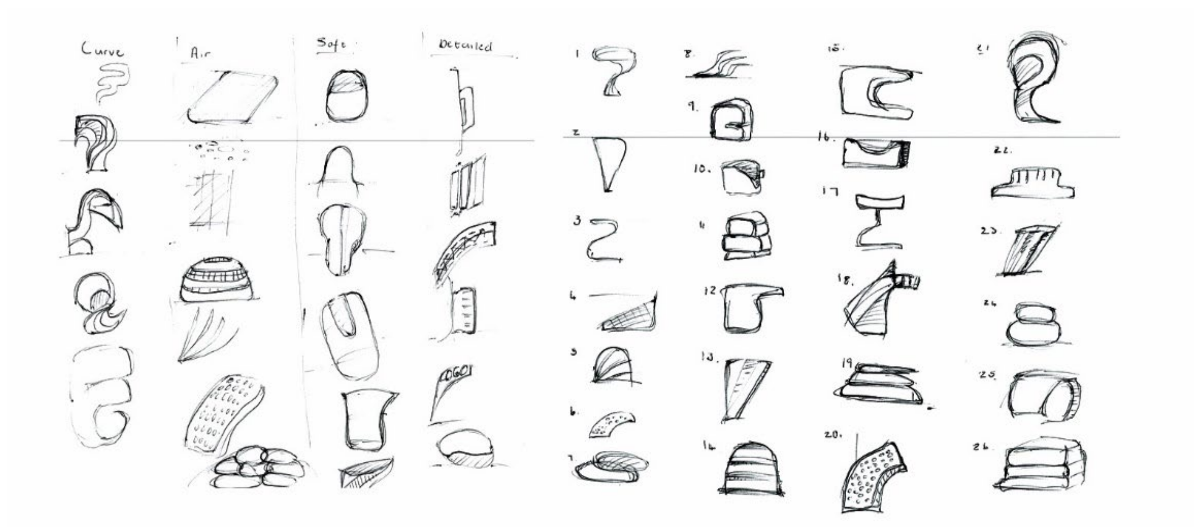


Figure 4 An example of students' initial ideation concept

Step 4. Exploration on near sources of inspiration

While students were generating their initial concepts, they were led to a local Design Within Reach (DWR) showroom to study chairs and furniture. This showroom showcases about 50 well-designed chairs including some classic modern designs. Students were instructed to conduct sketching exercise onsite and drew a minimal 5 chairs from multiple perspectives.

To improve students' chair design vocabulary, analytical sketching exercise was designed into this process. Right after the field trip to DWR, students were asked to draw their most favorite 5 chairs from the memory in two different perspectives plus 3 details of each chair. This exercise was timed for 30 minutes but extended to 45 minutes. Most students faced a challenge to draw from memory with relatively high quality and accuracy.

Figure 5 Onsite study at a Design Within Reach showroom.

Step 5. Further development

After onsite study and drawing exercises, students gained more knowledge about the fundamentals of designing a chair: sizing and proportion, sitting topologies, joineries, materials, and sitting ergonomics. They were prepared to develop their concepts into final designs in terms of applying the real materials to a full-scale prototype. Through iterations of drawings and prototypes, the chair structures were modified and developed with enough strength to sustain a person up to 250 lbs. The chair designs were also finalized with real materials and finishes. By the end of the project, students were required to build a fully functional appearance prototype which will be reviewed in a jury.

Figure 6 An example of design development from initial concept sketches to the final prototype.

3.1. Design Assessment

Each year, students' works were reviewed by a panel of jurors composed of a mix of professional designers and design faculties. Studio instructors were excluded from the final review to avoid subjective views. The same review sheet was used through three years as shown in figure 5. Jurors evaluated students' designs based on 5 listed criteria: originality, aesthetic quality, functionality, craftsmanship, and feasibility for mass production. More rating details were listed in the sheet for the juror's reference.

PROJECT NAME:

CRITERIA	SCORE
ORIGINALITY *A CHAIR/FURNITURE OF THE ORIGINAL DESIGN, CREATING A STRONG SOUL*	
AESTHETICS QUALITY *CHAIR/FURNITURE MUST BE AESTHETICALLY PLEASING*	
FUNCTIONALITY *SCALES, PROPORTION, SITTING ERGONOMICS*	
CRAFTSMANSHIP *THE QUALITY OF MAKING: APPROPRIATE PROCESS, MATERIALS, FINISHES, DETAILS*	
MASS PRODUCTION *FISCALLY FEASIBLE AND SUITABLE WITHIN THE CONSTRAINTS OF MASS PRODUCTION*	
(1-5 RATING SCALE: 1 IS POOR, 2 IS AVERAGE, 3 IS GOOD, 4 IS EXCELLENT, 5 IS EXCEPTIONAL)	

Figure 7 Jury evaluation criteria.

Juror's review summary is shown in table 1. Based on the assessments performed by the jurors, overall, students' work's scored 4 out of 5 in originality over three years and scored 3.92 in aesthetic quality. Students who fully engaged in the concept generation path, likely created more original work comparing to the rest of the students. On the other side, a few students had a hard time to follow through the process and quickly settled on a few ideas at the beginning, likely their designs were a close interpretation or iteration of some existing chairs.

Table 1 Mean values of jury assessment based on the rating scale of 1 to 5.

Criteria	**2017**	**2018**	**2019**	**Average**
Originality	3.75	4	4.25	4
Aesthetic quality	3.25	4	4.5	3.92
Functionality	3.5	4	4	3.83
Craftsmanship	3.25	3.5	3.75	3.5
Mass production	3.25	3.5	3.5	3.41

An external evaluation was realized through a design competition. For two years, some students' designs were recommended to participate in a furniture design competition which is a nationwide competition open to all design institutions. Both years, student's designs were recognized by the competition judges. In 2018, for the first time to participate in this competition as a school, Michael L. Dillon's chair 'ERGO' won the first place. In 2019, Dymon Johnson's chair 'LUFT' won second place. Both chairs are shown in figure 8.

Figure 8 The Furniture Design Competition winners: ERGO, the first place in 2018, LUFT, second place in 2019.

4. Observation and discussion

This process has been implemented over three years in a junior industrial design studio in the fall semester. Three years of experimentation revealed some results consistently in terms of affecting the ideation process by the distant and near source of inspiration.

4.1. Observation

Based on their reactions and performance through the process, students can be divided into three groups. The first group of students represents the majority of students. They were relaxed and immersed themselves into the process, engaged in drawing exercises in every step. They were not necessarily best sketchers and their sketches were not the best ones either. But they produced most concepts in the stage of transforming visual attributes to abstract sketching and then to the initial concepts. Their concepts were rated high in originality as well. As an example, figure 9 shows a students' process presenting a clear path from key attributes and distant inspirational images to initial concepts. The student demonstrated well in terms of abstracting the key visuals into lines and forms, then translating them into the concepts. This outcome indicated that the distant source of inspiration likely contributes to the quality and novelty of the initial concepts.

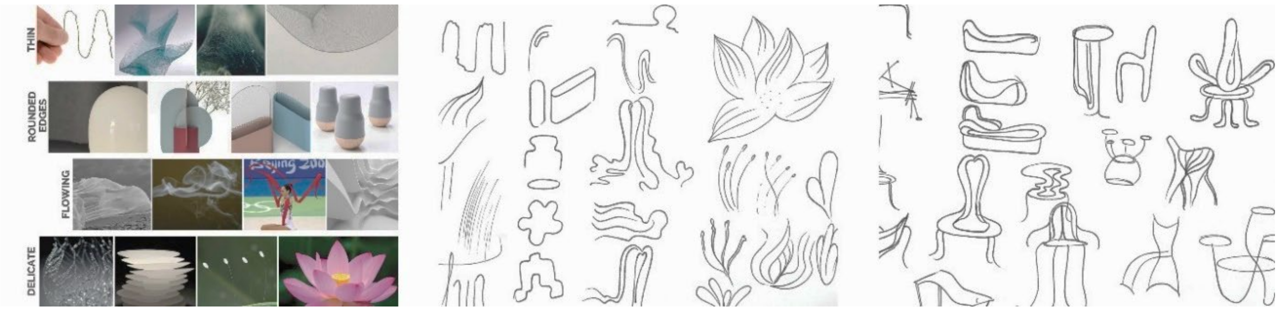


Figure 9 *An example showing the concept generating path: visual interests, abstractions, concepts.*

The second group was a few students in the studio. They reacted oppositely from the first group and almost completely shut themselves off from this process. They were constantly looking for a comfort stage in every step. As quickly as possible they settled down on a few concepts, and fixed on a design concept early and through the rest of the project. Their designs were evaluated low in novelty and originality. Two examples are shown in figure 10. Two students were from two different studios, but both followed through a similar process as described above. They fixed on their final design at the early stage of ideation and rejected any changes. One student's sketches were mostly a repetition of a couple of similar concepts through the process. The other student has produced a low number of sketches in design refinement once his mind fixed on one concept.

Figure 10 *Two examples of design fixation.*

The third group was another small cluster of students. Their reaction to the process and performance fell between the first two groups. They engaged in most activities through the process with a limitation in energy and concentration. The reasons behind this are varied. Some students were not fully engaged due to a lack of interest in the design subject. Some were not productive in personal interest exploration so they did not prepare well for the idea generation.

4.2. Discussion

Every year, a short survey was conducted at the end of the project to collect students' feedback followed by a group discussion about the survey questions and outcome. 7

questions were asked in the survey as shown in table 2. The question is rated at a scale of 1-10. 1 represents 'strongly disagree', 10 represents 'strongly agree'. On average, students recognized a positive impact on their concept generation through this process. Most of them are favorable to their performance in terms of effort and the design outcome. Key responses from students are boiled down as follows:

Table 2 The mean values of the survey result for over 3 years.

Question	**Score (average over three years)**
The inspiration board is effective to identify my passion for design.	8.5
The sketching abstraction process from inspiration to ideas is easy to follow.	7
This sketching abstraction process is helpful for my concept generation.	8
I am challenged in this process to find my true passion for design.	6.5
The process helps generate a large number of concepts.	9
The process helps generate novel concepts.	8.5
The focused chair study helps me to understand the chair design basics.	9

Particularly, students concur that this method helped them to generate a high quantity of concepts strategically. They are often required to generate a high number of concepts in studio projects. Due to a lack of effective approach and strategy, it is challenging for them to reach a self-satisfied quantity and quality in ideation. In this process, students appreciated and enjoyed the method of exploring their interests in design which became a noticeable stimulation to motivate them in design and provided them streams of inspiration. Some students liked the fast pace sketching based on the abstract sitting surface concept which contributed more constraint-free ideas. Both factors helped them to be liberated from a captive concept of designing a chair.

Another notable factor is that this process helped students to reflect on their true passion for design as a distant source of inspiration. The procedure of personal interest exploration allowed students to think over objects, designs, and attributes that excite them and visualize them through an analytical process. Most of the students' final designs were some forms of inspiration from this study. This process made a considerable contribution to the novelty in design ideas.

The survey result also indicates that studying near sources of inspiration is effective in supporting students' further concept development. Students' response to the survey question is consistent with the author's observation. During the design development, students' learning from the existing chairs and furniture in terms of structure, proportion, ergonomic sitting typology, etc., were naturally transformed in helping them develop their designs. Since their design concepts are already set in a clear theme, this process helped them to further refine their designs without altering their design direction or changing their original design ideas.

During the discussion, some students suggested allocating more time to concept sketching. While a majority of students enjoyed the process with better productivity and quality, students with a strong fixation during the exercise rated medium or low in the survey with less interest since it did not make a strong connection with them and brought not so much change to their normal way of design.

4.3. Limitations and Future Work

The practice of this concept generation process demonstrates that strategically managing distant and near sources of inspiration have the potential to positively impact students' creative performance. With a deeper understanding of the effects from varied sources through the process and knowledge to apply them at the right time, it will likely improve students' productivity and creativity in ideation. While the distant source of inspiration advocates the ideas' novelty and originality, the near source of inspiration supports design quality and details in further development.

This study is limited to a small number of participants (a total of 57 students over three years) and one testing design subject. The timing of introducing distant and near sources of inspiration was not carefully planned and evaluated. Due to the limited time allowed in the studio teaching context, both paths were running with a partial overlap. Near sources of inspiration might affect students' initial idea generation in some cases. While the case study over three years demonstrates a fruitful success in teaching and learning, there is a need to conduct a comparative study between this process and a conventional concept generation process to further investigate the strength and the weakness of this method. Further experimentation is called to hone in the process to be an effective teaching tool in the exploration of design concepts.

5. References

Booth, J., Elkin, A., Karthik, R., & Tahira, R. (2016). Interventions for Teaching Sketching Skills and Reducing Inhibition for Novice Engineering Designers. Design Studies 43, 1-23.

Chan, J., Dow, S. P., & Schunn, C. D. (2015, 08). Do the Best Design Ideas (Really) Come from Conceptually Distant Sources of Inspiration? Design Studies 36, 31-58.

Chan, J., Dow, S., & Schunn, C. (2014). Do the best design ideas (really) come from conceptually distant sources of inspiration? Design Studies.

Chan, J., Fu, K., Schunn, C., Cagan, J., Wood, K., & Kotovsky, K. (2011). ON the benefits and pitfalls of analogies for innovative design: ideation performance based on analogical distance, commonness, and modality of examples. Journal of Mechanical Design, 133, 081004.

Cheng, P., Megge, R., & Schoormans, J. (2014). A new strategy to reduce design fixation: Presenting partial photographs to designers. Design Studies.

Chiu, I., & Shu, H. (2012). Investigating the effects of oppositely related semantic stimuli on design concept creativity. Journal of Engineering Design, 23(4), 271-296. Retrieved from http://dx.doi.org/10.1080/09544828.2011.603298

Crilly, N. (2015). Fixation and Creativity in Concept Development: The Attitude and Practices of Expert Designers. Design Studies 38, 54-91.

Dogan, F., & Nersessiam, N. (2010). Generic abstraction in design creativity: the case of Staatsgalerie by James Stirling. Design Studies 31, 207-236.

Eckert, C., & Stacey, M. (1998). Fortune favors only the prepared mind: why sources of inspiration are essential for continuing creativity. Creativity and Innovation Management, 7(1), 1-12.

Enkel, E., & Gassmann, O. (2010). Creative imitation: exploring the case of cross-industry innovation. R & D Management 40(3), 256-270.

Finke, R. (1996). Imagery, creativity, and emergent structure. Consciousness and Cognition, 5(3), 381-393.

Freeman, A., & Golden, B. (1997). Why didn't I think of that? Bizarre origins of ingenious inventions we couldn't live without. New York: John Wiley.

Fu, k., Chan, J., Cagan, J., Kotovsky, K., Schunn, C., & Wood, K. (2013). The meaning of "near" and "far": the impact of structuring design databases and the effect of distance of analogy on design output. Journal of Mechanical Design 135(2), 021007.

Gentner, D., & Markman, A. (1997). Structure-mapping in analogy and similarity. American Psychologist, 52(1), 45-56.

Goldschmidt, G., & Sever, A. (2011). Inspiring design ideas with texts. Design Studies, 32 (2), 139-155.

Goldschmidt, G., & Smolkov, M. (2006). Variances in the impact of visual stimuli on design problem-solving performance. Design Studies, 27(5), 549-569.

Jasson, D. G., & Smith, S. (1991). Design fixation. Design Studies 12(1), 3-11.

Keller, A., Pasman, G., & Stappers, P. (2006). Collections designers keep: collecting visual material for inspiration and reference. CoDesign, 2(1), 17-33.

Liikkanen, L., & Perttula, M. (2008). Inspiring design idea generation: insights from a memory-search perspective. Journal of Engineering Design, 21 (5), 545-560.

Linsey, J., Clauss, E., Kurtoglu, T., Murphy, J., Wood, K., & Markman, A. (2011). An experimental study of group idea generation techniques: understanding the roles of idea representation and viewing methods. ASME Journal of Mechanical Design 133. 031008.

Marsh, R., Ward, T., & Landau, J. (1999). The inadvertent use of prior knowledge in a generative cognitive task. Memory & Cognition, 27(1), 94-105.

Perttula, M., & Sipilä, P. (2007). The idea exposure paradigm in design idea generation. Journal of Engineering Design, 18(1), 93-102.

Purcell, A., & Gero, J. (1996). Design and other types of fixation. Design Studies, 17(4), 363-383.

Sio, U., Kotovsky, K., & Cagan, J. (2015). Fixation or Inspiration? A Meta-Analytic Review of the Role of Examples on Design Processes. Design Studies 39, 70-99.

Tseng, I., Moss, J., Cagan, J., & Kotovsky, K. (2008). The role of timing and analogical similarity in the stimulation of idea generation in design. Design Studies, 29(3), 203-221.

Verstijnen, I., Hennessey, J., Leeuwen, C., Hamel, R., & Goldschmidt, G. (1998). Sketching and creative discovery. Design Studies 19, 519-546.

Ward, T. B. (1998). Analogical distance and purpose in creative thought: mental leaps versus mental hops. In K.J. Holyoak, D. Gentner, & B. Kokinov (Eds), Advances in analogy research: Integration of theory and data from the cognitive, computational, and neural sciences, 221-230.

Youmans, R., & Arciszewski, T. (2014). Design fixation: classifications and modern methods of prevention. Artificial Intelligence for Engineering Design, Analysis, and manufacturing, 28 (2), 129-137.

Zhang, J., & Norman, D. (1994). Representations in distributed cognitive tasks. Cognitive Science Journal, 18(1), 87-122.

About the Authors:

Jeff Feng is a design educator with over 25 years of research and design experience in the industries of healthcare, consumer electronics, product packaging, etc. His work has been published in ID magazine, Metropolis magazine, Medical Design, Appliance Design magazine.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Studying Material Interactions to Facilitate a Sense of Being with the World

Bilge Merve AKTAS[a]*, Camilla GROTH[b]

[a] Aalto University, Finland
[b] University of South-Eastern Norway, Norway
*Corresponding author e-mail: bilge.aktas@aalto.fi
doi: https://doi.org/10.21606/drs.2020.229

Abstract: Material interactions are fundamental to design and craft education; however, they might also provide opportunities to reflect on sustainable behaviour in general. In this paper, we present an interdisciplinary undergraduate course in which students interacted with clay and wool. By engaging novices in material-based craft processes, we examined renewed ways of experiencing the materials to reconsider our everyday material interactions and our dependency and responsibilities in regard to materials in general. Through this example, we discuss the potential of craft practice as an educational platform to discuss materiality and to facilitate a deeper and more holistic understanding of the consequences of our material behaviour beyond the creative practices. The students' reflections over the five weeks touched upon their renewed appreciation of materials, and their changed interactions with materials – moving towards a dialogical stance rather than only using them as a means to an end.

Keywords: design education; material exploration; interdisciplinary; novice makers

1. Introduction

The present environmental crisis indicates that we are not fully aware of the destructive extent of our material engagements. Understanding that we co-exist with our environment, animals and materials can change our thinking and behaviour from being destructive to becoming more inclusive and sustainable. In this study, we utilised craft practice as an educational platform to examine ways of engaging with and thinking about materials. Experiential knowledge of materials is built through personal engagement with material environments and material explorations (Groth, 2017; Aktaş, 2019; Nimkulrat, 2012). Reflecting on these experiences can also evoke a deeper understanding of human-material interactions in our everyday lives. Crafting requires co-operation between mind, hand and material (Sennett, 2013) that facilitates thinking while making (Ingold, 2013; Nimkulrat, 2012). Craft processes can, thus, illuminate material interactions more clearly and propose new ways to experience the materials.

Experiences emerging from material interactions shape our ways of thinking and behaving (Malafouris, 2013, p. 44). Therefore, we may perceive them as active factors in our everyday lives. Seeing material in a more active way has been studied to some extent within making processes, particularly to understand how they shape the emergence of an artefact through the intentions of the maker (Bolt, 2007; Ingold, 2010). Materials have also been studied to understand how the designer's decisions and the user's interactions can be interwoven through material qualities and the notion of *materials experience* (Karana, Pedgley & Rognoli, 2014).

In the present study, we examined the performativity of materials in the making processes and its contribution to new ways of interacting with them, not from a technical and solution-oriented viewpoint but from a reflective one, by studying personal experiences. Rather than working with professional craftspeople, we chose to work with university students who were mostly novice makers as we expected them to be sensitive to their new encounters. Thus, they could potentially reflect on making activities with a fresh lens that was not motivated by using the material as a means to an end.

The five-week-long *Human-Material Interaction* course familiarised students from multiple disciplines with the notions of material interaction from a theoretical, embodied, shared and societal point of view through lectures. In addition, the students concretised their theoretical learning through hands-on material ideation and experimentation.

The aim of the course was not to teach a new practice but a new way of experiencing the materials and to challenge established ways of thinking about materials. The hands-on materials experience was used as an educational tool for critical thinking by employing the materials as the main learning setting (as described also in Mäkelä & Löytönen, 2017, p. 254). As teachers, we initiated discussions about how our experiences are affected by materials and how our actions impact on our material surroundings. The empirical data used for this study consists of the reflective texts of eight of the 15 students in this course.

The analysis indicates that the bodily experiences of materials triggered a self-reflective process in which students challenged their established understandings of materials as inert instruments. Next, we present some theoretical views that underpin the study. Then we present the setting and the study, and finally, we discuss how studying material interaction through craft practice can generate critical questions about our everyday material engagements.

2. The role of the material in the process of making

In our everyday encounters, due to their different qualities, our experiences with materials affect how we feel, think or behave (Karana, Pedgley & Rognoli, 2015, p. 19). Political theorist Jane Bennett (2010) writes about material's power to affect us, and she calls this the *vitality of matter.* She argues that things and materials, or nonhumans in general, are vibrant, active, and creative since even when there is no contact with humans, materials continue transforming and making recognisable change (ibid. p.93). Thus, according to Bennett, the attentive power of things significantly shapes the world and affects human experiences (Ibid. p. 93).

Design researchers Elvin Karana, Owain Pedgley and Valentino Rognoli (2015) also refer to the activeness of materials and how this continues even when the material is transformed into an artefact. They argue that "A material ages with its users, matures in time, carries the traces of one's life span, facilitates the recall of memories, and relates one to the familiar and usual" (Ibid. p. 24). Focusing on the experience aspect of material engagement can significantly contribute to the meaningfulness of our material interactions. Understanding materials experience is important for designers and design students as through these, they can ideate and develop new products or user experiences (Karana, Barati, Rognoli, & Zeeuw van der Laan, 2015; Tung 2012; Mäkelä & Löytönen, 2017; Nimkulrat, 2010; Pedgley, 2019).

However, not only designers or craft practitioners interact with materials. Therefore, we find critically studying human-material interaction necessary to point to the urgent need for changing our behaviour with materials. A more attentive attitude towards material interaction may have the capacity to make a difference in our behaviour with the environment at large. Acknowledging this capacity can stimulate and provide a wider understanding of the lifespan of the material that is not limited to the direct engagement with products but also includes how the raw materials are obtained and what happens to them at various stages.

Crafting is a powerful platform to study material interaction since it conveys universal values contextualised locally through "social and cultural, economic and ecological settings" (Niedderer & Townsend, 2018, p. 196). Being local and universal at the same time enables craft-practitioners to start discussions based on personal experiences that are globally relevant (ibid.). Also, importantly, craft-making connects materials with body and mind through a dialogical relationship (Brink & Reddy, 2019; Sennett, 2013; Mäkelä, 2016). As anthropologist Tim Ingold (2010, p. 97) argues, while practitioners engage with materials, they follow the material properties to let the final artefact emerge. The maker travels *with* the material to *look with* it as the work unfolds (ibid.). While making, the maker is not expected to force a preconceived idea, but rather to collaborate with and listen to the voice of the material (Pallasmaa, 2009, p. 55).

In this dialogue, while making, we constantly follow the material's responses and re-evaluate our own intentions to accommodate the material's resistances and movements (Aktaş & Mäkelä, 2019, p. 64; Pickering, 1993, p. 576). The resistances and challenges emerging from the materials are also needed for the development of the maker's skills (Pallasmaa, 2009, p. 63). As Ingold (2012, p. 434) states, a craft skill is gained through learning how materials behave and how to be with these material challenges. This interaction grows into larger meanings for craft, which acknowledges existing knowledge, while also going beyond them and presenting new modes of knowing (Barrett, 2007, p. 118).

Similarly, archaeologist Lambros Malafouris (2013, p. 9) argues that material engagement actively shapes and co-constitutes the ways we think within an extended dimension of the material surroundings. According to Malafouris (2013), thinking occurs between brains, bodies and things, and this process is affected by people, artefacts, time, and space (p. 67). Through the engagement between the material and the body “the world touches us” and we understand “how this world is perceived and classified” (Ibid. p. 60).

Therefore, as philosopher Mark Johnson (2007, p. 265) argues, through our bodily coupling or interacting with the material environment we also understand abstract concepts or the meanings of things. We can further these meanings by following the possibilities emerging from our bodily interactions, and how they propose new connections or relations (Ibid., p. 265).

Ingold (2013, p. 8, 110-111) proposes that we are always part of the surrounding and our personal knowledge grows from, around and between being in the world. He argues that knowing and learning should come from inside practice and should emerge through being *with* it (p.10). Similarly, we propose that understanding human material interaction can shift our perspective from being in the world to *being with the world*. Such intense engagement with materials encourages a dialogical rather than dominating relationship between self and the material (Brink & Reddy, 2019). Material engagement, thus, becomes a co-constitution of the material and the practitioner. This discussion is especially important when our knowledge about a certain material is limited, as in the case of novice practitioners, or because the material is recently developed (Niinimäki, Kääriäinen & Groth, 2018).

According to research on expertise, novice makers follow rules to produce an artefact in a context-dependent way (Dreyfus, 2004, p. 177). As they gain experience, they learn how to handle various tasks simultaneously, and later they are able to lean on their skills intuitively.

Struggling with material resistances and experiencing the complex conditions emerging from the struggle can change dominating knowledge types or behaviours (Haraway, 1991, p. 68). Our idea was that if novice makers construct their material knowledge from a dialogical perspective rather than through a set of rules for controlling the material, then their material relationship could develop freely. They could then reconsider their sense of ownership of the material and the process of creating the artefact, the latter moving from being a dominance-oriented one to a dialogical one. To further elaborate on these thoughts, in the next section, we will present the course design and learning outcomes.

3. The Human-Material Interaction Course

The course was offered through the University-Wide Art Studies (UWAS) platform at Aalto University that aims at engaging undergraduate students with arts-based transdisciplinary thinking. UWAS presents a wide selection of arts-based elective courses to challenge students’ thinking and widen their perspectives across disciplinary boundaries. The idea is that by working in a diverse group and discussing problems from many angles, the students might be better equipped to build a common language and tackle complex problems and societal issues in the future.

To facilitate good discussions and to be able to handle the material processes and reflections of the students qualitatively, we set the maximum participants at 15 students. The course was conducted in spring 2019 with 15 students from the departments of electrical engineering, computer science, business, arts and design. Data from eight of these students has been analysed in this present study. Informed consent regarding their participation in this study, including consent to the use of images and data in publications, was gathered from all participants

Most of the students were novices, either in craft/design or to the material they used. Only one design student had been working with clay after primary school, the other students stated that their materials were new to them. As the course aimed at discussing materiality in creative making processes, we incorporated theoretical readings and lectures with hands-on craft making at the university's makerspaces and studios.

Each class was conducted in three parts: in the first part, the students discussed the course literature that they had read before the class, exchanging reflections on the readings that introduced that day's discussions on the topic of materiality and covered concepts such as experiential knowledge, material resistance and affordance, material agency and non-representational theories. This was followed by a 20 minute-lecture in which the teachers articulated the concepts further, connecting them to design and craft practices, and facilitated a discussion on students' interpretations of these ideas in relation to their own material processes.

The second part took place at the studios in which students worked independently but next to each other. Working at the studio provided a safe environment with peers around to exchange experiences and receive teacher-guidance when needed. Their making processes continued independently in their own time, which encouraged experimentation and provided freedom (Figure 1). After a couple of hours spent in the workshops, the group reassembled for a shorter reflection meeting in the lecture room to exchange their experiences.

Figure 1 Two students felting at the studio. Photo by Aktaş.

The students were free to choose their own materials, but we initially offered two materials to the students: clay for ceramics and wool for felting. These materials were selected since they were materials that the teachers have been working with in their research. Selecting materials that the teachers were competent in facilitated deeper conversations with the students. The students were given some demonstrations of the materials and also experienced the materials themselves by touching and manipulating them. Then they were asked to choose one of the materials to work with during the course. In the first two weeks, we encouraged the students to be explorative with the materials to understand their properties and aesthetic features. To deepen the discussions, the second author helped each student individually to throw clay on the potter's wheel while blindfolded. This exercise was designed to reduce the powerful impact of sight and let other senses experience the material (Groth, Mäkelä, Seitamaa-Hakkarainen, 2013).

The students were also asked to work with their material blindfolded sometimes to experience the material's haptic properties. Beginning with the third meeting, we encouraged the students to focus on one aspect of their material interactions and emphasise that experience or feature in their processes towards their final artefact. The students were also handed diary notebooks and encouraged to document their explorations and reflections as part of their making and thinking practice by taking notes, drawing and photographing (Figure 2). This was a new way of working for many of the science and business students, as were the studio-based material explorations and practices.

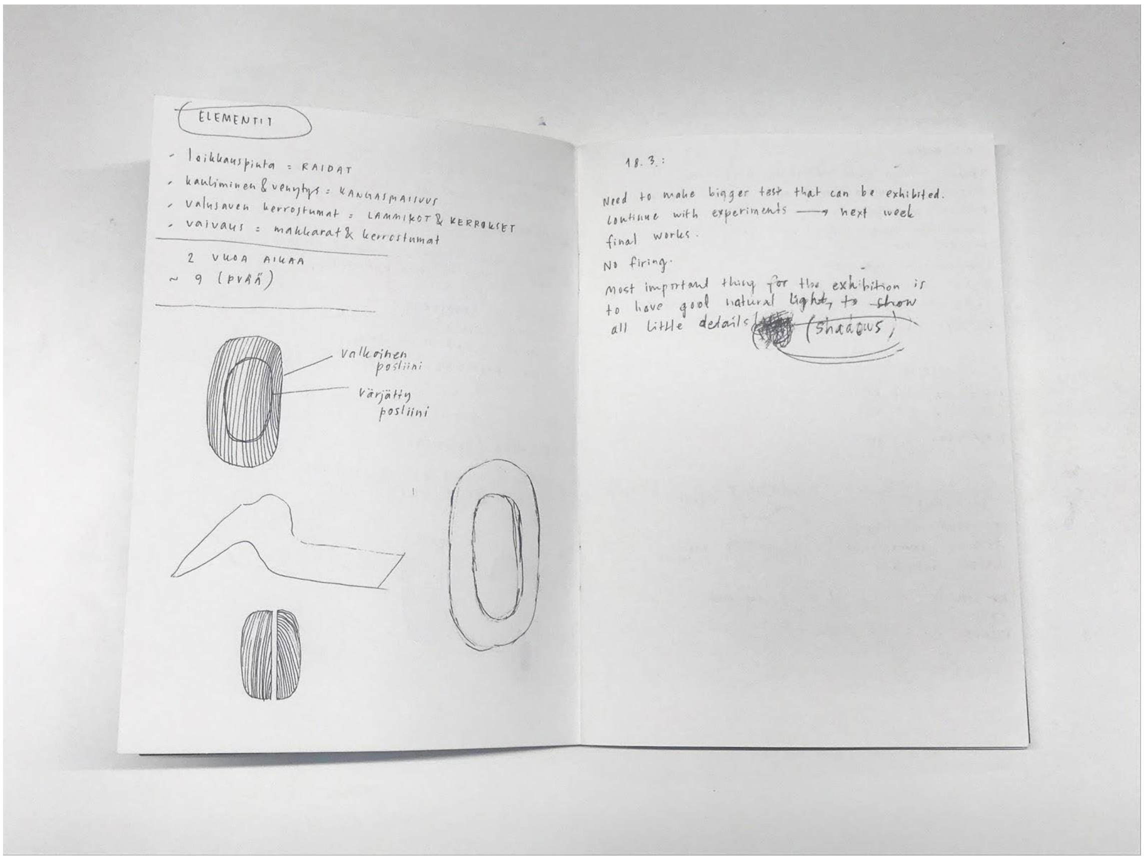


Figure 2 A reflective diary page depicting the textures of the material. Photo by Aktaş.

Our role as teachers, when in the workshops, was limited to being facilitators and to asking the students questions in order for them to articulate their thoughts. We started discussions and encouraged them to share their opinions and challenge the newly introduced concepts of the theoretical lectures.

Previously, other scholars that share similar ambitions also employed designerly methods, such as explorative making or reflective writing. Some also propose new methods, such as material-driven design (Karana, et.al. 2015), material-based design (Oxman, 2010), or DIY materials (Rognoli, Bianchini, Maffei & Karana, 2015). These approaches often seek new aesthetic experiences through material innovations by bringing design, science and technology together (Rognoli et.al. 2015). Although we used similar tools, our study differs from these examples as we do not aim to develop new materials or products in this course, but rather to generate a modus of experiencing and being *with* the world.

3.1 Explore, Adapt, Overcome

After working with the materials for five weeks and reflecting over material interaction in several ways and modalities, the students completed their final artefacts and prepared for the exhibition at the university gallery. They ideated the name and poster independently and entitled their exhibition “Explore, Adapt, Overcome” to describe their creative processes (Figure 3).

Figure 3 On the opening day of the exhibition, the interdisciplinary student group presented their work to their course mates and their teachers in a crit typical for courses in creative subjects. Photo by Groth.

Some of the works presented were the outcomes of explorations rather than finished art pieces. We selected exhibition as a method of assessment to increase the sense of responsibility and community. Being part of a public event with their course mates also provided a dynamic exchange among the students. By exhibiting one's work, the maker can see his/her work from the viewer's standpoint while a viewer can see the work from the maker's standpoint (Nimkulrat, 2010, p. 75). Thus, having a group exhibition provided a dynamic communication not only between students but also between the final works and the viewers. To facilitate such communication, the students prepared a final oral presentation and wrote a short reflective essay on their creative process and the artwork to be displayed next to the artefacts.

4. Reflections on the students' processes

The final assignments and the reflective diaries during the course constituted the main empirical data of this study. The first author also conducted notes in the teaching sessions while the students were discussing and reflecting over their experiences and the theoretical aspects of the course. We studied the students' texts through thematic analysis (Fereday

& Muir-Cochrane, 2006), and after reading the texts several times we searched for places where mention was made of material engagement and reflections on material experiences.

To find this information, we coded repetitions, use of unique words, metaphors and transitions between different topics. Later, we grouped these codes as large themes to understand patterns in their thinking (Braun & Clarke, 2006). Identifying these themes for each student's text provided basis for seeing similarities and differences between their reflections (Ryan & Bernard, 2003). The key themes emerging from the texts revealed how the students developed their reflective and critical thinking in relation to their creative processes and prior knowledge. The analysis also highlighted how students make sense of their experiences (Braun & Clarke, 2006, 78; Fereday & Muir-Cochrane, 2006, p. 81).

Some key themes emerging from the texts were related to (i) getting to know the material and its behaviour from a new perspective, both with and without human presence, (ii) referring to previous knowledge and experiences to make connections, and (iii) referring to natural environments that they had encountered earlier, such as being on a beach. While identifying these themes, we found that bodily experiences emerging from the craft-making facilitated thinking beyond the crafting activities.

The students bonded various senses together, such as the smell of the material and the studio, hearing the sounds coming from the surrounding and the tools, with particular attention to their use of their hands. Their thinking emerged through their peers, tools, and studio space, or in Malafouris's (2013, p. 67) words, within people, things and space. Being open to these multidimensional experiences also required accepting their lack of skill as a new angle to discover the material's properties. The students elaborated on the material's properties, nature-related features, transformations, movements, and what the material seemed to demand from them. While making, they studied both the material itself and their own relation to the material in a dialogical manner.

These findings encourage us to speculate on how first-hand material experience provides an educational platform to challenge the current understanding of materials and material environments more dynamically and collaboratively. Studying the first author's observational notes that she had written down after each class meeting also supported this examination. In the next section, we will present some quotes from the students' texts to exemplify how they articulated their experiences of the materials.

4.1 The student reflections

Often, the reflections of the students sought for co-operation between them and the material. Being open to the voice of the material and their bodily interactions with the material started a new dialogue that pointed at a more holistic understanding of material engagement. The initial experiences in the course helped students understand the materials' behaviour and how they could interact with them. One of the students examined the durability of the wool fibres, so he developed a form based on the properties of the materials.

> “The black wool that was used to craft this piece was so fragile, it was easy to pull apart with little force. After wet felting … the felt piece here is significantly sturdier than wool. This transformation had relatively little to do with me. Rather, it’s an intricate property innate to the material that I tried my best to explore and showcase.” (a computer science student, Figure 4)[1].

Figure 4 A student’s exploration of wool. Artefact presented in the student exhibition. Photo by: Aktaş.

The students also referred to how the tools and surrounding environment actively affected their experiences while interacting with the material. For several students, previous material experiences and prior knowledge played a significant role in how they interpreted the material’s possibilities. This also enabled them to interpret the concept of material agency in their own ways. They also referred to their embodied knowledge of other practices and discussed them as part of their reflections on the readings and the material interactions:

1 The texts from reflective diaries were written in English by non-native speakers and they have been edited slightly for clarity.

> "Embodied skills make me think of sports - in my case volleyball - … it can happen that a player is rewarded as the most valuable player (MVP). This can make people – or even players – think that the MVP did it, he won the game, he scored the most points. But actually, it is the global situation that allows him to score those points. The opponents made the mistakes and lost the ball, the MVP's teammate gave him the perfect set, the teammate sitting on the bench encouraged him to make the MVP more confident, the light of the gym was perfectly fitting with the sensitivity of the MVP's eyes." (reflection made by a business student).

Both in the final written assignments and in the reflective diaries, the students discussed their works in relation to their prior experiences by explaining what the *material experiences remind them of.* We interpret this as an attempt to make their experiences meaningful for the projects or interpret the abstract concepts in a way that is more personally relevant. This phenomenon also shows that the experience of the material is remembered and retriggered in the next similar encounter; thus, previous interactions can be revisited to find familiarity (Karana et.al. 2015).

As a result of experiencing the activeness of the material and the dynamism built around these interactions, some students questioned concepts, understandings, and approaches that are deeply embedded in creative fields. For instance, one student questioned the idea of functionality as this may be seen as solely human interest and how we can move from a function-oriented making process to an experience-oriented one. Another project, by a design student, focused on the aesthetics of the material as opposed to the aesthetics of the maker. She examined the use of tools and worked with the ways the tool marks left their presence on the artefact as an aesthetically valuable aspect instead of an error (Figure 5).

Figure 5 A design student worked with the clay to develop material-based textures and tool marks. Photo by: Aktaş.

In her project, she reflected more on the responsiveness of the material and questioned the sense of controlling the processes. As teachers in the course, we connect this to the understanding that when makers articulate their practical and theoretical knowledge through iterative making, they transfer their understandings of abstract concepts to their artefacts, too (Pöllänen, 2009, p. 255; Johnson, 2007 p. 228). This was also visible in the student's final text and artefact:

> "The main aim was to leave room for the material to show its features and emphasise the traces that are left during the process of making, either through hands or from the tools that are used. As a designer with a strong background in ceramics, the process of making is often tightly connected to the end results and the fulfilling of my own expectations. I have realised that these expectations can often restrict the creative process and set limitations on the maker and the material. Through this work, I wanted to avoid any expectations and purely focus on the process itself by making room for tactility, serendipity and movement." (A design student, Figure 5).

Another interesting discussion that emerged from several students' reflections was taking on the idea of the material's life cycle. After experiencing the *vitality* of the material, the students started discussing what happens to the material when there is no human presence such as, how material generates its own patterns without humans or how clay cracks while drying overnight. For many of the students from fields other than the arts or design, these were interesting experiences as they could concretely observe how materials make changes "on their own". One computer science student reflected over the aftermath of the material:

> "It's obvious that humans don't understand materials as well as they might think they do … The extent of material produced by humans is hard to comprehend without seeing it, as is the permanence of inorganic man-made materials lying on landfills or floating in the ocean … Think about how the material came to exist, how you will make use of it, and how and when it will eventually cease to exist."

Overall, the students challenged themselves to truly understand what the material was like and what it could become. At the end of the course, the students' idea of what and how a material can be was significantly broader than a means to an end. For example, a business student wrote:

> "Materials are employed by us in order to produce something we need … in this sense, the relationship between human and material is unidirectional and dominated by humans. This is the way I recognised materials before. Nevertheless, even the first touch of clay altered my mind. It was sticky and heavy but gave rise to a desire to knead and play (with) it. So, it has magic. The subsequent production process is the exploitation of its magic for me, in a way."

The reflections indicate that the students were able to question their own perceptions of materiality in general, which were mostly built through societal understandings. Craft making became crucial in concretising abstract concepts and in making new personal interpretations of the material's capacity as the students experienced the dialogical nature and dynamism of their material interactions. One student visualised this process by showing the cycle between feedback (thinking) and decision (making) within the material environment while throwing clay on a potter's wheel (Figure 6).

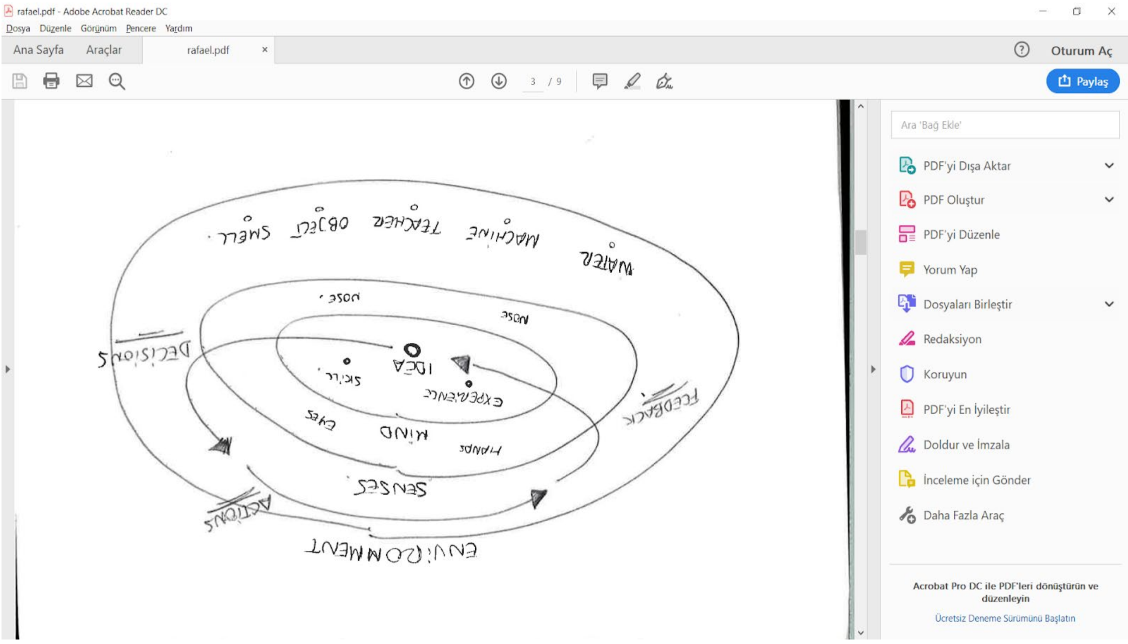


Figure 6 Visualisation of the material interaction by an electrical engineering student.

His drawing positions the responsiveness and dialogical nature of making in the centre and visualises how the surrounding elements come together in a sensible way. We believe that these material interactions helped students to position their actions in a wider context and understand the effects of other elements in their surroundings and how their own actions affect the environment. In the next section, we will discuss the potential of craft practice as an educational platform to discuss materiality and to widen the concept of sustainable material behaviour in contexts outside the creative practices.

5. Discussion

The final assignments and reflections indicate that for most students the process started with “losing control”. Several students referred to the importance of being open and attentive to the material features. Starting the course by blindfolded material explorations encouraged being with the material in a flexible and open-minded manner. Even when the students were frustrated at times because of the material resistance, they challenged themselves and continued working.

As the students documented their making sessions by writing and sketching in their diaries, they reflected on and articulated their thoughts, experiences and feelings further. Reflecting on craft making processes reveals the insider’s knowledge and how decisions are made during creative processes (Mäkelä & Nimkulrat, 2018; Groth, Mäkelä & Seitamaa-Hakkarainen, 2015). Reflections that emerge from craft making can inform both the practice and the theoretical understanding of the practice (Nimkulrat, 2012, p. 11). They also enable the reconstruction of the practice by reviewing processes and planning future material engagements (Aktaş, 2019). Thus, for the students, the documentation functioned both as a reflection on what they did and what they would do in the next session (Mäkelä & Nimkulrat, 2018, p. 12).

By using the craft experience to think about their material engagement, we encouraged students to also reconsider their other everyday material experiences. As the key themes that we identified from their texts suggested, students explored the materials, revisited their previous knowledge, and referred to their experiences of their natural environment to understand the material. These themes were later elaborated on in their material engagement, and the students reflected on the idea of controlling the material while interacting with it.

We found that first-hand material experiences facilitated a transition towards the sense of being *with* the world in five ways which emerged from the above themes. The reflections indicate that when the students employed an interactive way of working with the materials, they could understand their behaviour from a wider and more critical perspective, and follow the flow of the material rather than forcing through a preconceived idea (Bolt, 2007; Ingold, 2012; Pickering, 1993).

In this way, some students were ideating while making by employing material movements as a design element. Accordingly, the first-hand experiences enabled students to understand ***how the materials behave and how to be with the materials.*** In particular, starting the process through blind-folded working provided an invaluable experience for the students to “lose control” of the process and to become more open to material movements and their haptic sense.

Their journey included challenging their skills and established ways of thinking about material interaction, as well as developing the mental persistence to continue working *with* the material resistance rather than against it. Despite the frustration and intimidation of sometimes failing in their attempts, the students found their own ways to accommodate the material resistances (Pickering, 1993), by experimenting and perceiving making as a dialogue with the material (Mäkelä, 2016).

This process contributed to ***critically re-considering human-material interaction***. By provocatively looking at the materials as active participants of our everyday lives, students gained a wider perspective on what materiality means and how much it impacts our thinking and being in the world. As argued earlier, to make sense of the world and understand our position in it, it is necessary to recognise that material engagements shape thinking and making (Malafouris, 2013, p. 44). In a sense, the students stayed with the material resistances to find different ways to be with the material and what to do with it. They, as makers, were no longer dominating but following the intuitive flow of material transformations.

To concretise the new conceptual knowledge and review their existing knowledge from a new perspective, the students referred to their previous experiences and personal knowledge. This indicates that we need ***prior experiences to make sense of what we are experiencing today.*** Our previous knowledge and skills facilitate making sense of new materials and finding ways to overcome challenges emerging from new materials (Groth & Mäkelä, 2016, p. 18). This also enables us to understand our past experiences in relation to new ones (Haraway, 1991; Fredriksen, 2011). In our study, reviewing prior knowledge also enabled students to find ways to develop their own interpretations and ways of interacting with the material.

At the end of the course, the students were using the word ***material in a broader meaning***, referring to media, nature, and light as materials and actors in their projects. This also shifted the idea from one of using materials to one of working with them (Pallasmaa, 2009; Ingold, 2010). They also referred to their materials as a resource to learn a craft skill. In connection to the concept of experiential knowledge, students argued that listening to the *voice* of the materials can become a significant way to learn new knowledge, since "the material teaches the craftsman about its capabilities and limitations" (reflection by a computer science student), (See also Mäkelä & Löytönen, 2017).

As Bennett (2010, p. 12) proposes, we need to ontologically shift the ways we understand the material to overcome hierarchical social constructions. These constructions affect the ways we perceive the world, and the current situation indicates that this perception has been destructive. Thus, with this course, we aimed at starting a discussion on how we engage with materials and what other ways there might be than the normative.

We could observe that a shift in perspective was emerging from the course, and the students' material processes ***re-conceptualised established human values*** such as aesthetics or functionality. These re-conceptualisations offered to embrace the features emerging from the material as opposed to seeing them as failures, mistakes, or errors. This approach also questioned the idea of humans as owners of the materials and the world and instead emphasised co-existence and co-evolvement with it. Considering the growth in developing bio-based materials, most designers and makers will be novices in working with these materials. Thus, we need further studies to widen our perspective on material interactions that include environmental sustainability as well as ethics (see, for example, Niinimäki, Groth & Kääriäinen, 2019).

6. Conclusion

Our current ways of thinking about our interactions with materials are insufficient to understand the results of our actions. Often, our understanding of a material is limited to the engagement period, paying insufficient attention to how the material is before the interaction begins and after the interaction is completed.

By using craft practice as an educational platform in this study, the students engaged in reflections on material interactions and triggered critical thinking that could possibly also affect behavioural change. The thought-provoking concept of material agency, the notion of the "voice" of the material and a dialogical making process encouraged students to critically review their ways of engaging with their material surroundings.

A change in thinking about our relationship with the material environment begins on the personal level. Utilising first-hand experiences to understand human material interaction can become a powerful tool to better understand how we should interact with materials in a responsible and respectful way, realising that humans do not own or dictate but collaborate with materials. In our study, we observed a change in students' thinking and the benefit of having such an interdisciplinary group of students enlarged the scope of discussion beyond the individual and the specific disciplines.

7. References:

Aktaş, B.M. (2019). Using Wool's Agency to Design and Make Felted Artefacts. RUUKKU. Number 10. https://www.researchcatalogue.net/view/453632/453633

Aktaş, B.M & Mäkelä, M. (2019). Negotiation Between the Maker and Material: Observations on Material Interactions in Felting Studio. International Journal of Design. 13(2), 55-67.

Barrett, E. (2007). Experiential learning in Practice as Research: context, method, knowledge. *Journal of Visual Art Practice*. 6(2): 115-124.

Bennett, J. (2010) *Vibrant matter: a political ecology of things*. London: Duke University.

Bolt, B. (2007). Material Thinking and the Agency of Matter. *Studies in Material Thinking*, 1(1), 1-4.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Brink, I & Reddy, V. (2019). Dialogue in the making: emotional engagement with materials. *Phenomenology and the cognitive sciences*. Springer, Netherlands, July. 1-23. Retrieved on July 8th from: https://doi.org/10.1007/s11097-019-09629-2

Dreyfus, S. (2004). The Five-Stage Model of Adult Skill Acquisition. *Bulletin of Science, Technology & Society*, 24(3), 177-181.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, 5(1), 80-92.

Fredriksen, B. (2011). When past and new experiences meet. *FORMakademisk Journal*, 4. (1) 65-80

Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2013) Making Sense - what can we learn from experts of tactile knowledge? *FORMakademisk Journal*, 6, (2), 1-12.

Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2015) Tactile Augmentation: A multimethod for capturing experiential knowledge. Craft Research, Intellect, UK 6, (1), 57-81

Groth, C. & Mäkelä, M. (2016) The knowing body in material exploration. *Studies in Material Thinking*, AUT, University, Australia. 14, article 02.

Groth, C. (2017). Making sense through hands: Design and craft practice analysed as embodied cognition (Doctoral Dissertation). Aalto University, Espoo, Finland.

Haraway, D. (1991). *Simians, Cyborgs, and Women: the reinvention of nature*. London: Free Association Books.

Ingold, T. (2010). The textility of making. *Cambridge Journal of Economics*. 34: 91-102.

Ingold, T. (2012). Toward an Ecology of Materials. *Annual Review of Anthropology*. 41, 427–42.

Ingold, T. (2013). *Making: Anthropology, Archaeology, Art and Architecture*. New York: Routledge.

Johnson, M. (2007). *The meaning of the body.* Chicago: Chicago University Press.

Karana, E., Pedgley, O. & Rognoli, V. (2014). *Materials Experience: Fundamentals of Materials and Design*. Oxford: Elsevier.

Karana, E., Barati, B., Rognoli, V., & Zeeuw van der Laan, A. (2015). Material driven design (MDD): A method to design for material experiences. *International Journal of Design*, 9:2, pp.35-54.

Karana, E., Pedgley, O. & Rognoli, V. (2015). On Materials Experience. *Design Issues*. 31: 3 pp. 16-27.

Malafouris, L. (2013). *How Things Shape the Mind: a theory of material engagement*. London: MIT Press.

Mäkelä, M. (2016). Personal exploration: serendipity and intentionality as altering positions in a creative practice. *FORMakademisk*. 9(1), 1-12.

Mäkelä , M. and Löytönen, T. (2017), 'Rethinking materialities in higher education', *Art, Design & Communication in Higher Education*, 16:2, pp. 241–58, doi: 10.1386/adch.16.2.241_1

Mäkelä, M. & Nimkulrat, N. (2018). Documentation as a practice-led research tool for reflection on experiential knowledge. *FORMAkademisk*. 11(2), Art 5, 116

Niedderer, K. & Townsend, K. (2018). Making sense: Personal, ecological and social sustainability through craft. *Craft Research* 9(2): 195-200.

Nimkulrat, N. (2010), 'Material inspiration: From practice-led research to craft art education', *Craft Research* 1, pp. 63–84, doi: 10.1386/crre.1.63_1

Nimkulrat, N. (2012). Hands-on intellect: Integrating craft practice into design research. *International Journal of Design.* 6(3), 1-14.

Niinimäki, K., Kääriäinen, P. & Groth, C. (2018). *NEW SILK*: Studying experimental touchpoints between material science, synthetic biology, design and art. *Temes de Disseny Journal*, 34.

Niinimäki, K., Groth, C. & Kääriäinen, P. (2019). New Silk: Exploring design-science collaboration for new materials. *Clot magazine*, March 23.

Oxman, N. (2010). Material-based Design Computation. PhD Thesis at the Department of Architecture at Massachusetts Institute of Technology.

Pallasmaa, J. (2009). *The thinking hand: Existential and embodied wisdom in architecture*. Chichester: John Wiley and Sons.

Pedgley, O. (2019). Rapid Development of Materials Experience through Active Learning. In the Proceedings of DRS LearnxDesign pp. 521-530.

Pickering, A (1993) The Mangle of Practice: Agency and Emergence in the Sociology of Science. *American Journal of Sociology*. 99(3): 559-589

Pöllänen, S. (2009). Contextualising Craft: Pedagogical Models for Craft Education. *Journal of Art and Design Education*, 28(3): 249-260.

Rognoli, V., Bianchini, M., Maffei, S., & Karana, E. (2015). DIY materials. *Materials & Design, 86, 692–702.* doi:10.1016/j.matdes.2015.07.020

Ryan, G.W. & Bernard, A.R. (2003). Techniques to Identify Themes. *Field Methods* 15(1), 85-109.

Sennett, R. (2009). *The Craftsman*. London: Penguin books.

About the Authors

Bilge Merve Aktaş is a doctoral candidate in design at Aalto University, Finland. She holds a BSc degree in Industrial Product Design from the Istanbul Technical University and a MA degree in Design, Technology and Society programme from Koç University in Istanbul. Her research interests include textile crafts, design processes, practice-led research.

Camilla Groth apprenticed in ceramic crafts, studied ceramics and glass design (RCA, London) and holds a PhD from Aalto University. She is a post-doctoral researcher, University of Gothenburg, and a 20% Associate Professor in arts and crafts at the University of South-Eastern Norway. Her research interests include experiential and embodied knowledge and materiality.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Unfolding passion: Autoethnography on the emergence and impact of teacher's passion in the design studio

Miikka J. LEHTONEN[a]*, Gionata GATTO[a]*

[a] Dubai Institute of Design and Innovation, United Arab Emirates
*Corresponding author e-mail: miikka.lehtonen@didi.ae
doi: https://doi.org/10.21606/drs.2020.335

Abstract: While literature on (design) education understands passion as positively impacting learning experiences, our point of departure in this paper is to ask whether too much passion can be detrimental in the design studio. Using our autoethnographic accounts as design educators in a university recently established in the Middle Eastern and North African (MENA) region, we make visible broader social structures that granulate our analytical understanding of passion in the design studio. More specifically, our experiences highlight the temporality and contextuality of passion, and drawing on sociological studies on emotion work, we refer to the actions that individuals take to manage their passion as passion work. As passion work is a collection of activities balancing between individual desires and institutional frameworks, our findings contribute to the growing body of design education knowledge, with a conceptual lens oriented to unfold possible modes of passion-writing and its manifestations in the design studio.

Keywords: passion; passion work; design education; autoethnography

1. Introduction

> IDEO Shanghai is in search of a Design Research Lead who is passionate about leading project teams, adept at uncovering human-centered insights, and skillful at translating these insights into meaningful opportunities for design and innovation. (IDEO Shanghai job advertisement for design research lead, accessed 18 November 2019)

> The Digital Producer is a creative and strategic thinker who is passionate about partnering to create amazing work. You will work closely with creative, strategy and account teams. (Fjord job advertisement for digital producer, accessed 18 November 2019)

As the two excerpts above illustrate, passion has become a crucial currency in the contemporary design job market. It is no longer adequate to be good, but in order to pursue a career in design, passion is of utmost importance. In other words, passion has been understood by both practitioners and researchers as something that almost without exception yields positive impact or outcomes. Academic research also seems to support this as passionate people are often associated with positive outcomes stemming from their actions (Cardon, 2008; Cardon et al., 2009).

Given that design organizations seem to encourage their current and prospective employees to express their passion, how and from where do young designers discover about what they feel passionate? Moreover, given the importance of design schools in educating future generations of design professionals (Findeli, 2001; Frascara, 2007), how do design schools serve as sites for passion to emerge? More specifically, what is the role of design educators in exploring passion?

Especially the latter question serves as one of the foundations of this paper. If we consider design as a practice geared at future-making (Margolin, 2007) that moves plans and ideas from the inside to the outside (Kosonen, 2018), and passion as lived experiences of engaging with the power of possibilities (Solomon, 1976 in Greene, 1986, p. 74), then design and passion can be seen as deeply entangled. More specifically, following Vallerand et al. (2003, p. 756), we refer to passion as “a strong inclination toward a self-defining activity that one likes (or loves), finds important, and in which one invests a significant amount of time and energy”. As both passion and design are concerned with transformation, we build on this intersection to explore performative practices interconnected to the shifting perceptions of the self, the other and the environment by referring to this as passion work (as per Brown and Toyoki, 2013; Hochschild, 1979).

In this paper, we argue that passion work can emerge in the design studio, and here our role and inputs as educators are crucial in terms of enabling our students to learn what it means to feel passionate about design (Scagnetti, 2017). Granted, learning does not take place only within the confines of the design school (Chew, Lehtonen and Schilli, 2019), but since our paper deals with formal design education, passion for design outside the design school is left out of the scope of this paper. In this paper, we set forth the following research question:

> How do design educators communicate and manage their passion to the students, and how might these manifestations be connected with the design profession?

To the best of our knowledge there are no prior studies on passion in design education, which is why this paper is based on our personal experiences in joining a relatively new design school in the MENA region. We contribute to studies on design education by showing how exploring passion from a teacher’s point of view can offer novel vantage points to design profession and teaching design. With this, we wish to stimulate discussion on passion in design education and how reflecting on the different facets and the dialogical nature of passion can contribute to a more nuanced and transformative approach to teaching design (Greene, 1986, p. 72).

To accomplish this, we employ autoethnography (e.g. Boyle and Parry, 2007; Ellis and Bochner, 2000) as a research method that allows the researcher to talk about their personal experiences in order to broaden our understanding of specific phenomena (Wall, 2006; Xue and Desmet, 2019). Autoethnography has the potential to challenge existing societal norms by bringing into the conversation voices and issues often silenced or marginalized (e.g. McDonald, 2013; O'Shea, 2019). It has to be pointed out, however, that autoethnography is not a research method exclusive to the margins: as Tienari (2019, p. 577), a white male professor working in Northern Europe, writes, "by presenting myself as "different" from some essentialized autoethnographer, I am in fact positioning myself very much in the spirit of autoethnography". While we, an Italian and a Finnish male in our 30s, cannot say we represent the margins, the analytical strength in our autoethnographic accounts comes from the notion that we are working in a newly established higher education institutions in a cultural context that is foreign to both of us. Thus, having the roots of our professional identity in Europe's design tradition and now being located outside Europe allows us to simultaneously reflect on two institutional settings through our accounts.

The rest of the paper is structured as follows. First, we will go through relevant literature on passion, after which we separately offer our personal accounts based on existing frameworks on passion by focusing on its conceptualizations, antecedents and outcomes (as per Ruiz-Alfonso and León, 2016). Next, we will connect our personal accounts to discussions on design pedagogies, and this also serves as a springboard for providing future research avenues on how we could study passion in the design studio. Finally, concluding remarks note the end of this paper.

2. Literature review on passion in relevant disciplines

As Ruiz-Alfonso and León (2016) state in their systematic review on passion in education, scholarly interest towards passion within education has been gaining momentum since the beginning of this decade, and during these turbulent times, understanding the transformative capabilities of passion in teaching could not be more relevant. As Greene (1986, p. 72) writes: "teaching is oriented to provoking persons to care about what they are coming to understand […], to be concerned, to be fully present and alive". With this, Greene (1986) draws attention to passion as a catalyst for reflexive teaching.

Entrepreneurship research, on the other hand, has focused on how company founders can transmit their passion to the employees (Cardon, 2008). Covey's (2013) work, on the other hand, emphasizes the importance of educating people according to a whole-person paradigm, which sees intelligence as based on four interconnected capacities - vision, discipline, passion, and conscience. For Covey, the holistic intersection of these four capacities leads people to find their own inner voice and inspire others, establishing trust and developing shared vision. What is worth noting here, however, is that we know now passion to be present in internal and interpersonal aspects of people's life. In other words, passion is something that individuals experience within themselves and something that is enacted in relation to the surrounding socio-material context.

While passion has received less attention in studies covering design education, there is nonetheless a considerable body of knowledge focusing on interpersonal and embodied dynamics in design education (e.g. Findeli, 2001; Oak and Lloyd, 2016; Wang, 2010). While reasons for this interest are manifold, perhaps the most important factor here is that design education focuses on close interaction between the educator and the student in the design studio (Ferreira, Christiaans and Almendra, 2016; McDonnell, 2016). Similarly, in their study focusing on MA and PhD students, Addison (2011) investigated affect and emotions as essential elements of design pedagogies, and Luh and Lu (2012) explored the connection between cognitive styles and passion. What these studies seem to have in common is their call for more nuanced design education as Frascara (2007, p. 68) puts it:

> “We have to set the bar high enough that we abandon the idea of training designers, and get on with the practice of educating them, even if, in the end, they begin to think differently than us.” (Frascara, 2007, p. 68)

As design education places great emphasis on learning through thinking and making, we ought to pay close attention to what is going on in the design studio from a pedagogical point of view (Thoring, Desmet and Badke-Schaub, 2018). Through our autoethnographic accounts focusing on passion, we contribute to studies on design education by reflecting on our own pedagogical practices in the design studio.

To frame our reflections, we draw on studies in emotion work (Hochschild, 1979) and identity work (see e.g. Brown and Toyoki, 2013) that conceptualize ‘work’ in this context as the individual’s management of their feelings in relation to their self, interaction with others, and the surrounding structures and institutions. We refer to the enacted acts of passion in teaching and their reflections as ‘passion work’. In the instance of this paper, we see writing about passion as a way of highlighting and unfolding the individual’s reflective capacities in managing passion over time. This is in line with Vallerand et al.’s (2003) seminal study on passion as they, too, highlight the notion that passion is not something fixed, but instead fluctuates over time and space.

3. Setting the scene: Dubai Institute of Design and Innovation (DIDI) as a newly established design school in the MENA region

DIDI accepted its first students in the autumn of 2018, and as of writing this paper two cohorts have started their studies. DIDI was established to educate future design professionals to match the growing needs of the MENA region. While our university is not the first fully-fledged design school in the region, what makes the university’s Bachelor of Design curriculum special is its focus on cross-disciplinarity: after one year of foundation studies, our students choose two concentrations out of four (product, fashion, multimedia, and strategic design management), and we both are responsible for developing one of the aforementioned concentrations. While the faculty has a tremendous amount of freedom to develop the concentrations of which they are in charge, particular emphasis goes on discussing and negotiating ways to facilitate cross-disciplinarity within the institution. That is to say, while we are given relatively free hands to imbue our concentration with our passion, in practice we are also seeking ways through which we can collectively engage in passion work.

Given that the faculty has joined the university from different geographical contexts in order to create a new design school, it also implies we bring to the table our individual practices for expressing and enabling passion. Thus, studying passion work through autoethnography in such contexts becomes a performative act that enables analytical dances between personal and enacted experiences of passion. In the following section we will describe our individual journeys from passion's perspective, to illustrate how passion work emerges from interpersonal practices, institutional affordances, and reflections about them (see Figure 1 below).

4. Our journeys

In order to highlight our individual paths towards joining our current employer, we have decided to write our sections separately below. This has been done in order to maintain autoethnography's analytical power in shedding light on individual experiences. We connect these experiences on a more theoretical level through an analytical framework (Figure 1) that visualizes our standpoint to passion work, how passion emerges, and how passion and reflecting upon it are cyclical in nature.

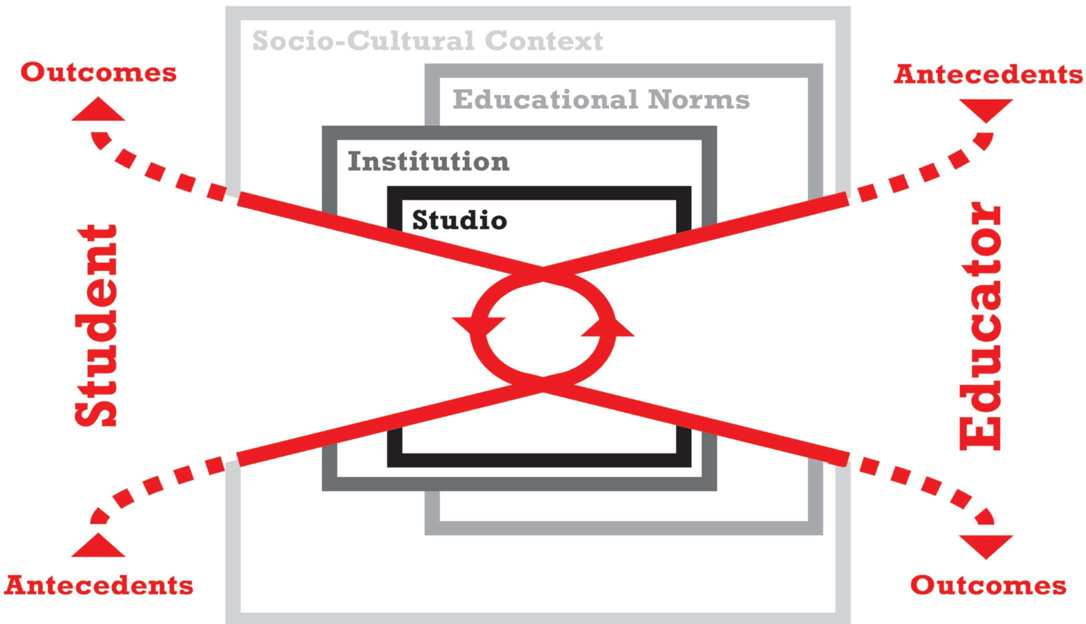


Figure 1 Analytical framework for passion in the design studio.

The framework above is based on prior literature on passion, our autoethnographic accounts as well as our conversations around them, thus illustrating the cyclical nature of passion. More specifically, to frame our journeys, we have focused on passion's antecedents, consequences, and manifestations (as per Ruiz-Alfonso and León, 2016): our aim is not to offer all-exhaustive accounts on passion in the design studio, but rather, in line with Tienari (2019), to explore how passion is intertwined with our identity as design educators.

4.1 First author's journey: heightened reflexivity through changing institutional frameworks

When I received my PhD from Aalto University in 2014, I moved to Tokyo and worked there in academia for three years before joining Aalto University again with a temporary contract. As my contract was ending, I was applying for jobs in Denmark and Japan without even considering my current country of residence as a potential location. However, the offer I received from DIDI was tempting content-wise, which is why I decided to accept the offer. My prior knowledge about the region or Dubai more specifically were limited to two short-term visits and what I had read from the news. In addition, I have several friends here, but I had never felt the urge to delve deeper into the cultural and societal matters. Thinking about this now, it fills me with a certain sense of shame as my preconceptions of the country were plagued by tourists' horror stories of getting into trouble with the officials. While my sense of shame is slowly waning, it is nonetheless a crucial element of my journey as I feel passionate about my career in academia, yet I was concerned to what extent could I let this manifest itself at and outside work.

While I was concerned about to what extent I could express myself at work, there was one incident during the recruitment process that greatly influenced my desire to join my new employer. This incident involved me dancing in a unicorn costume. I am one of the co-founders of Nordic Rebels, a movement aiming at transforming learning in higher education, and on our website (when the first interview was carried out) we had inserted a video of me dancing in a unicorn costume in my former employer's campus in Espoo, Finland. As I noticed during the Skype call the interview committee laughing at something, I could not stop myself from asking what made them laugh. Then they told me about the video, and at that point I was certain they would not choose me as I felt the video was 'too' passionate.

At Aalto University, I was pressured to remove the video and stop sharing it on social media, meaning that this was the perspective from which I was evaluating the interview committee's reactions. But during some of my first days in my new job, my supervisor started asking from me when do I start wearing the costume in class since all the students had been waiting for that. Hearing these words evoked contrasting emotions in me: it reminded me of the situation at Aalto University during which I was told to remove the video from the website. In that situation, I felt both betrayed and isolated since I thought there would be nothing harmful in me dancing in a unicorn costume given that one of the university's values focused on 'passion for exploration', and instead of having been provided with an opportunity to explain my actions I was only told 'a number of people' had expressed their dissatisfaction towards the video. Thus, I understood I had pushed the envelope too far, but was left without an explanation as to why this was the case. With this in mind, my current supervisor's question was also relieving in a sense that I was working in an environment where matters could be discussed. However, switching from being cautious to exploring my passion does not happen overnight, which is why it has been fascinating to reflect on how the institutional context affords, appreciates, and prevents certain kinds of behavior.

Another, somewhat contrasting, experience relates to physical proximity. Nordic countries have often been perceived as cultural contexts where respect for personal space is high, but at the same time hugging and other means of showing closeness through appropriate physical gestures have never been frowned upon. Especially after the #metoo campaign became a global phenomenon, I started reflecting on this issue especially within the context of interacting with my students. I would not, for instance, shy away if a student tried to give me a hug, and at the same time I would not try to hug my students out of respect for their personal space. Joining my current university, however, we were explicitly told it would not be appropriate for men to touch women based on religious customs. Being faced with this custom made me more aware of how I interact with the students, since in the beginning of the semester I felt a certain sense of distance. Granted, the students met me for the first time and vice versa, but I felt the no touching policy initially seemed to block me from showing to our students I was there for them.

No touching policy, however, provided me with opportunities to reflect on my bodily presence and how I have become sensitized towards students' signals that they are comfortable with me being passionate about what I teach. Instead of focusing my attention to whether I can reach out with my body or not, I started paying attention to bodily signals coming from the students. A local female student reaching out with her fist to bump it against my fist, for instance, was one of those moments I retrospectively have realized I do not have to be the initiator of passion: instead, giving space to the students to take the lead in signaling passion has made me understand the cyclical nature of passion.

Moreover, instead of equating passion and engagement with touch, I reflected upon and enacted on alternative tactics for communicating to our students I was passionate about the topic I was teaching. For instance, when giving lectures on topics I feel I know enough about, I have noticed myself pacing in front of the classroom to portray a sense of excitement about the topic. Conversely, being the only person teaching in my concentration, I cannot choose the topics I want to teach, which means some topics have been uncomfortable for me since I do not know enough about them. In these instances, I seemed to have been less mobile in the teaching situation: while I am not crafting a causality here, key point here is movement as communicating passion, and how this is regulated by institutional limitations (i.e. faculty headcount not being significant enough to ensure everyone gets to teach only what they feel passionate about).

4.2 Second author's journey: encouraging 'vision' and 'passion' within the design studio

My experience in university teaching draws on my professional experience as a designer. Since 2009, I have been designing products and installations for galleries, museums and design-related events. I believe to owe my appointments as lecturer to the projects that I developed across my studio practice: exploratory works, mostly driven by a fascination for imagining scenarios and future users. In a sense, what allowed me to teach design is connected to this imagery, and to my dedication to follow it. A mindset that I developed during my studies at the Design Academy Eindhoven, a school whose pedagogical approach focuses on the knowledge of the 'self' and the exploration of subjective design aptitudes. The students of DAE are mainly educated to train mental and emotional intellectual aspects, intended respectively as vision and passion, and to exploit them as a way to get to better know themselves as persons and designers. If it is true that the first (vision), especially for designers, is mainly expressed through the development of innovative and solid concepts, I see the emotional component (passion) as a subjective driving element, yet the one really capable of stimulating motivation and resilience.

As a designer first, and Professor later, I tried to adhere to this forma mentis. What I try to teach to the students of my classes is the expression of vision and passion for their design ideas, and the tenacity and courage to carry them out. I strongly believe in the importance of forging relationships of reciprocal understanding, empathy and sympathy between those who teach design and those who learn about design. One main reason is that by entering the heart of the teacher/student relationship, I find it possible to experience fragments of a student's identity, and then operate to tailor the teaching method and offered support to what I like to call: the 'subjective vision', that is, the individual sensibility towards possible modes of being-a-designer. When I worked as a visiting lecturer for WdKA (Willem de Kooning Academie) I taught two courses, namely "Future Thinking" and "Future Products". My way of forging empathic/sympathetic relationships within both courses was based on a dialogic principle. For instance, it often happened that, during my individual desk crits in the studio, my conversation with students exposed some of their actual life experiences, even intimate ones. Interestingly, my desk critiques moved towards the discussion of how such experiences could be used as an identity 'propeller', that is, a powerful blend of motivating factors capable of triggering the student in the exploration of his/her own design mindset. I began to notice that such mode of teaching, which used the personal experience to promote vision, engendered some positive reactions in the students. My perception was that, by focusing on vision and passion in the studio, I was contributing to promote the development of the students' individual skills and their resilience to distress connected to their work. As suggested, this occurs for me through wordiness and empathy; there is, however, a third element, connected more to factors of proximity in interaction. As a good Italian, I'm used to express enthusiasm for students' ideas using physical gestures, particularly moving my head, arms and hands. Bruno Munari, in "Supplement to the Italian Dictionary", emphasize indeed how we Italians communicate through intense combinations of words and bodily expressions. During my end-of-the-course review with some students, I realized that, in the specificities of that cultural context (White, European and male-dominant classes) gestuality was perceived as an element of encouragement and appreciation of the teacher towards the students' work and functioned as a motivation propeller.

When, after completing my PhD at Loughborough University, I began to coordinate the Product Design concentration at DIDI, I taught a studio formed by a predominantly female class (9 women and 1 man), composed of second-year Bachelor students who came from the MENA region, India and different Asian countries. Many of them came from previous training experiences in which education, rather than being seen as a horizontal process, was based on principles of vertical learning. Perhaps this is why, in the advancement of my first studio class, I noticed a form of resistance to my empathic/sympathetic approach. Not so much for what concerns the student's desire for relationships, but more in terms of motivation to expose the depth of their personal stories. I felt that some students were struggling to share their experiences, while I saw that as an important factor for initiating design work and ignite it with passion. I also felt very much observed from the viewpoint of bodily gestures. During one lesson, for example, one of the students photographed me while I was teaching, and later manipulated the picture using a twirling filter, to ironically emphasize the constant movements of my body. Instead of becoming a form of encouragement and motivation for the students, I felt somehow exposed to vulnerabilities on a personal and professional level. From my conversation with the school's Dean, I also had the perception that my pedagogic approach was at times intimidating the students, mediating the idea that I expected a lot from them and their work. Ultimately, I do believe that my forma mentis on education, based on promoting vision and passion, has a great impact on students; however, the experience at DIDI reveals me that such aspects are not to be taken for granted, neither in terms of how they are communicated nor in how they are perceived. Instead, it might be important to work *with* students in the studio to get to better know each other and activate a virtuous circle oriented to encourage freedom in self-expression. The question of how to balance these two aspects, given the diversity of contemporary educational contexts, still remains to be explored, especially in view of the fact that universities have a continuous turnover of staff, and teachers, while moving from university to university, are forced to interact with a multiplicity of different cultural contexts.

4.3 Synthesizing journeys: how individual's passion is cyclical and dialogical

In our journeys described above, we have shed light on passion in the design studio from an educator's point of view by framing our reflections based on existing literature on passion as well as our discussions based on the accounts we have written. While analyzing our teaching and presence in the design studio from passion's perspective, we realized passion to be inextricably connected to reflexivity and reflectivity: sensations of passion are personal experiences, and as such the moment we start reflecting on passion in our work, we may start a long process that enables us to unravel and become aware of all those moments of thinking and making where we engage in passion work. Building on this, becoming aware of our own passion as well as passion's contested nature, enables us to focus on critical incidents as making visible our passion while at the same time helping us understand how institutional settings influence what kind of passion and forms of expressing it are desirable. This, we believe, highlights the cyclical and dialogical nature of passion: we might not always be aware of passion whilst living in the moment, but through reflection we can identify passion in our past and thus pave way for passion to emerge in the future.

In addition to both of us becoming more aware of our respective viewpoints to passion, through our conversations we have also come to realize how our experiences are both intertwined and connected to the design profession more broadly. Whereas the second author has an extensive career working as a design practitioner, the first author has entered design more as an academic from a neighboring discipline. Realizing that passion is more than just cognitive processes that we experience in solitude, has led us to reflect on our autoethnographic accounts with the design profession in general. For instance, prior research (Kosonen, 2018) has shown designer's exploration for her professional identity to be a cognitive process that does not stop after graduation.

Moreover, how designers express their passion is also inextricably bound to the norms and conventions governing each branch of design discipline (e.g., service, product, graphic design, etc.). In the case of our design school, where each student has to build their professional profile on cross-disciplinary foundations, these disciplinary conventions mean our students have to negotiate between novelty and traditions (Hargadon and Douglas, 2001). That is to say, although the institutional setting (i.e. the design school) nudges them to channel their passion across disciplines (novelty), during and after their studies the professional domain (traditions) influences how these expressions of passion are received (Hirsch, 1972). Even though the students might express their passion through crossdisciplinary means, they might have to narrow down their communication to only one branch of design.

5. Discussion

While passion is often identified as something positive or beneficial (Cardon, 2008; Chen, Yao and Kotha, 2009; Ruiz-Alfonso and León, 2016; Vallerand et al., 2003), at the same time our individual reflections illustrate how passion can make visible institutional barriers and support. Relocating ourselves to a different (cultural and geographical) context has enabled us to reflect on how higher education institutions allow or prevent passion to flow between people and nonhuman actors. For example, the unicorn 'incident' being treated in two different ways is a prime example of this: in the previous context, manifesting passion through dancing in a unicorn costume was seen as a threat to the institutional and cultural stability, whereas in the current context it is regarded as an extension of the university's brand. Through our autoethnographic accounts on passion work we have been able to surface institutional and cultural boundaries of passion. These, in turn, not only serve as constraining forces, but they also enable us to analytically explore our passion and how it develops in different spatio-temporal contexts.

As previous research has shown (e.g. Vallerand et al., 2007), passion seems to be built on healthier foundations through accumulated experiences, and our explorations in this paper illustrate design schools, and design studios in particular, as spaces that support reflections on passion through interactions with materials and other people (Goldschmidt, Hochman and Dafni, 2010; Stevens, 2019). While we fully agree that passion is something worth achieving and maintaining, at the same time we have unpacked certain problematics concerning passion and how its manifestations are being negotiated with what is accepted and desirable within the design profession and, more broadly, situated socio-cultural settings. From education's point of view, passion work acts as a reflexive regulatory process that does not focus on self-censorship but instead operates as a navigating act between the individual and what is considered legitimate within the social and cultural context.

Finally, analyzing passion in our current university also allows us to analyze respective practices in our prior universities, and while the latter is not the focus of this paper, these reflections nonetheless make our insights stronger by linking them to different contexts (Reed-Danahay, 1997). Building on this, we often conduct ethnographic research focusing on one context, and here autoethnography is a powerful approach to constructing knowledge, as the authors are in charge of what is being reflected on and why.

6. Conclusion

In contemporary societies passion is seen as something admirable or almost crucial if one pursues a career in design, and while we agree that passion is something positive, at the same time our autoethnographic accounts showed how passion work makes visible institutional and cultural elements that either support or suffocate passion.

As Tienari (2019, p. 576) mentions, "autoethnography is not for the faint of heart", and we agree with this remark. Taking our own experiences as a point of departure to explore passion in the design studio, we also exposed our thinking and emotions connected to passion work in ways that might make us vulnerable, whilst at the same time produced knowledge about design pedagogies. That is to say, research informants are always provided with the freedom to decide what kind of information to disclose to the researcher, but when it comes to autoethnographic practice, disclosing information becomes a balancing act between generating knowledge and protecting oneself. In a way, passion work extends to writing about passion: do we let it all out, or do we control our passion to protect ourselves from being regarded as too open?

Building on this, such reflections also serve as directions for future research. During the course of this paper, we have explored passion from a teacher's point of view, and a logical follow-up inquiry could focus on studying both teachers and students. In addition, and echoing prior works on global design education (Amagai, 2003; Buchanan, 2004), more contextually sensitive studies on passion could broaden our understanding of design education across countries. As prior research on passion in education has highlighted (Ruiz-

Alfonso and Léon, 2016), more diverse research methods could be employed to explore passion from alternative perspectives. For instance, design research and practices that are strongly linked to materiality and the interwoven relationship between craft and cognition, might provide novel methodological contributions through participatory approaches that involve cultural or design probes (Gaver, Dunne and Pacenti, 1999; Gaver, Boucher, Pennington and Walker, 2004).

While literature on passion has not explicitly made the connection to emotions, this seems like a potential avenue, especially from the viewpoint of well-being (Tugade, Fredrickson and Barrett, 2004). Introducing the concept of psychological resilience, Tugade et al. (2004) define it as the ability to recover from negative events through positive emotions. In this respect, our journeys in this paper also suggested that passion work can increase personal resilience when facing educational challenges, such as developing new curricula for institutions situated in foreign contexts.

Finally, in terms of implications for design education, our study has at least three contributions. First, autoethnography as a method is suited for potentially developing teacher's competence through heightened reflexivity. Second, our findings draw attention to the interpersonal and intercultural dimensions of passion in design education: becoming more sensitized to these dimensions might help educators to design engaging and at the same time safe environments for students. Finally, understanding passion work as cyclical and dialogical helps in seeing design education as beneficial for teachers and students alike, and thus emphasizing education over training.

7. References

Addison, N. (2011). Moments of Intensity: Affect and the Making and Teaching of Art. *International Journal of Art and Design Education*, 30(3), 363–378. https://doi.org/10.1111/j.1476-8070.2011.01729.x.

Amagai, Y. (2003). The Kobu Bijutsu Gakko and the Beginning of Design Education in Modern Japan. *Design Issues*, 19(2), 35–44. https://doi.org/10.1162/074793603765201398.

Boyle, M., and Parry, K. (2007). Telling the whole story: The case for organizational autoethnography. *Culture and Organization*, 13(3), 185–190. https://doi.org/10.1080/14759550701486480.

Brown, A. D., and Toyoki, S. (2013). Identity Work and Legitimacy. *Organization Studies*, 34(7), 875–896. https://doi.org/10.1177/0170840612467158.

Buchanan, R. (2004). Human-centered Design: Changing Perspectives on Design Education in the East and West. *Design Issues*, 20(1), 30–39. https://doi.org/10.1162/074793604772933748.

Cardon, M. S. (2008). Is passion contagious? The transference of entrepreneurial passion to employees. *Human Resource Management Review*, 18(2), 77–86. https://doi.org/10.1016/j.hrmr.2008.04.001.

Cardon, M. S., Wincent, J., Singh, J., and Drnovsek, M. (2009). The nature and experience of entrepreneurial passion. *Academy of Management Review*, 34(3), 511–532. https://doi.org/10.5465/amr.2009.40633190.

Chen, X-P., Yao, X., and Kotha, S. (2009). Entrepreneur Passion And Preparedness In Business Plan Presentations: A Persuasion Analysis Of Venture Capitalists' Funding Decisions. *Academy of Management Journal*, 52(1), 199-214. https://doi.org/10.5465/amj.2009.36462018.

Chew, J. Y., Lehtonen, M. J., and Schilli, K. S. (2019). The rise of design dyslexia and how to overcome it. *Design Management Review*, 30(1), 8–15. https://doi.org/10.1111/drev.12156.

Covey, S. R. (2013). *The 8th Habit: From Effectiveness to Greatness*. Free Press.

Cross, A. (1984). Towards an understanding of the intrinsic values of design education. *Design Studies*, 5(1), 31–39. https://doi.org/10.1016/0142-694X(84)90026-7.

Ellis, C., and Bochner, A. P. (2000). Autoethnography, personal narrative, reflexivity, in Denzin, N. K. and Lincoln, Y. S. (eds.), *Handbook of Qualitative Research*, SAGE, pp. 733–768.

Ferreira, J., Christiaans, H., and Almendra, R. (2016). A visual tool for analysing teacher and student interactions in a design studio setting. *CoDesign*, 12(1-2), 112–131.https://doi.org/10.1080/15710882.2015.1135246.

Findeli, A. (2001). Rethinking Design Education for the 21st Century: Theoretical, Methodological, and Ethical Discussion. *Design Issues*, 17(1), 5–17. https://doi.org/10.1162/07479360152103796.

Fjord (2019). Digital Producer – Washington, D.C. https://tinyurl.com/wpzouto (Accessed 18 November 2019).

Frascara, J. (2007). Hiding Lack of Knowledge: Bad Words in Design Education. *Design Issues*, 23(4), 62–68. https://doi.org/10.1162/desi.2007.23.4.62.

Gaver, W., Dunne, T., and Pacenti, E. (1999). Design: Cultural probes. *ACM Interactions*, 6(1), 21–29. https://doi.org/10.1145/291224.291235.

Gaver, W., Boucher, A., Pennington, S., and Walker, B. (2004). Cultural probes and the value of Uncertainty. *ACM Interactions*, 11(5), 53–56. https://doi.org/10.1145/1015530.1015555.

Goldschmidt, G., Hochman, H., and Dafni, I. (2010). The design studio "crit": Teacher–student communication. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 24(3), 285–302. https://doi.org/10.1017/S089006041000020X.

Greene, M. (1986). Reflection and passion in teaching. *Journal of Curriculum and Supervision*, 2(1), 68–81.

Hargadon, A. B., and Douglas, Y. (2001). When Innovations Meet Institutions: Edison and the Design of the Electric Light. *Administrative Science Quarterly*, 46(3), 476-501. https://doi.org/10.2307/3094872.

Hirsch, P. M. (1972). Processing Fads and Fashions: An Organization-Set Analysis of Cultural Industry Systems. *American Journal of Sociology*, 77(4), 639–659. https://doi.org/10.1086/225192.

Hochschild, A. R. (1979). Emotion Work, Feeling Rules, and Social Structure. *American Journal of Sociology*, 85(3), 551–575. https://doi.org/10.1086/227049.

IDEO (2019). Design Research Lead. https://tinyurl.com/y3h5qaqe (Accessed 18 November 2019).

Kosonen, K. (2018). *Finding One's Own Way in Design - Reflections on Narrative Professional Identity*. Aalto University School of Arts, Design and Architecture.

Luh, D.-B., & Lu, C.-C. (2012). From cognitive style to creativity achievement: The mediating role of passion. *Psychology of Aesthetics, Creativity, and the Arts*, 6(3), 282–288. https://doi.org/10.1037/a0026868.

Lund, R., and Tienari, J. (2019). Passion, care, and eros in the gendered neoliberal university. *Organization*, 26(1), 98–121. https://doi.org/10.1177/1350508418805283.

Margolin, V. (2007). Design, the Future and the Human Spirit. Design Issues, 23(3), 4–15. https://doi.org/10.1162/desi.2007.23.3.4

McDonald, J. (2013). Coming out in the field: A queer reflexive account of shifting researcher identity. *Management Learning*, 44(2), 127–143. https://doi.org/10.1177/1350507612473711.

McDonnell, J. (2016). Scaffolding practices: A study of design practitioner engagement in design education. *Design Studies*, 45(A), 9-29. https://doi.org/10.1016/j.destud.2015.12.006.

Munari, B. (2014). *Supplemento al Dizionario di Italiano* [Supplement to the Italian Dictionary]. Corraini Editore.

Papanek, V. (1971). *Design for the Real World*. Academy Chicago Publishers.

Reed-Danahay, D. E. (ed.) (1997). *Auto/ethnography. Rewriting the Self and the Social*. Berg.

Ruiz-Alfonso, Z., and León, J. (2016). The role of passion in education: A systematic review. *Educational Research Review*, 19, 173–188. https://doi.org/10.1016/j.edurev.2016.09.001.

Scagnetti, G. (2017). A dialogical model for studio critiques in Design Education. *The Design Journal*, 20, S781-S791.

Simon, H. (1969). *Sciences of the Artificial*. MIT Press.

Stevens, T. (2019). Design Domain: Created Space, Creative Space. *International Journal of Art and Design Education*, 38(4), 757-768. https://doi.org/10.1111/jade.12274.

Thoring, K., Desmet, P., and Badke-Schaub, P. (2018). Creative environments for design education and practice: A typology of creative spaces. *Design Studies*, 56, 54-83. https://doi.org/10.1016/j.destud.2018.02.001.

Tienari, J. (2019). One flew over the duck pond: Autoethnography, academic identity, and language. *Management Learning*, 50(5), 576–590. https://doi.org/10.1177/1350507619875887.

Tugade, M. M., Fredrickson, B. L., and Barrett, L. F. (2004). Psychological Resilience and Positive Emotional Granularity: Examining the Benefits of Positive Emotions on Coping and Health. *Journal of Personality*, 72(6), 1161–1190. http://doi.org/10.1111/j.1467-6494.2004.00294.x.

Vallerand, R. J., Blanchard, C. M., Mageau, G. A., Koestner, R., Ratelle, C. F., Leonard, M., ..., and Marsolais, J. (2003). Les passions de l'Ame: On obsessive and harmonious passion. Journal of Personality and Social Psychology, 85(4), 756–767. https://doi.org/10.1037/0022-3514.85.4.756.

Vallerand, R. J., Salvy, S.-J., Mageau, G. A., Elliot, A. J., Denis, P. L., Grouzet, F. M. E., et al. (2007). On the role of passion in performance. *Journal of Personality*, 75(3), 505–534. http://doi.org/10.1111/j.1467-6494.2007.00447.x.

Wall, S. (2006). An autoethnography on learning about autoethnography. *International Journal of Qualitative Methods*, 5(2), 146–160. https://doi.org/10.1177/160940690600500205.

Wang, T. (2010). A New Paradigm for Design Studio Education. *International Journal of Art and Design Education*, 29(2), 173–183. https://doi.org/10.1111/j.1476-8070.2010.01647.x.

Xue, H., and Desmet, P. (2019). Researcher introspection for experience-driven design research. *Design Studies*, 63, 37-64. https://doi.org/10.1016/j.destud.2019.03.001.

About the Authors:

Miikka J. Lehtonen is an Assistant Professor at Dubai Institute of Design and Innovation and one of the co-founders of the Nordic Rebels movement. He earned his PhD from Aalto University School of Business in 2014. Miikka's current research interests focus on visual methodologies, design management, and the game industry.

Gionata Gatto (PhD) works as design practitioner and Assistant Professor at DIDI, where he curates the concentration of Product Design. His research winds between collaboration of different disciplines and emerges as a result of participatory and speculative design research methods.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Philosophy at work: Postphenomenology as a generative lens in design research and practice

Sander VAN DER ZWAN[a]*, Maarten SMITH[a]*, Jelle BRUINEBERG[b]*, Pierre LÉVY[a], Caroline HUMMELS[a]

[a] Department of Industrial Design, Eindhoven University of Technology, The Netherlands
[b] Department of Industrial Design, Eindhoven University of Technology, The Netherlands; Department of Psychiatry, Academic Medical Centre, The Netherlands
*Corresponding author e-mail: s.v.d.zwan@tue.nl
doi: https://doi.org/10.21606/drs.2020.337

Abstract: We investigate the use of five postphenomenological concepts by bringing them to design practice and using them as a "generative lens" in design research. The use of these concepts in design research creates tension between the general and the particular. In a constructive design research process, we resolve this tension. We follow two complementary lines of inquiry: first, we design a ritual to support a postphenomenological analysis of the workplace. We discuss insights regarding ordering and formulation of the concepts, selecting a technological intermediary and assessing technologies. In the second, we use postphenomenology as a generative lens in designing the ritual. We discuss the iterative process in which the designer shapes specific uses by proposing different designs and reflecting on them using postphenomenological concepts. These reflections point to a responsibility of the designer to incorporate ways of being, ways of knowing and values on top of specific uses and utility.

Keywords: postphenomenology; design research; design practice; generative lens;

1. Introduction

Postphenomenology is an empirically oriented philosophy of technology (Ihde, 1993; Selinger, 2006; Rosenberger and Verbeek, 2015). It has developed theoretical concepts and handles to analyse and reflect on the particularities of technologies and how they might affect our everyday lives. Postphenomenology focuses on the description of human experience and action from a first-person perspective and on how these experiences and actions are mediated by technology. Key to postphenomenology is the idea that things "are not neutral 'intermediaries' between human and world, but mediators; they actively mediate this relation" (Verbeek, 2005, p. 114). They "carry morality" because they co-shape how we act, perceive and interpret the world around us (Verbeek, 2006b, p. 127).

1.1 Outline

Hauser et al. (2018) show that postphenomenology is an "under-utilized yet productive" (p. 10) framework for design researchers. In particular, they discuss two opportunities for how postphenomenology could be drawn upon in design research. Firstly, to better support the analysis of design artefacts, and secondly, as a "generative lens" (p. 10) to frame the crafting of such artefacts. We follow up on this suggestion by reporting a design process in which postphenomenology acts as a generative lens. Namely, we use postphenomenology (with foresight) to inform or guide the design process, as opposed to its typical use, i.e. to analyse the mediation of existing technological artefacts (in hindsight). We emphatically agree with Hauser et al. that postphenomenology is under-utilised in the analysis of technological artefacts and emphasise that this is not only the case for design *researchers*, but for design *practitioners* as well. With this said, we arrive at the two lines of inquiry conducted in this study. The first is an inquiry into how postphenomenology could support design practitioners in analysing technological artefacts. The second is an inquiry into the novel proposition brought to us by Hauser et al.: the use of postphenomenology as a generative lens.

Both these lines of inquiry, articulated in this way, immediately introduce a tension between *the general* and *the particular,* which is a central theme in this paper. On the one hand, we are presented with abstract, theoretical concepts and on the other, concrete designs in use. In navigating and resolving this tension, we uncover insights and questions worth pursuing with regards to the application of postphenomenology in design practice and design research.

2. Theoretical Concepts

In order to scope our inquiry, we specifically draw upon four different dimensions that postphenomenology gives us to describe characteristics of technological mediations: the *practical*, *ontological*, *epistemological* and *ethical* dimensions of technological mediation (Kiran, 2015). These dimensions all have a two-sidedness. This should not be read as a positive-negative, but rather a mutually dependent relation, as "there can be no shaping movement without a corresponding downplaying movement" (Kiran, 2015, p. 123). In addition to this, we draw upon the concept of *multistability* (Ihde, 1986, 2012)*,* which is in direct relation to these dimensions. The concepts can be briefly described as follows:

2.1 The ontological dimension

In their ontological dimension, technologies exhibit a *revealing-concealing* structure. Technologies co-shape what the world *is* for us. In using a technology, it *reveals* a relevant context of engagement, while at the same time *concealing* other possibilities for action that do not belong to that context (Kiran, 2015, pp. 125-128). The technology is thereby simultaneously shaping the world and us as humans. For example, should you become skilled in using a coffee grinder to make coffee every morning, the coffee grinder *as an object* will withdraw from your experience and show up as something *for-grinding* (unless it e.g., breaks down). In a different context, for example when cleaning the kitchen with a cleaning cloth, the coffee grinder might reveal itself as something that needs cleaning. With the cleaning cloth in your hand, the grinder, as ready to be used to grind coffee, is concealed.

2.2 The epistemological dimension

In their epistemological dimension, technologies exhibit a *magnifying-reducing* structure. Technologies may augment certain perceptual capabilities and simultaneously weaken others. They may *magnify* some aspects of our experiential presence and *reduce* others. In doing so, technologies shape our ways of gaining knowledge of the world (Kiran, 2015, pp. 128-131). For example, if your workspace is getting cold, you might have a look at the thermostat showing that indeed the temperature is below 18°C. The thermostat therefore magnifies the temperature in your experience of the room while at the same time it might reduce your experience of, e.g., the amount of oxygen in the room.

2.3 The practical dimension

In their practical dimension, technologies exhibit *an enabling-constraining* structure. Technologies *enable* specific actions and ways of performing them, while *constraining* others. In using a technology, we are forced to adapt to its material and social reality (i.e. to the affordances that it does and does not offer). Technologies therefore shape how we behave and act (Kiran, 2015, pp. 131-134). For example, if you have printed this paper, the paper document enables you to make drawings or write things down with a pen. However, it constrains you from sharing those remarks instantly with other people as a digital version might enable you to do. Different media enable and constrain you to read and understand it in a different way.

2.4 The ethical dimension

In their ethical dimension, technologies show an *involving-alienating* structure. The three aforementioned dimensions have ethical implications and, in addition to this, technologies might open up their own ethical issues. As such, a technological mediation often pulls towards various moral directions (Kiran, 2015, pp. 134-137). For example, digital communication technologies such as collaboration or teamwork hubs (e.g. Microsoft Teams, Slack) grant many people the opportunity to do a lot of work from home. They *involve* these people in a particular way of working, independent of their regular workplace. However, at the same time, these technologies imply *alienating* aspects, as users are alienated from physical social contact with coworkers.

2.5 Multistability

The described four dimensions might give designers the illusion that they can *ensure* a certain change in values through design, but this would be to underestimate the complexity of technological mediation. *Multistability* brings part of this complexity to light. The concept points to the indefinite meanings and uses a technology can have (Ihde, 2012). For example, one could use a screwdriver as a way to screw the components of a table together. However, it could just as well be used to open a can of paint or, as we are doing now, to make a point. This means that a design has the potential for being put to multiple purposes in multiple contexts. These purposes may surpass (or be entirely different to) what the designer may have considered in the design process. In other words, a technology potentially has unintended applications or consequences.

3. Approach

To pursue our first line of inquiry, into how postphenomenology could support design practitioners in analysing technological artefacts, we conducted a *Constructive Design Research* (CDR) process (Koskinen et al., 2011). In such a process, knowledge is generated through design processes in which constructing and materialising (prototyping) play a key role. Carrying out this process, we designed a tool, embedded in a ritual, that supports design practitioners in analysing technological artefacts in their workspace using the aforementioned postphenomenological concepts. This analysis was done in a workshop setting, whereby a specific focus was laid on the *everyday* of these organisations. The *everyday* pertains to the reality in which they act and perceive through unremarkable experiences (Levy, 2018). In the context of these organisations, the *everyday* is about hanging up your coat, having a meeting, drinking tea or coffee, making plans, reading a report etc. It is therefore entangled with a milieu of unremarkable technologies: the coat hanger, the meeting table, the teacup or coffee mug, the whiteboard and the report to be read. We tested this ritual during five workshops in five different design organisations including an urban planning company, two design agencies in the Netherlands and two design research departments in Sweden. These organisations were sized between five and fifteen employees.

The tension at play here is between the postphenomenological concepts (*the general*), and the workshop participants' workplace (*the particular*) [Fig.1]. The iterative process of testing the ritual in the workshops, developing both low- and high-fi prototypes and uncovering new insights in and during this development is our effort to resolve this tension. The final result, the ritual, is thus a concrete response to our first line of inquiry.

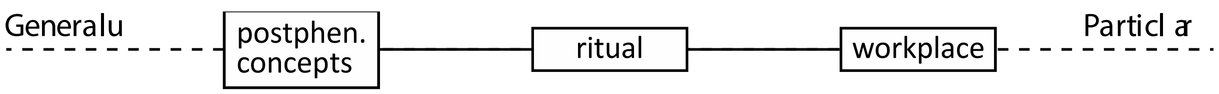


Figure 1 The tension between the general and the particular in the first line of inquiry.

In pursuit of our second line of inquiry, that is, the use of postphenomenology as a generative lens for design researchers, we utilised the postphenomenological concepts to frame and guide the crafting of the ritual as explained in our first line of inquiry. In this case, there is a tension between the postphenomenological concepts (*the general*) and the ritual (*the particular*). The use of these concepts in our design rationale is our effort to resolve this tension [Fig. 2].

Figure 2 The tension between the general and the particular in the second line of inquiry.

4. A Postphenomenological Ritual

The outcome of the CDR process undertaken is a ritual that supports design practitioners in analysing technological artefacts in their workplace using the postphenomenological concepts. In the following section the different steps of this ritual are described [Fig. 3-10].

Step 1

Figure 3 [Translation: "stairs are good for physical movement"]. Participants select artefacts in their workplace by taking photos of these objects and making annotations in a text overlay using Snapchat.

Step 2

Figure 4 *The pen is given to one of the participants and they become the note-taker.*

Step 3

Figure 5 *The printer is placed in its printing position. This reveals a set of cards.*

Step 4

Figure 6 *The printer prints a randomly selected picture of an artefact selected during step 1 of the ritual.*

Step 5

Values:

- Start with trusting others *instead of* trying to control people
- Get to know yourself better *instead of* hiding your true self
- Dare to be honest and critical *instead of* skewing the truth to avoid conflict
- Seek and claim your responsibility *instead of* conforming and picking up unfitting jobs
- Be transparent *instead of* hiding information that could be interesting for the collective
- Have fun *instead of* only reasoning by productivity
- Care for others *instead of* only being involved in the collective for yourself

Figure 7 *An expression of an ethical vision of 'a good work life' in the form of a set of values along* *with counterparts, printed on an A4 sheet of paper, is introduced as inspiration for an ethical vision to work towards. The aesthetics of this formulation reflect the in-process and imperfect nature of it. Participants can alter the vision as they please.*

Step 6

Figure 8 *The cards revealed in step 3 are used to support a postphenomenological reflection on the artefact in use which are captured in the printed picture. The cards contain brief descriptions of each of the four dimensions of technological mediation and questions to guide a reflection on them.*

Step 7

Figure 9 *Having reflected on the artefact, participants write down how they are going to take action on the reverse side of the printed picture.*

Step 8

Figure 10 *Finally, in step 8 of the ritual, the result is placed somewhere visible (e.g., on the fridge door) using 10 numbered magnets, shaped to fit the photographs.*

5. Observations and Reflections From the Two Lines of Inquiry

The described ritual tacitly holds the knowledge generated in pursuit of the first line of inquiry. At the same time, the design rationale behind this ritual is the result of our second line of inquiry. Both inquiries were fully entangled over time. For the sake of clarity, we proceed to arrange the knowledge generated under two headings. In the first, we make explicit three insights that came to light in our attempt to bring postphenomenology as an analytical tool to design practitioners. In the second, we explicate part of the design rationale behind the development of the ritual in which the concepts played an important role.

5.1 Line of inquiry 1: a ritual to support postphenomenological analysis and action

Shifting and reformulating the concepts

In "Four Dimensions of Technological Mediation" (Kiran, 2015), the four dimensions of technological mediation are laid out in a particular order. Kiran indicates that the ontological dimension should be concerned with first (p. 125). However, for the purpose of the ritual it appeared to be too abstract to grasp as a first step in the reflection. Although not demonstrated here, this difference may be due to a difference of approach and perspective between philosophy and philosophy-informed design. Therefore, in order for the participants to perform a postphenomenological reflection, we changed the order in which the concepts were presented: beginning with the practical, then the ontological, the epistemological, and finally the ethical. This way, participants started with the most concrete and easy to apply concepts and ended with concepts directly related to their ethical vision. Secondly, the concepts needed to be understandable and guide participants through the reflection. To do this, we reformulated the concepts in terms of non-jargonistic reflection questions with corresponding examples and presented them on small reflection cards.

Supporting the selection of the technological intermediary

With the intention of changing an already existing technological milieu that is used by multiple people in their everyday, such as the workspace, come criteria for selecting the technology to be reflected upon. These are different from those relevant for a typical postphenomenological analysis (e.g., possibility of theory development). In order to support this selecting, we initially presented the participants with an ethical statement in terms of values and asked them to pick a value that they agreed was important in their organisation. Following this, we asked them to collectively select a technological intermediary in their milieu that they associated with that specific value. However, this turned out to come with two major challenges. First of all, associating an abstract value with concrete technologies was very difficult to do for most participants. In some cases, participants resorted to selecting abstract concepts such as communication, instead of concrete technologies (e.g., a telephone). Secondly, we see here that *that what is to be reflected upon* has no inherent boundaries outside an interpretation of 'technological intermediary'. What this technological intermediary *is* depends on where you choose to set the boundaries, and this has consequences for the practicality of the reflections. For example, in one case an entire office building including its thousands of uses was selected. This reflection did not lead to practical changes as for the participants the selection was not practical to change. They had little control over the entire building. All its different uses meant that judgements on whether or not it should be changed were difficult to make and concrete handles to act on were hard to find. To address these challenges, we handed the participants a smartphone with Snapchat and asked them to take pictures of those technological intermediaries that intuitively affected them in a positive or negative way. This reasoning from the everyday experience instead of abstract values turned them towards those artefacts that were relevant for reflection from their experience. At the same time, taking pictures with Snapchat revealed to them only those artefacts that were present in the building itself and turned participants away from abstract concepts.

Technology assessment

In a typical postphenomenological analysis, one does not necessarily have to take a normative stance towards the technological intermediary. However, when the design practitioners were asked to write down next steps for action, questions arose, such as: "Should we include or exclude the technology?", "Should we redesign the technology to fit the vision better?" and "How can we change our relation with the technology?".

Therefore, when aiming to practically change the technological milieu, some discussion about ethics has to be carried out. In order to take action *towards* something, participants need to have a common understanding of *towards what* they desire to take action. In order to provoke this discussion, from workshop 3 onwards, we introduced an ethical vision after the selection of the technologies (step 5 of the ritual). We formulated this vision in terms of values which allowed for a discussion taking into account a variety of views. The addition of counterparts to these values aided participants in recognising how certain artefacts may be pulling in different ethical directions.

5.2 Line of inquiry 2: postphenomenology as a generative lens

In the following, we make explicit how our understanding of the concepts shaped some of the decisions we made in the design of the ritual.

Multistability

As technologies have multiple stabilities depending on, for example, their material qualities and the (social) context, we cannot ensure that a certain design will be used in the way that we intend it to be. On the other hand, a design cannot be used to do simply anything (you cannot use the ritual we designed to grind coffee). An understanding of this concept permeated our design process in two ways. Firstly, it shaped our understanding of the appropriation of technology in the crafting process. For example, in order to afford participants to take photographs in step 1 of the ritual and make notes immediately in these photographs, we could have designed a dedicated smartphone application. However, understanding that Snapchat already provided these affordances, and with an understanding of multistability, we appropriated the app to become part of the ritual. Once a photo was taken and annotations were made on it in Snapchat, we instructed people to save the Snap. This immediately uploaded the resulting image to the printer. Embedding Snapchat in a different practice than its developers intended for it (as social medium), meant we were able to give it a different stability, namely, as a selection tool for technological artefacts, affording people to quickly take photos and make annotations on these photos.

Secondly, and more radically, an understanding of this concept brought a certain fragility to our design intentions. We found ourselves talking about 'opening up' and 'closing off' stabilities of the artefact we were crafting. For example, we did not intend that participants engage in a postphenomenological analysis of artefacts while they were selecting them in the first step of the ritual. To close off this stability, we designed step four of the ritual in such a way that the reflection cards were only revealed once the printer had been placed on its stand, thus only once the selection was made and automatically uploaded to the printer. At the same time, when designing the eighth step of the ritual (placing the numbered magnets somewhere visible) we intended for participants to be able to place the next steps for action (which they wrote down) somewhere visible in their surroundings, but wanted to leave room for them to find a suitable place for this themselves. We designed ten magnets, specifically to open up more stabilities for this placing (on any visible metal surface). With this frame in place, the four dimensions of technological mediation become handles that give some grip to navigate this opening up and closing off.

The practical dimension (technologies exhibit an ***enabling-constraining*** structure)

In step 8, once the reflection on a certain technology has been carried out, participants make decisions about what action should be undertaken with regards to this technology. We learned that in the everyday practice of an organisation, it often does not make sense to take action immediately after a decision has been made about what that action may be. At the same time, if left unnoted or hidden away, these decisions can be easily forgotten. Also, if the ritual would be repeated a number of times, there would be a possibility for reflections to pile up and action to be left untaken. With these insights in mind, we attempted to design the ritual in such a way that the reflections would not be easily forgotten, and participants would in some way be triggered to take action. To do this, we purposely designed ten numbered magnets, precisely shaped to fit the photographs, hereby *enabling* participants to place the actions somewhere visible in their surroundings (for instance on the fridge door) and *enabling* them to prioritise actions. At the same time, we *constrained* participants from being able to place more than ten reflections by only providing ten magnets, thereby, to a certain extent, *constraining* them from continuing to reflect on technologies without being triggered to take action.

The ontological dimension (technologies exhibit a ***revealing-concealing*** structure)

In the first step of the ritual, participants need to end up with technological artefacts that they desire to reflect on. In the everyday comings and goings of a workplace, many of such artefacts are likely to be used without their users reflecting on them i.e., they are approached as ready-to-hand (Heidegger, 1927/1962). If this would not be taken into account, there would be a likely possibility for many technological artefacts to be left unselected, not because they would not be relevant to reflect upon, but simply because they would go unnoticed. To *reveal* the workplace as a constellation of technological artefacts that could be reflected upon i.e., as present-at-hand (Heidegger, 1927/1962), and *reveal* the participants as 'searchers' of these artefacts, we gave participants a smartphone with the Snapchat camera running. Pictures taken with this smartphone loaded automatically onto the printer and would be randomly selected for reflection later on. With this knowledge, and the smartphone in their hands, the use of these technologies as ready-to-hand was *concealed*.

The epistemological dimension (technologies exhibit a ***magnifying-reducing*** structure)

In step 6 of the ritual, participants use the question cards provided to reflect on technological artefacts selected during the first step. Understanding that technologies shape our ways of gaining knowledge about the world made us think carefully about how to present this selection to participants, as different media would *reduce* and *magnify* different experiential aspects of the artefacts. One thing that characterises postphenomenological research is the analysis of (technologically mediated) experiences 'from within' (Rosenberger and Verbeek, 2015, p. 20). This means such analyses describe first-person experiences of technologies in use. With this in mind, we designed the ritual in such a way that it printed pictures of these artefacts. By doing this, we knowingly *reduced* participants' perception of the artefacts' material qualities, temperature, smell and temporality and *magnified* their perception of the static, visual representation of the artefact in use. In doing this we sought a balance in, on the one hand providing the affordance of writing on the back of the photographs and easily placing them in one's surroundings, and on the other providing as rich as possible reference to the artefact as it is experienced in use. We considered, for example, having participants film the artefact during the first step. This medium would not have *reduced* participants perception of e.g., sound, as much as the photographs, but the affordances of, for example, writing on the back, would not have been present.

The ethical dimension (technologies exhibit an ***involving-alienating*** structure)

The understanding that technologies can pull in different ethical directions, and that, through postphenomenological analysis, we might be able to describe these directions to some extent, led us to consider ethical directions the ritual might pull towards in advance. With this in mind, we made an effort to elicit certain values through the ritual. For example, it was our intention for the ritual to *involve* all participants in taking responsibility for their surroundings and *alienate* the use of mere authority to steer these changes. For this reason, in step 4, the ritual *randomly* selects which technological artefact will be reflected on. This random selection does not take authority into account, which could have been (as it often is) a factor if this selection process had been carried out through negotiation.

6. Discussion

In this paper we started with five postphenomenological concepts: the *practical*, *ontological*, *epistemological* and *ethical* dimensions of technological mediation and *multistability*. We aimed to bring these concepts to design practitioners (our first line of inquiry) and use them ourselves in the crafting of a design research artefact (our second line of inquiry). Following our first line of inquiry, we discussed Kiran's (2015) order of the dimensions, and proposed presenting the concepts in a different order, starting with the most concrete. Secondly, we found that it was necessary to support the selection of the technological intermediary to be reflected upon and proposed a way of doing this through the ritual. Finally, we found that some ethical vision had to be discussed in order to aid technology assessment and lead to practical next steps for action.

As a result of the second line of inquiry, we note a few consequences of using postphenomenology as a *generative lens*. The practical dimension is already commonplace for most designers as the *enabling-constraining* structure is in line with a traditional view on *affordances* as introduced by Gibson (1979). However, both the ontological and epistemological dimensions build on top of this understanding of affordances and offer novel perspectives to work with. Suddenly, designers are put in charge of not only designing human-technology relations (focussing e.g., on concepts such as cognitive strain and transparency), but also of co-shaping how humans experience and act in the world (human-technology-world relations). This simultaneously brings to light that design and designing have always been interwoven with ethics (Trotto, 2015). We are "materializing morality" (Verbeek, 2006a, p. 369). Now that these other dimensions have been laid down by postphenomenology, we advocate that designers take up the responsibility that comes with this. Incorporating the four dimensions and multistability in design processes, first of all, leads to design intentions that incorporate ways of being, ways of knowing and values on top of specific uses and utility. Secondly, it involves the designer in an iterative process in which they try to open or close specific stabilities by jumping back and forth between proposing different designs and reflecting on them using the different concepts.

6.1 An eye on the future

In this paper we explicate how postphenomenological concepts can be used as generative lens by designers. The success of the generative lens hinges on the resolution of the tension between the general and the particular: abstract postphenomenological concepts, and concrete designs. In this last section we connect the process that was undertaken in this study to a fundamental issue in design research: the tension between the aim of design research (working towards general theories) and the aim of design (working towards particular designs) (Nelson and Stolterman, 2012; Redström, 2017). Navigating and resolving this tension is imperative if design research is to address its own foundational concepts.

In this study, we worked from postphenomenological concepts to a particular design (i.e. the ritual). Moreover, this design, in turn, mediates and facilitates the postphenomenological analysis of the workplace. In this way, design research can contribute to and shape the methodology of postphenomenology. This is a first step in closing the loop between postphenomenology and design: in not only having postphenomenology transform design practice, but in design practice transforming the philosophical apparatus of postphenomenology (i.e. design-informed philosophy).

7. References

Gibson, J. (1979). *The ecological approach to visual perception*. Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Hauser, S., Wakkary, R., Odom, W., Verbeek, P. -P., Desjardins, A., Lin, H., … De Boer, G. (2018). Deployments of the table-non-table: A reflection on the relation between theory and things in the practice of design research. In *CHI'18. Proceedings of the 2018 CHI conference on human factors in computing systems* (Paper No. 201). New York, NY: ACM Press.

Heidegger, M. (1927/1962*). Being and time*. Oxford: Blackwell Publishers. (Macquarrie, J. and Robinson, E., trans)

Ihde, D. (1986). *Experimental phenomenology: An introduction* (2nd printing). Albany, NY: SUNY Press.

Ihde, D. (1993). *Postphenomenology: Essays in the postmodern context.* Evanston, IL: Northwestern University Press.

Ihde, D. (2012). *Experimental phenomenology: Multistabilities* (2nd ed.). Albany, NY: SUNY Press.

Kiran, A. (2015). Four dimensions of technological mediation. In R. Rosenberger and P. -P. Verbeek (Eds.), *Postphenomenological investigations* (pp. 123-140). Lanham, MD: Lexington Books.

Koskinen, I., Zimmerman, J., Binder, T., Redström, J and Wensveen, S. (2011). *Design research through practice: From the lab, field and showroom*. Waltham, MA: Morgan Kaufmann.

Levy, P. D. (2018). The beauty of making hot chocolate: An inquiry on designing for everyday rituals. In *Proceedings of DRS 2018 international conference: Catalyst* (Vol. 5, pp. 2126-2135). London, UK: Design Research Society.

Nelson, H. G., and Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world.* Cambridge, MA: MIT Press.

Redström, J. (2017). *Making design theory*. Cambridge, MA: MIT Press.

Rosenberger, R. and Verbeek, P. -P. (2015). *Postphenomenological investigations*. Lanham, MD: Lexington Books.

Selinger, E. (Ed.). (2006). *Postphenomenology: A critical companion to Ihde.* Albany, NY: SUNY Press.

Trotto, A. (2015). On Making and other froths. In L. T. Dimitriou (Ed.), *Making and Thinking*. Firenze: Edizioni Polistampa.

Verbeek, P. -P. (2005). *What things do: Philosophical reflections on technology, agency, and design.* University Park: Penn State University Press.

Verbeek, P. -P. (2006a). Materializing morality: Design ethics and technological mediation. *Science, Technology and Human Values*, *31*(3), 361-380.

Verbeek, P. -P. (2006b). The morality of things: A postphenomenological inquiry. In Selinger, E. (Ed.). *Postphenomenology: A critical companion to Ihde* (pp. 117-128). Albany, NY: SUNY Press.

Verbeek, P. -P. (2011). *Moralizing technology: Understanding and designing the morality of things*. Chicago, IL: University of Chicago Press.

About the Authors:

Sander van der Zwan is pursuing a PhD at the Department of ID at TU/e, NL, where he also earned his MSc. His interests lie in the intersection between philosophy and design practice, and their convergence on complex societal challenges.

Maarten Smith is pursuing a PhD at the Department of Industrial Design, Eindhoven University of Technology, and has an MSc from the same department. His current activities concern the bringing together of philosophy and design to address complex challenges.

Jelle Bruineberg is postdoctoral researcher on Design and Embodiment at the Department of Industrial Design, Eindhoven University of Technology. His research focusses on enactive and ecological approaches to the mind and their relation to philosophy of technology and design research.

Pierre Lévy is assistant professor on Enchanting the Everyday at the department of Industrial Design, Eindhoven University of Technology. His research focuses on the relation between theory and practice in transformative practices, philosophy and design, addressing beauty in the everyday.

Caroline Hummels is professor Transformative Qualities at the department of Industrial Design, Eindhoven University of Technology. Her activities concentrate on designing and researching transformative practices based on design-inspired philosophy, with a focus on embodied interactions, technology-in-becoming, sensemaking, aesthetics, and social resilience.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Co-Evolving Towards Evil Design Outcomes: Mapping Problem and Solution Process Moves

Shruthi Sai CHIVUKULA[a]*, Colin M. GRAY[a]

[a] Purdue University, United States of America
*Corresponding author e-mail: cshruthi@purdue.edu
doi: https://doi.org/10.21606/drs.2020.107

Abstract: Creative outcomes require designers to continuously frame the problem space and generate solutions, resulting in the co-evolution of problem and solution. Little work has addressed the value dimensions of design activity with regard to this co-evolutionary process and the role of the designer in acting upon specific and value-laden framings and/or solutions. In this paper, we identify how triads of student designers from user experience (UX) and industrial engineering (IE) disciplines frame the problem space and generate solutions, foregrounding the ethical character of their judgments in response to an ethically-nuanced design task. Using sequence analysis to analyze the lab protocol data, we describe the frequency and interconnectedness of process moves that lead the design team towards unethical outcomes. Based on our findings, we call for additional attention to ethical dimensions of problem-solution co-evolution, and identify key interaction patterns among designers that lead towards unethical outcomes.

Keywords: co-evolution; ethics; problem framing; sequence analysis; decision-making

1. Introduction

Creative outcomes require the cognitive ability of designers to continuously frame the problem space and generate solutions, resulting in what Dorst and Cross (2001) have called a “co-evolution of problem–solution,” building upon a similar concept of co-evolution from Maher, Poon, and Boulanger (1996). While the framing activities of designers have been studied from numerous perspectives, little work has addressed the value dimensions of design activity with regard to this co-evolutionary process and the role of designers in selecting or choosing to act upon specific and value-laden framings and/or solutions.

In this paper, our primary contribution is to describe the co-evolution of solution and problem space through a value-focused lens, identifying process moves among designers that represent potential value inscriptions taking place as a set of inter- and intra-designer patterns. Through the identification and articulation of these patterns, we move beyond co-evolution as a cognitive or pragmatic representation of design activity alone, and identify the value relationships inherent and foundational to these process moves—both within a designer's own cognition and as distributed among the frame negotiation of multiple designers—further elaborating the ethical nature of design work.

2. Related Work

2.1 Co-Evolution and Design Cognition

The cognitive work that designers engage in has been the subject of substantial prior scholarship, beginning with an effort to describe and elucidate the "black box" of design in the 1970s (Jones, 1970), and then later with attempts to describe characteristic behaviors of designers and design complexity as part of a "second generation design methods" (H. Rittel, 1984). While we cannot recount the entire movement from a focus on design as a rational enterprise to design as contextually and socially situated, we wish to call attention to specific features of design cognition that have particular impact on the framing of our present study. The notions of problem and solution spaces that are investigated through various forms of framing have been substantial components of design scholarship since the 1970s (H. W. J. Rittel & Webber, 1973; D. A. Schön, 1990). These efforts identified the social and cognitive complexity of design work, and the need for the designer to "frame a problematic design situation: set its boundaries, select particular things and relations for attention, and impose on the situation a coherence that guides subsequent moves" (Donald A. Schön, 1988). Many scholars—Kees Dorst in particular—have built upon this notion of problem framing, noting the role of framing in managing design complexity and identifying paradoxes that might be productively addressed (Dorst, 2015).

Building upon notions of problem framing and the generation of potential solution spaces, Maher, Poon, and Boulanger (1996) proposed that the concept of *co-evolution* acted as a set of evolutionary processes whereby problem spaces continuously interacted with potentially related solution spaces, and that design activity could be productively viewed as an set of explorative and co-evolutionary processes. Building on this work, Dorst and Cross (2001) validated this concept through a protocol study, defining the co-evolutionary processes of expert designers. Since the early 2000s, numerous scholars have further extended the concept of co-evolution, describing interactive characteristics that emerge in design teams (Hey, Joyce, & Beckman, 2007; McDonnell, 2018), identifying transitions in relation to methods and goals (Storm, van Maanen, & Gonçalves, 2019), and clarifying the moment of creative emergence (Dorst, 2019).

In this paper, we built upon these investigations of co-evolution with a particular focus on the trajectory of design behavior, highlighting the ways in which co-evolutionary moves can be considered as value-laden, as also argued by Lloyd (2009) as he parsed the role of ethics in design thinking and in the unfolding of design process. We do this by tracking co-evolutionary design moves as they are sequentially shaped by the priorities of individual designers, leading to outcomes which could be considered hostile to human values. While acknowledging that the notion of co-evolution is a well-established design concept, used in this paper as our theoretical framework to define our unit of analysis, the novelty of our work lies in overlaying ethics as an important component of co-evolution.

2.2 Ethics and Values in Design

Ethical engagement has long been considered as a core aspect of design behavior, as design itself is committed to shaping new futures through the creation of the "not-yet-existing" (Nelson & Stolterman, 2012). Ken Friedman described this commitment as follows: "To serve human beings, outstanding professional designers must master an art of human engagement based on ethics and on care. Design education must foster such skills and knowledge." (2012, p. 150). However, studies on design cognition have infrequently focused on the value commitments that designers take on in their work, even as value-focused methods have risen in prominence (e.g., B. Friedman & Hendry, 2019). In this sense, we wish to foreground notions of ethics and values as a key dimension of design activity, expanding upon two sets of related disciplinary literature: 1) professional ethics; and 2) notions of inscription from Science and Technology Studies (STS).

The professional ethics literature in design and technology contexts has been dominated by work in engineering ethics (e.g., Bucciarelli, 2008; Harris, Pritchard, Rabins, James, & Englehardt, 2013; Herkert, 2000), at least in part due to licensure and accreditation requirements. While the topic has been raised in a design education context (e.g., Buwert, 2018; Findeli, 2001), these instances have been somewhat rare, and lacking the substantial integration into educational programs that has been true in engineering and technology education. In our own work, we have built on revised codes of ethics in human-computer interaction and computer science contexts (Brinkman, Gotterbarn, Miller, & Wolf, 2016) to identify opportunities for engagement with ethics and value-related dimensions of design behavior (Gray, Toombs, Light, & Vines, 2018). In prior work, we have investigated how designers implement "dark patterns" into digital and physical systems, subverting user value in exchange for shareholder value (Gray, Kou, Battles, Hoggatt, & Toombs, 2018). This integration of manipulative or coercive intentions has also led us to identify how designers convert their value-centered or manipulative intentions into concrete solutions and support them through rationale (Chivukula, Gray, & Brier, 2019). In this paper, we seek to build on this prior work to identify the interactivity of this ethical exchange, using co-evolutionary processes to describe where and how evil intentions are being introduced and built upon in the design process.

Research in STS has engaged substantially in the ethical character of design activity and the value-laden nature of designed outcomes. While a variety of methods have been created to highlight and support the values that designers incorporate into their work, these methods have failed to reach broad adoption by designers, and it is unclear how the routines that are supported by these methods relate to specific design activities. Value-Sensitive Design (VSD) is perhaps the most prominent methodological framework (e.g., B. Friedman &

Hendry, 2019), but Albrechtslund (2007) has critiqued earlier iterations of this framework for attending more to “backwards-looking” design without enough focus on “forward-looking” design potential as an outgrowth of the multistability of design outcomes. Other STS voices, such as Verbeek (2006, 2010) have also highlighted the ways in which designers inscribe values in their design work, which we have expanded on as an expression of the designer’s character in prior work (Gray & Boling, 2016). These accounts of inscription—whereby values are intentionally or unintentionally embedded into the physical and interactional potential of a designed artifact—also raise the issue of what (and whose) values should be considered. More recent expressions of these values, arising from a range of critical feminist and social justice perspectives (Costanza-Chock, 2018; Dombrowski, Harmon, & Fox, 2016; Manders-Huits, 2011), encourage attention to not only a pre-determined set of human values (e.g., B. Friedman & Kahn, 2003), but also to discovering values that may have relevance for specific groups or underserved and disempowered populations. In this paper, we build upon these critical traditions to describe what values designers are aware of while they engage in design work, and how this inscription process is supported by co-evolutionary design moves.

3. Method

We used lab protocol approach (Gero & McNeill, 1998) to capture dialogue and interactions among designers that provide detail to describe their value orientations, tensions, and sensitivity while addressing an ethically-nuanced design task. This method allowed us to replicate portions of real-world UX practice settings and capture ethically-related process moves of the designers as they ideated, discussed, and built solutions for a given problem space. We conducted four one-hour lab protocol sessions with three student designers each, and video-recorded all participant interactions. We observed the designers exchanging ideas and framing the design space to solve the given task during these sessions. A thematic and sequence analysis of these interactions helped us describe the co-evolution of problem and solution during decision making by an individual as well as among the designers. Taking this approach, we answer the following research questions:

1. What design moves do participants engage in that have an ethical character?
2. What patterns of co-evolution of problem solution and rationale are present, and how do these patterns relate to ethical dimensions of decision making?

3.1 Participants

We conducted four protocol sessions with three participants each. In total, we recruited twelve student designers from UX (User Experience) and IE (Industrial Engineering) programs, at both the undergraduate and graduate levels at a large Midwestern university in the USA. We recruited these participants through e-mails sent through departmental listservs and professional networks to create a stratified sample based on academic classification and degree objective. To participate in our study, the students had to have previously either worked on design-related projects, have taken a design-related course, or worked as a practitioner or intern in a design firm. Two sessions (Group 1 and 4) had a mixture of UX and IE students and two sessions (Group 2 and 3) had UX or IE students only. For this study, we do not seek to analyze the impacts of cross-disciplinary interactions between the UX and IE designers.

3.2 Study Design

Each protocol session was one hour in duration, including: an introduction (5 mins), design activity (45 mins), presentation to the researchers (5 mins), and follow-up questions to the participants based on the observations (5 mins). The substance and framing of the design tasks were based on prior interviews and conversations with practitioners, with the goal of replicating the bluntness and calls for explicit persuasion that are typical in real world stakeholder requests. Additionally, it is well-established in captology (Atkinson,2006) and in Fogg's (2009) persuasive strategies that one approach to persuasion and nudging is to manipulate users without their knowledge. This literature was used to motivate the task framing and learn more about the designer behaviors in these contexts. Additionally, this task and protocol design was one of three protocol studies we conducted where the design tasks moved from persuasion for altruistic purposes towards more typical and problematically capitalistic goals. The group of designers was asked to address a task for Amazon, with the request to collect more user data to improve Alexa's experience. The design task stated:

> "*We would like you to help us manipulate the user into giving up privacy permissions for their Amazon Alexa. We are hoping to gain the ability to listen in on all of the users' conversations and use this data to help advertisers better personalize the experience of using Amazon product.*"

Participants were provided with current wireframes of Alexa's mobile application, including the home page, settings, and permissions pages. The participants were asked to iterate on these wireframes or completely change the user interactions in order to address the design goal. Alongside these materials, they were given a flyer that consisted of basic interaction design principles (Norman, 2013) and persuasive principles (Fogg, 2009) using neutral language. The design principles included visibility, feedback, affordance, mapping, constraint, consistency, learnability and usability. The persuasive principles included persistence, reduction, suggestion, prominence, tunneling, and exclusivity. The participants were provided with sketching material, Post-Its, whiteboards, and markers for sketching and discussion purposes.

3.3 Data Collection

During the protocol session, the participants were video and audio recorded using cameras from above and the front. The front angle captured the entire conversation, expressions, and movement of the participants during the session and the top angle recorded sketching actions and exchanging of the participants in more detail. The recordings were fully transcribed and verified by the researchers. We used the interaction analysis method (Jordan

& Henderson, 1995) to clean these transcripts, adding pseudonyms to our participants, indicating "inaudible" instances and adding time stamps to each speech act, defined for this study as a single conversational turn. Pseudonyms were used in the form P0nA, B, and C, where n (=1,2,3,4) for the four sessions and the uppercase letter represents each participant in a single session. Session 4 was excluded from this study due to low audio quality.

3.4 Data Analysis

We conducted data analysis in three iterative rounds. Initially, we started by open coding (Saldana, 2015) the different design moves taken by the participants in each group based on their design decisions. We define *design moves* through their communicative speech acts as decision making instances which take the design action forward. For example, a design move could include a designer proposing a solution to achieve the goal given in the design task. Conducting a thematic analysis to axially organize the open codes (Braun & Clarke, 2006), the design moves we identified include: solutions, problem or rationale, agreement, disagreement, and design production. This process was conducted by one graduate student, who was trained in qualitative research through prior projects and coursework. The themes were cross checked with the principal investigator to finalize and create a codebook. We then created a codebook (Table 1) with the final categories of design moves that would structure a sequence analysis.

Table 1 Thematic codes of Design Moves

Theme	**Description**	**Example**
Solution	Design moves proposing an idea or concept to solve the given design task	"*...you could bundle that and be like, "Access your microphone and contacts."*
Problem Definition	Design moves framing the design space to generate or support their solutions or build scenarios.	"*So they have no other choice, but to put that and access everything. 'Cause if you keep giving people options, they'll start thinking more and more about it, like something, their privacy being taken away.*"
Agreement or Disagreement	Bidding moves where the designer is agreeing or disagreeing to the conversation, ideas or process during discussion.	Agreement: "*Yeah*" or "*Mm- hmm (affirmative)*" Disagreement: "*Nah. I would say not a pop up again.*"
Implementation	Design moves planning the interface design for the proposed solution, user task flow in a real scenario or visual design of the solution	"*if you click this, then this [button] comes up. But if you click this [button], the disclaimer will come up.*"

Research / Design Logistics	Speech acts that were not directly related to decision making and look at only logistics such as time, sketching practices, division of labor or planning of the logistics. **Note:** We removed all these speech acts from our analysis and numerical results provided in the findings section.	"*Yeah. I mean, why wouldn't you just draw up on black, on white board.*"

In the second round of analysis, each speech act was coded using this codebook. We then conducted two different types of analysis to describe the sequence and interactions among the various design moves, particularly focusing on capturing the temporal progression of these activities in relation to co-evolution behaviors. First, we identified the design moves used by the three designers in each group in a holistic manner, limiting our analysis to the 45 min design task portion of the transcripts. We calculated the total number of speech acts under each theme as well as the number of speech acts per each participant under each theme. These descriptive statistics informed our understanding of each designer's role in decision making (generating solutions or framing the space through rationales) as well as the patterns of communication among the designers (agreeing, disagreeing and implementing the decisions). These quantitative results, while useful, did not provide adequate detail regarding how the designers built off of each other's decision making, which prompted us to conduct a sequence analysis.

The final phase of analysis included a sequence analysis, building on concepts from interaction analysis. This type of analysis focused on how the three participants exchanged and interacted with each other in the context of design moves. To begin this process, we initially chunked various design moves in each session to divide the 45 min session into multiple *vignettes*. These design moves were indicated by conversational turns from one topic to another or a conversation to an action. For example, a vignette while discussing a certain solution was separated from a shift to discussing another solution or the design act of sketching ideas. These vignettes became our new unit of analysis. Within each vignette, we identified patterns of interactions, as shown in Figure 1.

4. Findings

Based on the analysis described above, we present our findings in two related sections. First, we present a holistic view of the co-evolution of problem and solution in each protocol group among the triad of designers. Second, we present the observed patterns of co-evolution of problem and solution, describing the function of each pattern in foregrounding ethical decision making, and providing two vignettes from one protocol session to illustrate these patterns.

4.1 Evidence of Co-evolution

In this section, we provide a holistic view of how the co-evolution of problem and solution occurred through the number of speech acts. Descriptive statistics of the number of speech acts for each design move—solution, rationale, agreement, disagreement and implementation—for each designer through the first three protocol sessions are presented in Table 2. The percentages are calculated over the total number of speech acts in the session (excluding speech acts related to research/ design logistics). Solutions were generally focused on explicit and concrete design outcomes, while statements of the problem space were generally foregrounded through rationale for pursuing a specific problem frame or set of constraints. Therefore, we use the term "problem definition" through the remainder of the findings section to refer to the team's working definition of the design problem being addressed.

Table 2 Descriptive Statistics of coded design moves

Group	**Designer**	**Solution**	**Problem Definition**	**Agreement**	**Disagreement**	**Implementation**	**Total # (per participant)**	**Total # (in session)**
1	P01A	**21** (7.34 %)	**41** (14.34 %)	**17** (5.94%)	**5** (1.75%)	**20** (6.99 %)	**105**(36.71%)	286
	P01B	**12** (4.2%)	**18** (6.29%)	**1** (0.35%)	**2** (0.7%)	**15** (5.24%)	**55**(19.23%)	
	P01C	**27** (9.44%)	**47** (16.43%)	**27** (9.44%)	**2** (0.7%)	**20** (6.99%)	**126**(44.06%)	
2	P02A	**12** (2.99%)	**36** (8.96%)	**13** (3.23%)	**1** (0.25%)	**35** (8.71%)	**96** (23.88%)	402
	P02B	**14** (3.48%)	**24** (5.97%)	**60** (14.93%)	0	**47** (11.69%)	**146**(36.32%)	
	P02C	**19** (4.73%)	**47** (11.69%)	**39** (9.7%)	**1** (.25%)	**53** (13.18%)	**160**(39.8%)	
3	P03A	**16** (3.46%)	**40** (8.64%)	**12** (2.59%)	**1** (0.22%)	**53** (11.45%)	**123**(26.57%)	463
	P03B	**10** (2.16%)	**47** (10.15%)	**13** (2.81%)	**1** (0.22%)	**67** (14.47%)	**138**(29.81%)	
	P03C	**12** (2.59%)	**59** (12.74%)	**40** (8.64%)	**6** (1.3%)	**85** (18.36%)	**202**(43.63%)	

These descriptive statistics reveals substantial engagement with the problem definition and potential related solutions, accounting for 43% of all speech acts averaged across the three protocol sessions. Problem definition was engaged in at a rate 2.5 times that of solutions, representing a high level of awareness of the problem being addressed, with visual support for solution generation which may have impacted the quantity of verbalization. The combination of problem definition and solution speech acts also represented a large proportion of all conversation, including 58% of all acts in Protocol A, and 38-40% in Protocols B and C. This is likely to be expected, given the ubiquity of this design move as suggested by Dorst and Cross (2001), and does not in itself represent the ethical character of the design activity. However, the agreement or disagreement allows insight into the amount of cohesion or tension among designer perspectives. Through these measures, it is clear that agreement with the presented solution or problem definition strongly outweighed any disagreement. Across all three protocols, 222 speech acts agreed with the design move in play, while only 19 speech acts represented dissent or disagreement. This level of agreement, especially when the design task being presented is explicitly presented as manipulative, is informative and also scary to consider. This was anticipated to be the situation and we hoped to observe our participants identifying a matter of ethical concern and then reframing the brief in a more value-centered way. However, as presented in our results, participants almost uniformly chose to accept the given design task and related problem framing, resulting in outcomes that explicitly manipulated end users. Our covert intentions were to describe factors that foregrounded these unethical behaviours, which required that we begin the design task in an unethical framing in order for the designers to be able to reframe the problem to support end users. Implementation speech acts were also an important part of the design discourse, representing 34% of all speech acts. These indications of implementation generally included the finalization of solutions, as the designers were thinking through how the users would interact with the designs. Thus, while not the focus of study in this paper, these speech acts do represent relatively high engagement in both problem framing/solution activity and the concretization of these decisions in specific design representations.

4.2 Patterns of Value-laden Co-evolution

In this section, to describe the co-evolution of the rationale-solution space with an ethical lens, we will present various patterns of value-laden co-evolution observed through our data as presented in Figure 1 and illustrate these patterns through a case study. We were inspired by foundational work on Linkography (Goldschmidt, 1990) and our prior work on an extension to this method known as Ethicography (Chivukula, Gray, & Brier, 2019) and the use of these relational analytic approaches to represent (visually or conceptually) the patterns as they link from one design move to another. Providing an ethical, value-centered lens on Linkography using the language of co-evolution of problem and solution space is a the primary research contribution in this paper. We have detailed the ethical overlay of these patterns through the descriptions provided in Table 3. Finally, we use Group 1’s protocol session to illustrate all the patterns from three vignettes of the session to demonstrate coherence, but these patterns exist across the dataset.

Patterns of Value-laden Co-evolution of Problem–Solution space:

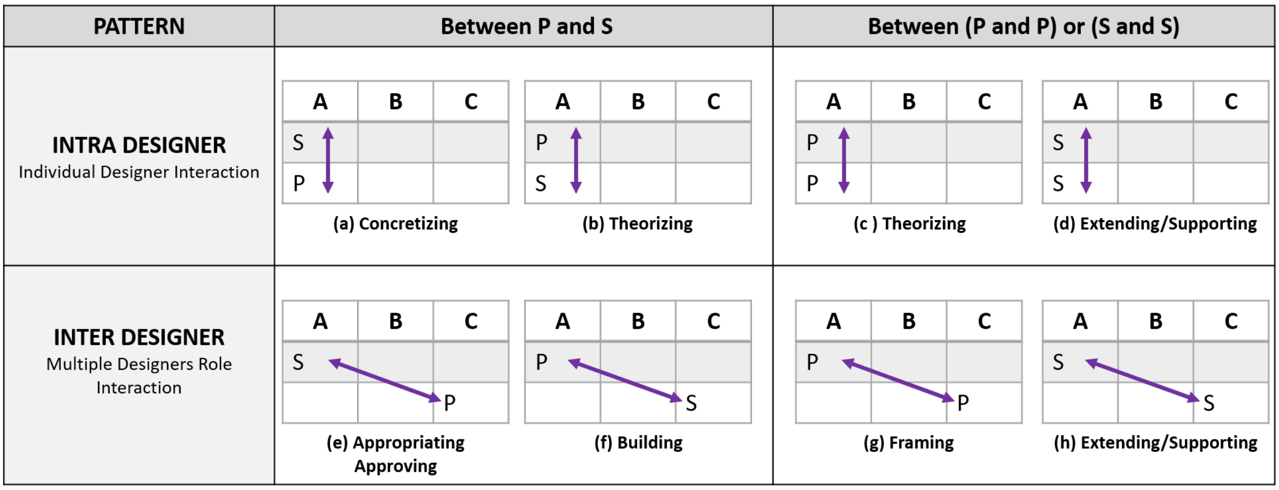


Figure 1 *Patterns of Co-evolution: describing the patterns of co-evolution of solutions and rationales within an individual designer [patterns (a)- (d)] and among multiple designers [patterns (e)- (h)]*

As depicted in Figure 1, these patterns are formed with various combinations of interaction within an individual designer’s own speech acts (intra) and among multiple designers (inter) vs. a shift between solution-focused (S) and problem-definition-focused (P) or extending the same role. These combinations with examples and definitions are described in Table 3 below:

Table 3 Patterns of value-laden co-evolution with description and example speech acts.

Pattern	Description	Example Speech acts
Pattern (a) Intra S-P	Co-evolution of solution (S) and problem (P) in consecutive speech acts by an individual designer, **concretizing their manipulative intention** in one's own solution by providing a rationale.	***P02B:*** *you could bundle that and be like, "Access your microphone and contacts." So like {Put it all together}.* **[Solution]** ***P02B:*** *So they have no other choice, but to put that [agree] and access everything. 'Cause if you keep giving people options, they'll start thinking more and more about it, like something, their privacy being taken away.* **[Rationale]**
Pattern (b): Intra P-S	Co-evolution of problem (P) and solution(S) in consecutive speech acts by an individual designer**, theorizing their manipulative notion design space and amplifying evil** through the generation of solutions.	***P01A:*** *So, first of all, they [Amazon] can't really ask them directly "Oh, we're going to listen to all of your conversations." Because nobody would ever approve that, most of the people wouldn't.* **[Rationale]** ***P01A:*** *So, um, it has to be created in a way such that the user doesn't feel, you know, like um, I don't know, like very uns, the user should be sure that whatever he or she is doing is like, you know, perfectly alright and they've seen this before in like other applications maybe, like, a similar language so that there is somebody who will click yes without thinking like-* **[Solution]**
Pattern (c): Intra P-P	Evolution of problem (P) in consecutive speech acts by an individual designer, theorizing their design space **to support their manipulative intentions** and further build possibilities to achieve the design task.	***P02C:*** *Yeah. I would just go into settings and let 'em use the microphone.* **[Rationale]** ***P02C:*** *'Cause that would be very annoying.* **[Rationale]**
Pattern (d): Intra S-S	Evolution of solution (S) in consecutive speech acts by an individual designer, **extending and conceptualizing their manipulative or dark solution**.	***P01A:****If they try to use like a feature, let's block some features right? If they say no?* **[Solution]** ***P01A:****Just don't give them access to the stuff that they will need.* **[Solution]**

Pattern (e): Inter S-P	Co-evolution of solution (S) and problem (P) in consecutive speech acts, where a fellow designer is **appropriating and approving another designer's manipulative or dark solution** through a manipulative intention communicated through their rationale.	***P01C:*** *Yeah 'cause then, then you're forced to like do it.* **[Solution]** ***P01A:*** *Yeah. And most of those people will click okay.* **[Rationale]**
Pattern (f): Inter P-S	Co-evolution of problem (P) and solution(S) in consecutive speech acts, where a fellow designer is building or **operationalizing another designer's manipulative intentions** communicated through their rationale.	***P01C:*** *Yeah, are you sure want to say no to this? It's, it's kind of important, and so it just makes it really hard, really awful, to like get out of it.* **[Rationale]** ***P01A:*** *Yeah. Then you can say something like "To fully like, um, like use, like to make the fully use out of your device, uh, you would want to enable this."* **[Solution]**
Pattern (g): Inter P-P	Evolution of problem definition (P) in consecutive speech acts, where a fellow designer is **supporting the framing proposed by another designer's manipulative intentions** communicated through their rationale.	***P01C:*** *So, uh, this is interesting. To, it's, I mean, what are your guys' thoughts? Like, I mean, so it, the idea is that the word, "manipulating users to get their information," which is kind of rough. Like, but I mean, um, it's interesting. Okay, so, like what do you guys think, thought on like doing this?* **[Rationale]** ***P01A:*** *So, first of all, they can't really ask them directly "Oh, we're going to listen to all of your conversations." Because nobody would ever approve that, like, most of the people wouldn't.* **[Rationale]**

Pattern (h): Inter S-S	Evolution of solution (s) in consecutive speech acts, where a fellow designer is **extending or supporting another designer's manipulative or dark solution**.	*And then, after, do we block some of the features, do you, we ask them again at some definite feature or not?* **[Solution]** *Yeah, so that's the idea of like, yeah, the idea about like if they say no it's still gonna be like, it's gonna be like a prominent part of the app like how like advertisements, if they pop up at the bottom like constantly, if you're like not a premium member of it, 'cause they're always there, they're always popping up always saying-* **[Solution]**

In the following sections, we present three vignettes from Group 1 protocol session to illustrate the described patterns. These three vignettes were selected as a unit of analysis for the richness of the conversation as well as demonstrating all the patterns in Figure 1. We describe the context, sequence of conversation among the designers (Figures 2, 3 & 4) and occurence of patterns of interactions in the subsections below.

Vignette 1: *Making it difficult to get out of the task flow or say "no" [9:07-10:50].*

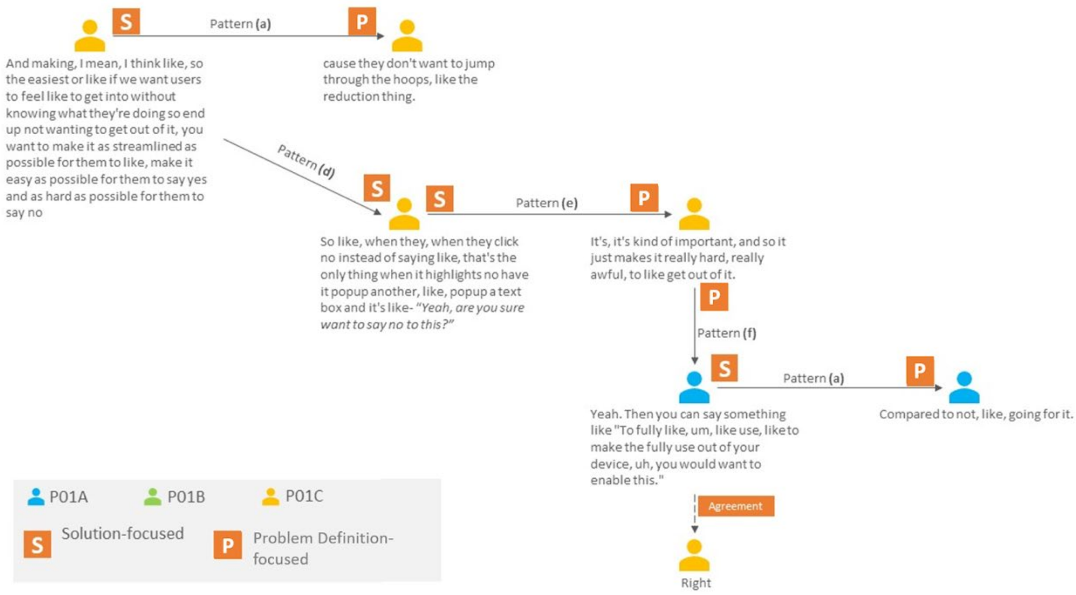


Figure 2 Sequence analysis of Vignette 1 [demonstrating patterns (a), (d) & (e)]

The sequence of conversation represented in Figure 2 occurred when the designers were planning to make the task flow "streamlined" and "hard" for the users to disagree to the microphone access. The vignette starts with P01C suggesting a solution (S) to make it "as streamlined as possible" and rationalizing that decision (P) by drawing on a persuasive principle—“reduction”—presented in the flyer given to them along with other materials. Here, we see the example of *pattern (a)* where an individual designer is trying to concretize an evil solution through a dark rationale. We observe *pattern (d)*, when the same designer P01C builds on a solution (S-S) from making it “hard” to keep nagging the user asking “*Are you sure you want to say no?*”. This pattern continues from this solution to rationalize the problem definition (P) through emotions to make it “really awful” to say no to the permissions. Based on the rationale provided by P01C, P01A suggests another solution (S) to emotionally present the scenario for the user saying “to make full use of your device” the user has to agree to permissions of the microphone access, illustrating *pattern (f)* of inter-designer P-S interaction. The vignette ends with P01A rationalizing (P) the problem definition to say that the user will not have any other option than to accept as any user would like to avail the full functionality, described in pattern (a) of intra-designer S-P interaction.

Vignette 2: *Updating the information architecture of the “Settings” menu [32:38- 33:15].*

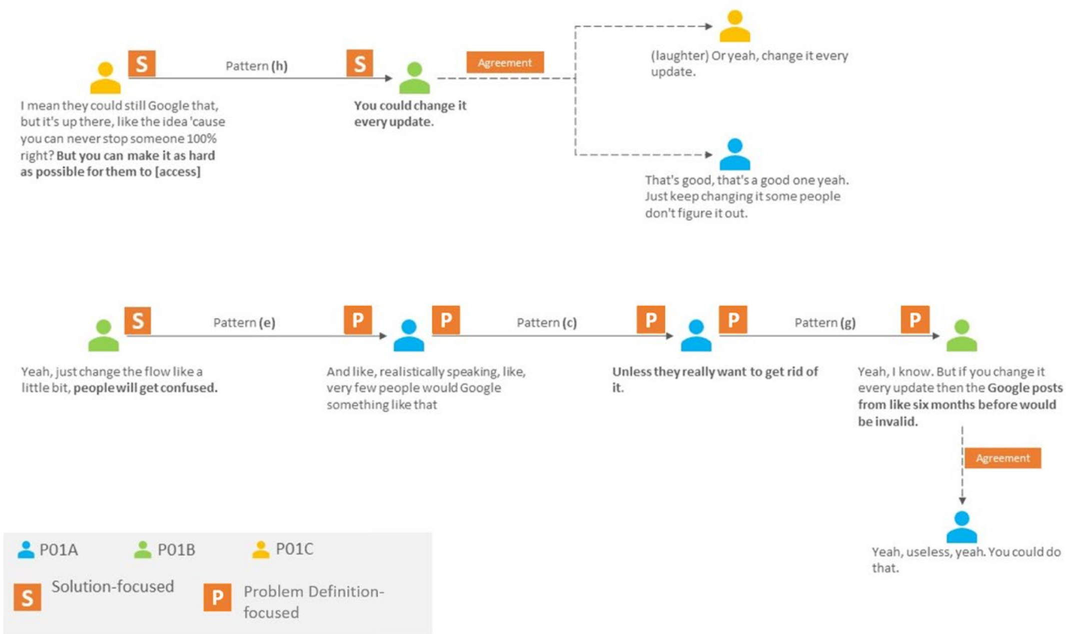


Figure 3 Sequence analysis of Vignette 2 [demonstrating patterns (c), (e), (g) & (h)]

The sequence presented in Figure 3 occurred in a conversation where the designers were trying to hide the privacy settings in the “Settings” menu, thereby making it difficult for the user to turn off the microphone access during the experience. This vignette is followed by a conversation where the designers assumed that users could always Google any solution or “help” for settings. This vignette began with P01C suggesting a solution (S) that the privacy settings should be positioned in a way that is “hard for [the users] to access”. P01B continued the conversation by suggesting a solution (S) to “change [the position of privacy] every update”, illustrating *pattern (h)* where one designer supports and extends another designer’s evil solution. P01B continued to rationalize the problem definition (P *pattern (a)*) saying that “people will get confused” when there is a change in the task flow. This was supported through a cynical rationale by P01A that there are rare cases for users to “Google something like that”, showcasing *pattern (g)* where one designer shows agreement to another through a rationale that supports the overall problem definition (P-P). P01A conditions their own rationale by offering an edge case that people would not Google “unless they want to get rid of it”, just as in pattern (c) where an individual designer self-rationalizes their own design decision/ move. P01B looped back to connect the solution on every update and Google search by providing a rationale that “Google posts from six months would be invalid”, illustrating another case of *pattern (g)* in this vignette. This repetition of supporting, extending and rationalizing other’s solutions is evident in the interactions in this vignette through patterns (g) and (h).

5. Discussion and Future Work

Through our analysis of the value-laden co-evolution of problem definition and solution, we have demonstrated how design students reconcile or perpetuate value inclusion through practical examples and empirical data. In the following sections, we present our discussion and synthesis of the findings. First, we describe the propagation of evil that occurred through co-evolution of problem and solution among the triad of designers, drawing on a few examples from the patterns presented in this paper. Second, we highlight the need for methodological and pedagogical interventions for developing a designers’ ethically aware character through the subversion of evil outcomes or the further enabling of value discovery in the co-evolution process.

5.1 Propagation of Evil through Co-evolution

The patterns of value-laden co-evolution we have defined represent how designers supported each other’s decisions through extending, building, supporting and framing each other’s solutions and problem definition rationale. These patterns not only represent the co-evolutionary moves, but also how specific manipulative intentions are propagated or otherwise accepted by fellow designers. We term this as a “propagation of evil” as the design process was begun within an “evil” frame to manipulate the end user; in addressing this given problem space, the designers chose to accept the frame and manipulate the user to give up their microphone access even if it meant trading off the human values of privacy and informed consent (Friedman and Kahn 2003). The designers thereby accepted and propagated the stakeholder’s intention by creating and rationalizing design outcomes that were hostile to user needs, articulating and strengthening an unethical problem space in the process. This kind of propagation is resonant with existing critiques of design accountability and responsibility, such as Willis’ (2006) notion of ontological designing, alongside emerging critiques of design activity from decolonizing, social justice, and feminist perspectives (e.g., Costanza-Chock, 2018; Forlano, 2017; Tlostanova, 2017).

This propagation is evident especially in patterns of inter-designer (patterns e,f,g,h) conversations and intra-designer S-P patterns (patterns a,b) to which other designers show “agreement.” For example, in vignette 2 (Figure 3), the conversation starts with P01C suggesting a manipulative design outcome and P01B extending the solution shows the support for a manipulative move, to which both P01A and P01B both show agreement. In real world practice, this phenomenon of propagation of evilness or manipulation during design decision making can result in unethical designs which can have broad societal impact. In a recent paper, Dorst (2019) calls for researchers to look at “co-evolution on a societal scale,” in the sense of seeing an “upward jump” from solution space to problem space. The paper provides an example of how technology (reified as a solution) impacts the “human culture, values and meaning,” thereby articulating a socially-bound problem space. Based on our analysis we are able to account for social interactions among designers that may lead to the acceptance of value-misaligned design decisions, and the precursors to this acceptance that may be productively supported or disrupted through the use of design methods. Ultimately, we view the coevolution of problem-solution as site of value manipulation and inscription which points to the importance of designer responsibility and awareness. In doing so, we link longstanding concerns from the STS community regarding the value-laden nature of design work and cognitive models of design activity from the design studies community.

5.2 Subverting or enabling value discovery for ethical action

We have illustrated how the triad of designers were involved in co-evolution through holistic results as well as identified the patterns manipulative intentions and dark solutions and their propagation through co-evolutionary moves. Through the examples presented in this paper, this decision-making included occurrences of both value-centered and manipulative intentions. These design students had previously taken coursework in ethics, and were made aware of various methods and approaches to be more value-sensitive throughout their curriculum, but instead chose to accept a manipulative problem frame in a real-world scenario when they were given a value-laden task.

It is likely that few student designers had the explicit intention to be evil, but the trajectory of each protocol did still result in solutions and related problem frames that accepted the stakeholder aims in a way that undermined the user’s human values. However, interestingly and perhaps useful for future work, even in moments where evil or unethical outcomes were identified, there were moments when one or more designers recognised that they would not want those design outcomes for themselves. Thus, this study reveals opportunities to encourage the subversion or enablement of value discovery as a key part of the co-evolutionary process.

For pedagogy and practice, it might be necessary to see how to provide support to enable the value-centered and subvert the evil intentions in decision making to lead to value-centered design outcomes. This calls for a methodological support and intervention for developing an ethically aware design character, particularly in student designers, building not only a set of methods to support what Nelson and Stolterman (2012) describe as “wise action,” but also the communicative ability to reframe problems to highlight areas of ethical concern.

Based on the empirical work presented in this paper, we call for more methodological tools to support the required critical reflection through the process of decision making that map onto the challenges presented by problem-solution coevolution. These tools must engage with the design complexity present in practice (Stolterman 2008), enabling designers to communicate effectively to stakeholders. This requires the ability of designers to use a variety of skills such as "methods of communicating to stakeholders, representing design activity and outcomes, promoting design approaches in the enterprise, and negotiating complexity in cross functional teams" (Gray 2014).

6. Limitations

As with all studies, our selection of study design and factors such as sample size, participants and design task point towards important limitations of our work. Even considering a relatively small number of groups and participants, we identified numerous insights of co-evolution across multiple patterns with data saturation. While the scope of this paper and protocol focused only on the most "evil" and directly manipulative design task, the patterns of design reasoning and unethical outcomes are resonant with other protocol studies conducted we had conducted in our larger project setting with design tasks varying in the spectrum of evilness and capitalistic goals (Chivukula, Gray, & Brier, 2019; Chivukula, Brier & Gray, 2018). The differences in participant population is also important to consider in this and future studies. Using a lab protocol approach, we sought to replicating professional practice settings in terms of problem frame, but without fully capturing important ecological and business constraints that may impact designing for end users. We did include participants who have had professional experiences, increasing the ecological validity of the task and outcomes, but there are clear differences between students with professional experience and seasoned professionals working in an established business environment. However, given the difficulty in capturing designers' behaviours in relation to an unethical design task "in the wild," we find the trade-off to still provide a valuable and informative addition to the design literature.

7. Conclusion

In this paper, we have built upon existing conceptions of problem-solution coevolution, describing the ways in which values impact the negotiation of problem definition and resulting solutions. Through analysis of our protocol study findings, we identified a set of patterns of intra- and inter-designer interaction that propagated evil intentions into design outcomes, described through the language of coevolution of problem-solution. We build upon these findings to describe the need for further attention to the ethical dimensions of design activity, and the potential role of design and communication methods in encouraging the subversion and redirection of problem space and solution manipulation to foreground ethical aspects of design work.

8. References

Albrechtslund, A. (2007). Ethics and technology design. *Ethics and Information Technology*, *9*(1), 63–72. https://doi.org/10.1007/s10676-006-9129-8

Atkinson, B. M. C. (2006). Captology: A Critical Review. In Proceedings of the International Conference on Persuasive Technology (pp. 171–182). https://doi.org/10.1007/11755494_25

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brinkman, B., Gotterbarn, D., Miller, K., & Wolf, M. J. (2016). Making a positive impact: updating the ACM code of ethics. *Communications of the ACM*, *59*(12), 7–13.

Bucciarelli, L. L. (2008). Ethics and engineering education. *European Journal of Engineering Education*, *33*(2), 141–149. https://doi.org/10.1080/03043790801979856

Buwert, P. (2018). Examining the Professional Codes of Design Organisations. *Proceedings of the Design Research Society*. https://doi.org/10.21606/dma.2017.493

Chivukula, S. S., Brier, J., & Gray, C. M. (2018). Dark Intentions or Persuasion?: UX Designers' Activation of Stakeholder and User Values. Proceedings of the 2018 ACM Conference Companion Publication on Designing Interactive Systems, 87–91.

Chivukula, S. S., Gray, C. M., & Brier, J. A. (2019). Analyzing Value Discovery in Design Decisions Through Ethicography. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 77:1–77:12. https://doi.org/10.1145/3290605.3300307

Costanza-Chock, S. (2018). *Design Justice: Towards an Intersectional Feminist Framework for Design Theory and Practice*. Retrieved from https://papers.ssrn.com/abstract=3189696

Dombrowski, L., Harmon, E., & Fox, S. (2016). Social Justice-Oriented Interaction Design: Outlining Key Design Strategies and Commitments. *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, 656–671. https://doi.org/10.1145/2901790.2901861

Dorst, K. (2015). *Frame innovation: create new thinking by design*. MIT Press.

Dorst, K. (2019). Co-evolution and emergence in design. *Design Studies*. https://doi.org/10.1016/j.destud.2019.10.005

Dorst, K., & Cross, N. (2001). Creativity in the design process: co-evolution of problem–solution. *Design Studies*, *22*(5), 425–437. https://doi.org/10.1016/S0142-694X(01)00009-6

Findeli, A. (2001). Rethinking Design Education for the 21st Century: Theoretical, Methodological, and Ethical Discussion. *Design Issues*, *17*(1), 5–17. https://doi.org/10.1162/07479360152103796

Fogg, B. J. (2009). Creating persuasive technologies: an eight-step design process. *Proceedings of the 4th International Conference on Persuasive Technology*, 44. https://doi.org/10.1145/1541948.1542005

Forlano, L. (2017). Posthumanism and Design. *She Ji: The Journal of Design, Economics, and Innovation*, *3*(1), 16–29. https://doi.org/10.1016/j.sheji.2017.08.001

Friedman, B., & Hendry, D. G. (2019). *Value Sensitive Design: Shaping Technology with Moral Imagination*. Retrieved from https://market.android.com/details?id=book-C4FruwEACAAJ

Friedman, B., & Kahn, P. H., Jr. (2003). Human values, ethics, and design. In J. A. Jacko & A. Sears (Eds.), *The human-computer interaction handbook* (pp. 1223–1248). Retrieved from https://content.taylorfrancis.com/books/e/download?dac=C2009-0-12021-5&isbn=9781410615862&doi=10.1201/9781410615862-81&format=pdf

Friedman, K. (2012). Models of design: Envisioning a future design education. *Visible Language*, *46*(1/2), 133–153.

Gero, J. S., & Mc Neill, T. (1998). An approach to the analysis of design protocols. *Design Studies*, *19*(1), 21–61. https://doi.org/10.1016/S0142-694X(97)00015-X

Goldschmidt, G. (1990). Linkography: assessing design productivity. *Cyberbetics and System'90, Proceedings of the Tenth European Meeting on Cybernetics and Systems Research* (pp. 291–298).

Gray, C. M. (2014). Evolution of Design Competence in UX Practice. *Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems*, 1645–1654. https://doi.org/10.1145/2556288.2557264

Gray, C. M., & Boling, E. (2016). Inscribing ethics and values in designs for learning: a problematic. *Educational Technology Research and Development: ETR & D*, *64*(5), 969–1001. https://doi.org/10.1007/s11423-016-9478-x

Gray, C. M., Kou, Y., Battles, B., Hoggatt, J., & Toombs, A. L. (2018). The Dark (Patterns) Side of UX Design. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 534:1–534:14. https://doi.org/10.1145/3173574.3174108

Gray, C. M., Toombs, A. L., Light, A., & Vines, J. (2018). Editorial: Ethics, Values, and Designer Responsibility. *Proceedings of the Design Research Society Conference*, 83–85. https://doi.org/10.21606/drs.2018.003

Harris, C. E., Jr., Pritchard, M. S., Rabins, M. J., James, R., & Englehardt, E. (2013). *Engineering Ethics: Concepts and Cases*. Retrieved from https://market.android.com/details?id=book-CfoWAAAAQBAJ

Herkert, J. R. (2000). Engineering ethics education in the USA: Content, pedagogy and curriculum. *European Journal of Engineering Education*, *25*(4), 303–313. https://doi.org/10.1080/03043790050200340

Hey, J., Joyce, C. K., & Beckman, S. L. (2007). *Framing Innovation: Negotiating Shared Frames During Early Design Phases*. Retrieved from https://papers.ssrn.com/abstract=1576473

Jones, J. C. (1970). *Design Methods*. London, UK: Wiley-Interscience.

Jordan, B., & Henderson, A. (1995). Interaction Analysis: Foundations and Practice. *Journal of the Learning Sciences*, *4*(1), 39–103. https://doi.org/10.1207/s15327809jls0401_2

Lloyd, P. (2009). Ethical imagination and design. In J. McDonnell & P. Lloyd (Eds.), Design Studies (Vol. 30, pp. 154–168). CRC Press.

Maher, M. L., Poon, J., & Boulanger, S. (1996). Formalising Design Exploration as Co-Evolution. In J. S. Gero & F. Sudweeks (Eds.), *Advances in Formal Design Methods for CAD: Proceedings of the IFIP WG5.2 Workshop on Formal Design Methods for Computer-Aided Design, June 1995* (pp. 3–30). https://doi.org/10.1007/978-0-387-34925-1_1

Manders-Huits, N. (2011). What values in design? The challenge of incorporating moral values into design. *Science and Engineering Ethics*, *17*(2), 271–287. https://doi.org/10.1007/s11948-010-9198-2

McDonnell, J. (2018). Design roulette: A close examination of collaborative decision-making in design from the perspective of framing. *Design Studies*, *57*, 75–92. https://doi.org/10.1016/j.destud.2018.03.001

Nelson, H. G., & Stolterman, E. (2012). *The design way : Intentional change in an unpredictable world* (2nd ed.). Cambridge, MA: MIT Press.

Norman, D. (2013). *The Design of Everyday Things: Revised and Expanded Edition*. Retrieved from https://play.google.com/store/books/details?id=nVQPAAAAQBAJ

Rittel, H. (1984). Second-generation design methods. *Developments in Design Methodology*, 317–327.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169. https://doi.org/10.1007/BF01405730

Saldana, J. (2015). *The Coding Manual for Qualitative Researchers*. Retrieved from https://market.android.com/details?id=book-ZhxiCgAAQBAJ

Schön, D. A. (1988). Designing: Rules, types and worlds. *Design Studies*, *9*(3), 181–190. https://doi.org/10.1016/0142-694X(88)90047-6

Schön, D. A. (1990). The design process. In V. A. Howard (Ed.), *Varieties of thinking: Essays from Harvard's philosophy of education research center* (pp. 111–141). New York: Routledge.

Storm, R., van Maanen, J., & Gonçalves, M. (2019). Reframing the Design Process: Integrating Goals, Methods and Manifestation into the Co-Evolution Model. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 359–368. https://doi.org/10.1017/dsi.2019.39

Tlostanova, M. (2017). On decolonizing design. *Design Philosophy Papers*, *15*(1), 51–61. https://doi.org/10.1080/14487136.2017.1301017

Verbeek, P.-P. (2006). Materializing Morality: Design Ethics and Technological Mediation. In *Science, Technology & Human Values* (Vol. 31, pp. 361–380). https://doi.org/10.1177/0162243905285847

Verbeek, P.-P. (2010). *What things do: Philosophical reflections on technology, agency, and design*. University Park, PA: The Pennsylvania State University Press.

Willis, A.-M. (2006). Ontological Designing. *Design Philosophy Papers*, *4*(2), 69–92. https://doi.org/10.2752/144871306X13966268131514

About the Authors:

Shruthi Sai Chivukula is a PhD Candidate at Purdue University. Her research focuses on describing everyday ethics in sociotechnical practice, particularly focussing on ethics-focused methods to provide support for ethical decision making.

Colin M. Gray is an Assistant Professor at Purdue University and program lead for an undergraduate major and graduate concentration in UX Design. His research focuses on the interplay between design theory and practice, and particularly the development of design expertise and ethical design character.

Attuning Contraception Choice and Patient Values

Michael ARNOLD MAGES[a]*, Janice LIN[a]*, Anni XU[a]*

[a] Northeastern University, United States of America
*Corresponding author e-mail: m.arnoldmages@northeastern.edu
doi: https://doi.org/10.21606/drs.2020.110

Abstract: In designed medical decision aids, supporting contraception decision-making is typically approached as supporting choice-making via the examination of features and benefits of the various contraceptive methods. In this paper, we examine the relevant goals of the immediate actors: personal goals of the patient and physician as well as the goals of the public health system. We argue that rather than supporting a single choice, that designing for contraception decision-making is best re-framed as supporting iterative attunement between the patient's values, body and a contraceptive regimen.

Keywords: contraception; decision aid; mobile technology

1. Introduction

Designing to support health decisions is a burgeoning area of practice for designers. Currently, activity in this area is driven by growing complementary interest in shared decision-making as an aspect of clinical care in the medical profession.

Designers who endeavor to design for shared decision-making face a challenging and complex situation. They are designing to support a conversation between a patient and a medical professional that is nested in an ongoing web of relationships that includes the needs of the patient, the various medical professionals, institutions, and (at times) is conducted while the patient is experiencing unexpected medical ailments. Designers are designing to support decision-making between the doctor and patient, attempting to create artifacts that provide information and support, and encourage deliberative conversations in fraught or emotionally difficult situations. In these conversations, patients often need material support to help them make sense of information in a domain where they have little expertise.

Decision aids (DAs) are a form of material support for patients or physicians attempting to evaluate different options, surface their values in the face of uncertainty, or plan for ongoing medical care. DAs might be used by patients or physicians to help structure a conversation or communicate complex information, including — for example — trade-offs in treatment regimens, efficacy or side effects of a variety of medications, or risk of lifestyle impacts upon health outcomes.

This paper focuses upon understanding the context of designing to support decision-making about revocable contraception options in the context of the encounter between an adolescent female and her physician. This situation holds particular interest as a design case. The adolescent female may approach the encounter as her first experience with a consequential medical decision. The decision process may serve as a model for future decisions regarding her own health. From this experience, she may be able to develop, and later transfer skills developed in consulting resources, identifying personal values, and advocating for herself and her needs with a person in a perceived authority role.

In this paper, we approached this process from a different perspective, adopting design approaches from deliberative inquiry and integrating them with service and interaction design approaches. Our goal is to develop a rich understanding of each actor's goals in the situation and support the patient in surfacing their values as pertains to contraception. Ultimately, we feel much of the work supporting patient decisions is authored from a predominantly medical perspective, focusing on communicating medical knowledge, such as efficacy, side-effects, and medical risk. Although this is of predominant importance, we feel design has the opportunity to reframe the conversation, leveraging attention to the human aspects of the experience, namely: supporting the dignity of the patients, considering how a medical experience might be perceived in the context of a broader set of services offered by the medical profession, and supporting ongoing attunement between systems of contraception and the needs and values of adolescent women.

2. Goals in medical contexts

The consideration of goals in software design and usability contexts is well established. (Cooper, 2007) When thinking of designing a facilitative object — an object that provides a catalyst for a number of actors to interact within the context of a system — like a decision aid, it is useful to think of goals for both the user and the service-provider. Further, goals may be considered beyond the immediate user of the product or service. Goals may be meaningfully considered beyond the scope of the individual human, to account for goals of relevant system, in this case, the goals of public health, or the goals of the set of systems that provides and funds healthcare activity. The following section delineates relevant goals from the perspective of the patient, and the physician, as well as the goals for the broader system of public health. Considering goals as multi-level, as complementary or conflicting helps to gain a richer picture of how a facilitative object, like a decision aid, might function in situ.

2.1 Goals for the physician

In the United States, a consultation with a certified health care provider is required in order to receive a prescription for contraception. As a result, the role this provider has during the process of making a decision regarding contraception is integral. The health care provider is the clinical expert and most equipped to answer any questions regarding the factual-based inquiries for contraceptives which includes efficacy, safety, and proper instructions for administration (Madden & Kleinlugtenbelt, 2017). As a result, it is integral to the physician to be able to provide medically accurate information utilizing evidence-based recommendations to help a patient be appropriately informed when making a decision about contraception.

The use of a decision aid (DA) may be an appropriate supplement for a patient to use in conjunction with or outside of the consultation. It is important to ensure the information represented in a DA is medically accurate and appropriate for a patient to reference. Not only is the information itself important to be in line with the provider's clinical knowledge, but it must also appropriately communicate the benefits and harms.

The physician's promise to the patient is that they will uphold the values of medical ethics. There are four fundamental primary values as stated in the *Principles of Biomedical Ethics* which are patient autonomy, non-maleficence, beneficence, and justice. (Beauchamp & Childress, 2013) To effectively support the consultation, and the decision-making process, it is imperative the DA is representative of and upholding of these values. Moreover, to support the contraception conversation, the DA must have an equal and fair display of the safety risks associated with contraception while also highlighting the efficacy and appropriate additional benefits.

Furthermore, in today's practice environment, efficiency and time maximization of each visit (which is often limited) is important to the physician. The addition of a DA may help reduce the time spent going over the basic principles and lead to a more productive conversation in person (Jardine & Robinson, 2013). The DA may be utilized as a tool to give to a patient prior to presenting to a consultation as an introduction or during the visit as a reference to guide the patient through the options. Having a physical piece of paper to show a patient and consult during the process is helpful to alleviate some of the time the physician would use to convey specific information that can be easily read by a patient.

The identification of the physician's goals shows the importance of the physician's values and responsibilities, pertaining to themselves in terms of medical accuracy, their patient in terms of beneficence, and the medical system in terms of efficiency.

2.2 Goals for the patient

Goals for the patient as regards this experience could be meaningfully organized into two aspects: the goals of the patient as pertains to the use of the decision aid (DA) in the consultation situation, and the goals of the patient as pertains to the use and ongoing contraceptive care management and health.

The patient in this context is female in her adolescent years. At this age, the majority of young women in the United States have led generally uneventful medical lives with 97.8% of 12–17 year olds surveyed indicating they are in good, very good or excellent health during the combined years 2017–2018 (USDHHS 2019). It is likely that she has not had a previous interaction where she was responsible for making a decision pertaining to her own health. The decision to choose a contraceptive method may therefore be the first significant interaction she has, where she has primary agency for decision-making (Hartman, Monasterio & Hwang, 2012). Navigating this unfamiliar world may result in feelings of being lost and confused. In the United States, there is no consistent curriculum to teach children skills in health literacy, and therefore, the medical jargon describing all of the possible methods holds the potential to derail her inquiry.

Specific goals for the use of the DA include allowing the individual's own values and preferences to be heard by the medical professional in the context of the decision encounter. Just as the physician is the expert on medical facts, the patient is the expert on her own values and lived experience (Madden & Kleinlugtenbelt, 2017). It is important to be able to help the young female identify what factors are important for her, and what would make her feel most comfortable and secure. Examples of values include desired levels of efficacy, permanency, convenience, religious/cultural synchronicity, cost and accessibility (Rubin, Felsher, Korich, & Jacobs, 2016). These factors may have differing levels of importance to each individual. Therefore, it is important to recognize how a specific ordering and weighting of each value can impact her choices. For the DA, taking these considerations into account is paramount. It must be flexible and adaptive in responding to her preferences.

Having the ability to take her time to consider the fit of a medication with her lifestyle, values and preferences, and also the ability to change her decision without repercussions is unique to contraception decision-making. The DA, although inherently supposed to conclude with the arrival of a decision, should actually be written in a more open manner to mimic the dynamic nature of her options (Hartman, Monasterio, & Hwang, 2012). It should convey to the user that her options do not close even if she makes a decision. All of her options are still available and just as valid as they were before. For the adolescent woman, contraceptive activity is an ongoing process of attunement (Mol, 2008) to an approach, rather than a moment of choice that is experienced and passes.

Tangential to understanding the patient's goals in the context of decision-making in a clinical encounter, is understanding the patient's goals in the ongoing use of a contraceptive approach. The relation between the patient's goals in the decision-making process and the use of contraception are related, but subtly different. Goals for use inform and shape goals for decision-making.

A number of studies have shown that for predominantly healthy adolescent women, pregnancy is a more prevalent concern motivating contraceptive use than the prevention of sexually-transmitted disease (STD). Pregnancy avoidance remains a key factor motivating adolescents and young women to seek contraception. Over time, a number of studies (Weisman et al. 1991, Roye & Seals 2001, Melo et al., 2016) have examined decision-making processes as regards contraception choice and found the avoidance of unintended pregnancy to be one of the most salient factors motivating adolescents and young women to seek out contraception. Roye & Seals (2001), go so far as to suggest attending nurses reframe condom use as an additional protection against pregnancy as well as disease prevention for women using hormonal contraception to increase condom use among women already using oral contraceptives.

Bernstein & Jones (2019) cite the existence of an "expectation effect" in which a woman may expect whether and when to have a child, which allows her the individual freedom to plan her future around her own goals. The control contraception gives to the adolescent is incomparable to anything else that can be offered. It allows her to have the freedom to aspire for continued education and opens up the career field options. By giving the resources to appropriately inform and educate adolescent women about their options regarding their own body, an adolescent female is able to take control of her future.

Barriers to effective use of contraception are an additional consideration an adolescent woman may experience. Such barriers may be relational in character, such as partner assent (Weisman et al., 1991) or parental attitudes (Fisher & Hall 1988, Roye & Seals 2001), physical, such as a physical feeling of irritation when using condoms (Roye & Seals 2001) or a response to the hormonal content of OCs or long-term contraception. Misinformation and the consequent misuse (Dehlendorf et al., 2017) presents another significant barrier to effective contraceptive use. Identification of barriers that are specific to the patient experience are important to surface in the clinical encounter. The DA must therefore allow the patient to share and reflect on possible barriers pertinent to her story. This will allow health care professionals to help provide outcomes that facilitate her overcoming any anticipated problems.

Finally, as pertains to the patient's goals and the maintenance of a contraceptive regimen, there is also a fundamental difference in the revocability of contraception decision-making and use that differs from most other medical contexts. Generally, if a patient needs to make a decision from a selection of treatment options such as: wait and see, medication, or surgery, there is a gradient of ascending irrevocability (also understood as permanence or opportunity cost) the patient needs to be made aware of. In many medical contexts risk assessment for different choices is a critical component. For example, if a patient elects to delay medical intervention (*wait and see*) and the condition worsens, that entails consequences. However, in the context of contraception, the impact of possible consequences is minimal by comparison. A patient is able to switch between methods — such as an oral contraceptive to an intrauterine device, and vice versa — without impacting her successful return to pregnancy or increasing risk of an unintended pregnancy. Furthermore, if the patient decides to suspend the decision, and wait, she does not need to fear that she is incurring risk or diminishing future opportunity.

2.3 Goals as pertains to public health

The introduction of contraception, with the approval of the first contraception pill in the United States in 1960, resulted in significant improvements in a variety of aspects for women and the general public health. For example, there is a positive economic impact as avoidance of unintended pregnancy, especially for adolescents, allows a woman to complete her high school or college education and thus, yield a higher future earning potential (Bernstein & Jones, 2019).

Educating adolescents about contraception is a fairly inexpensive solution that yields a high economic savings. Not only does it result in reduced chances of living in poverty for the adolescent, but it also helps save the health system the additional costs of abortions or cost of birth. In 2010, the direct medical costs of unintended pregnancies was found to be $21 billion USD. When the total federal and state governmental spending on unintended pregnancies are averaged, it comes out to $336 USD for every woman aged 15-44 in the United States (Sonfield & Kost, 2015). Imagine how those funds could be better allocated for preventive services and education.

Not only is there a benefit for the individual adolescent, but there is also a benefit for the subsequent generation. When a mother is able to choose to delay her pregnancy until she is mentally and financially prepared, it results in an improved situation for the child. There is greater financial and emotional security available for the child with family planning. Being appropriately prepared for pregnancy also results in a healthier baby overall with higher rates of prenatal care measures taken, folic acid appropriately supplemented, and breastfeeding initiated earlier and lasting longer. (Kingston, Heaman, Fell, Chalmers 2012)

By educating adolescents about contraception, not only are unintended pregnancies lowered, but also a reduction of sexually transmitted infections (STIs) occurs through talk of safe sex practices. There is an additional economic savings from avoidance of STIs that occurs through reduction of clinic appointments, treatment of the STI, and treatment of complications arising from the STI.

Moreover, there have been studies linking unintended pregnancy with having a greater impact on the new mother's mental health. The risk of postpartum depression is twice as likely for an adolescent mother than a woman giving birth at age 25 and older. (Kingston et al., 2012) Other associations included (and which may also influence each other) are higher levels of stress, depression, and substance abuse. (Hodgkinson, Beers, Southammakosane, Lewin, 2014) The resulting impact on the public health landscape via appropriately educating adolescent women about contraception yields a benefit in a multitude of ways.

3. Developing a platform to explore values

3.1 Critical Questions

When we initiated this project, the goal was to design a decision aid to support female Hispanic adolescents to better engage in a discussion with a healthcare practitioner about contraception choices. In the course of developing preliminary research, and examining the problem of designing an interface to support deliberative engagement with contraception choices, we surfaced a number of critical questions and came to realize that there were some important culturally local specificities, and there were broad similarities — many shared needs among female adolescents seeking contraception advice from a physician — that current DAs do not support.

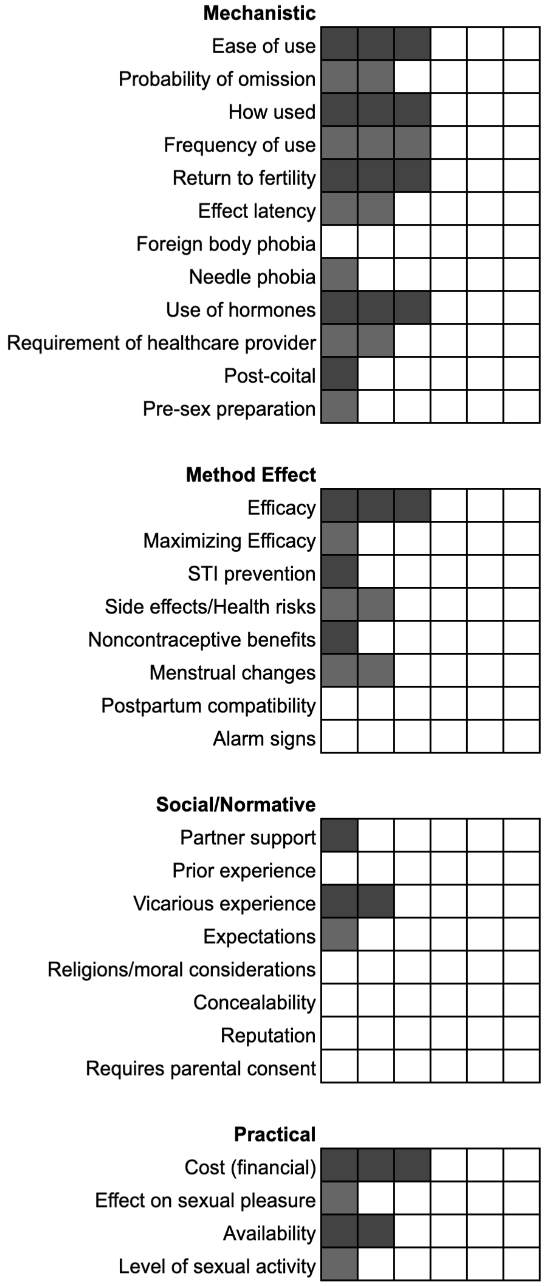
Adolescents are in a prolonged liminal state. Turner (1970) considers liminality primarily as an ambiguous state that occurs during *rites du passage*. However, in a culture like that of the United States, where there are fewer formal ritualized events that mark the transition from youth to adulthood, the idea of the liminal state may be extended to encompass the state characterizing biological adolescence. Neither children nor adults, adolescents are entering into a stage of life where they might make adult decisions and experience the consequences of those decisions, but they have yet to develop a catalog of personal experiences. Adolescent women from a variety of cultures may have this particular experience: a discussion of contraception being the first significant time that they ask for the support of a health-care professional in an independent way. Contraception is an intensely personal decision, and engages the body physically, biologically and psychologically. While the decision for nearly all methods of contraception is revocable and without consequence, the experience of the doctor-patient interaction at this early point in life may become an aspect of a frame through which the adolescent woman views future healthcare interactions.

3.2 Artifact Review

As has been detailed above, a healthcare decision aid (DA) is a tool that helps inform patients about available treatments, possibilities, risks, consequences, costs and other information during a medical encounter. It seeks to use the best available evidence to guide decisions about the care of an individual patient, taking into account their needs, values and preferences. DAs also endeavor to provide a frame for the questions and solutions discussed to facilitate interaction and shared understanding between patient and physician. One key approach the design team encountered is DAs can go beyond supporting choice-making. DAs can facilitate engagement of patient and physician in a deeper deliberative conversation that entails attunement and fit of the contraceptive regimen to the patient's life, values and preferences.

High-quality DAs can facilitate patient and physician engagement and can be used before, during or after a consultation to enable patient participation. It may help to improve a person's knowledge of the options and outcomes and give them more realistic expectations. No matter what form they come in, an effective DA should serve to empower women by giving them options, address concerns, and define values for informed preferences.

Table 1 Content frequency in 6 decision aids.



As pertains to supporting contraceptive decision-making, there are a number of shared decision-making aid tools available, produced by Planned Parenthood, the National Institute of Health (NIH), physicians conducting research, among others. While each DA has their particular focus and supports patients answering existing questions, extant DAs mostly serve to provide information in a one-sided approach of question and answer. What is lacking in the picture is the humane side of a patient's needs: the fear of an unfamiliar healthcare system, the lack of intimacy with a physician, and the sense of independence an adolescent woman might want emerging to adulthood.

Using an evaluation rubric developed by Wyatt et al. (2014) we examined several contraception DAs not available in Wyatt's study. Out of the seven we examined, three take the form of an app, three are HTML/javascript web-based articles/sites, and one video. One of the seven — an online decision assistance tool — was discontinued during the writing of this paper.

Wyatt's rubric accounts for four main aspects of information: mechanistic, method effect, social normative, and practical, each with a number of subordinate aspects. In reviewing the relevant attributes included in decision aids, Wyatt derived these overarching categories and subordinate aspects that influence contraceptive choices. The *mechanistic* category covers contraceptive usage, the frequency of use and reversibility. This attribute is covered by most DAs we have examined. The second category is *method effect*, which covers efficacy, side-effects and potential symptoms after the use of contraceptives. As with the *mechanistic* information, information about contraceptive *method effect* is also effectively presented. Third, is *social/normative*, covering information derived from social interactions between the patient and other people (sexual partners) or normative societal systems. Similarly to the artifacts covered in Wyatt et al., *social/normative* information received significantly less coverage in the DAs examined. The fourth category *practical*, examines issues of cost, frequency of use or other aspects of use that can be externally quantified. We found this to be moderately well discussed in the DAs examined. Information included in each DA is accounted in Table 1.

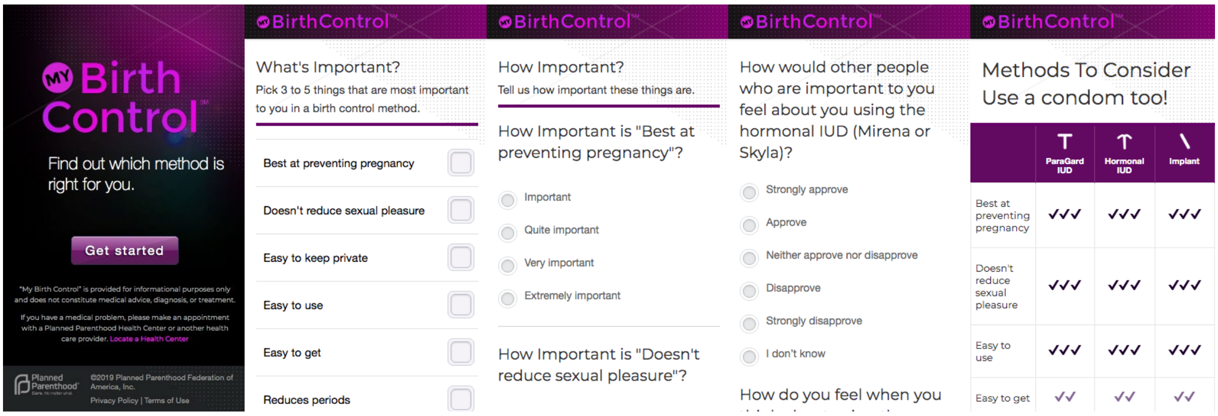


Figure 1 *Example screens from My Birth Control (Planned Parenthood)*

Among the DAs examined, from the perspective of accomplishing the user's goals, we found the *My Birth Control* app made by Planned Parenthood (Figure 1) to be the least effective. Intended for informational purposes, the mobile application comes in the form of a quiz, and promises it will "Find out which method is right for you." The first section collects demographic information of a user's age, gender, ethnicity and location of residency. After this, the app experience involves rating the importance of the three to five top concerns of users, followed by questions like: whether the user has insurance, are they open to use method of hormones and vaginal contraception. There are no forms of dialogue or feedback that allow for the user's doubts and concerns. A user could potentially feel trapped in the limited options without much prior information about contraceptive methods.

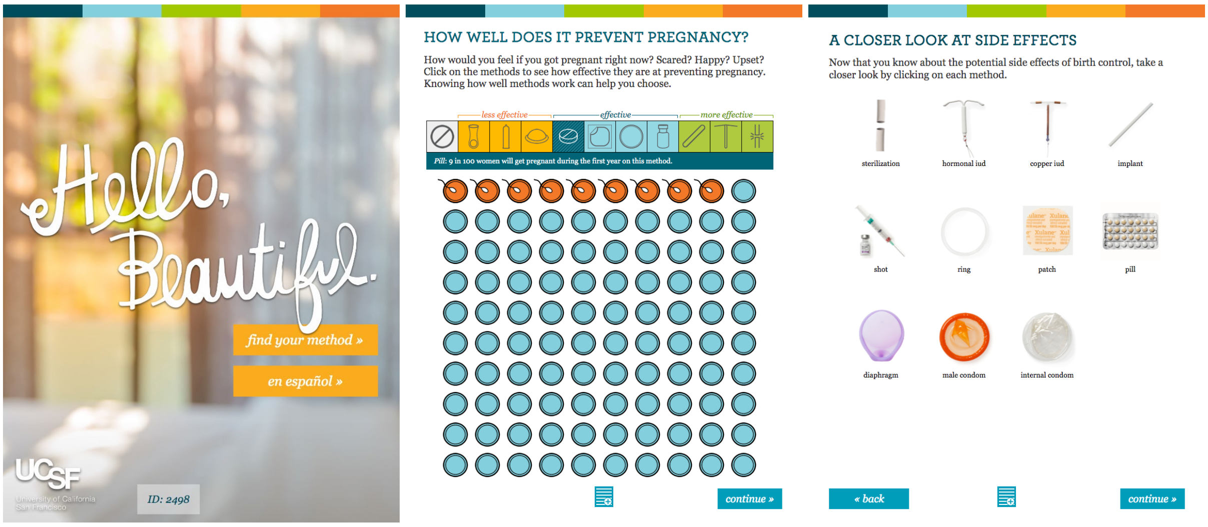


Figure 2 Example screens from My Contraception

A DA that we identified as providing a successful user experience was *My Contraception* (Figure 2) (Dehlendorf et al., 2017). Delivered in the form of a tablet-based application, it states a very simple and focused goal on the introductory screen — "we're helping make the decision-making process much easier." The home page greets users with a bright and vibrant color background displaying the text "Hello Beautiful…" in an informal, cursive script. The app provides information that is separate from the survey of preference, and allows young women to find out about five major topics: how efficient each contraceptive method is, how to use, frequency of intervention, side-effects, and what to do if you want to get pregnant.

My Contraception uses simple and familiar graphics to visualize basic information, and also allows for user's interaction supporting the exploration and comparison of different contraceptive methods, displaying the information in multiple modes: text, illustration, photograph. It puts the needs of users first and allows users to learn about potential methods before a consultation and allows them to prioritize their needs and consider the side effects, efficacy and ease of use.

After a thorough examination of these approaches, as well as the original study by Wyatt et al. (2014) we came to the conclusion that a rationalistic, scientific model of decision-making for contraception is extremely well-supported by many DAs. There are a number of DAs that support developing an understanding of the mechanical usage, different side-effects, and the practical aspects of contraceptive methods. Considering the contraception decision as multimodal, complex and relational, (Downey, Arteaga, Villaseñor, Gomez, 2017) and imminently patient-centered (Dehlendorf, Fox, Sobel, Borrero 2016) supporting the decision process with other models besides rationalistic offers the opportunity to generate new knowledge as relates to the medical decision process.

3.3 Mapping Values

The question of contraception may be approached from many perspectives, but one valuable and rigorous perspective is the perspective of deliberation. Further, a mobile phone experience provides an effective mix of familiarity, personal privacy, and access to many adolescents. While democratic deliberation is typically practiced in small groups, where participants engage with other participants and hear a range of values, beliefs and approaches, (Fishkin, 2008) the mobile phone facilitates a more solipsistic experience, involving interaction principally with the self, and with other participants mediated through software.

To ensure that a mobile phone-based deliberation offers the opportunity to encompass a range of values, the design team mapped their collective view of the scope of approaches that might be taken, from a philosophic or ethical standpoint (Figure 4). The maps are used to ensure that a diversity of perspectives are represented. For example, one could approach an understanding of the scope of dialog graphically by mapping the range of attitudes toward sex, from conservative to liberal. Other opportunities for gradients of understanding could include other aspects of a contraception choice, such as physical versus hormonal interventions. While some scales of attitudes towards sex include only a single variable, focusing on permissive versus conservative attitudes towards sex (Fisher, Hall 1988), we agree that the complexity of the decision space as pertains to contraception is better served by a multidimensional perspective of understanding several aspects of contraception in relation to one another. (Hendrick, Hendrick 1987)

Considering designing to develop an understanding of the values that intersect a contraception choice, we noticed that different questions entail a different choice architecture. When considering the importance of the effectiveness of a contraception method, a related, and quite consequential question might be: “What would an unintended pregnancy mean for me?” While the actual experience of an unintended pregnancy might be complex, from a reductive viewpoint this might be understood as three potential paths (Figure 3) that might be taken: voluntary termination of a pregnancy or carrying the pregnancy to term, then raising the child or adoption. A second valence that could frame each of these potential paths would be how the woman feels about a decision. Other questions related to contraception have more diffuse and less consequential outcomes.

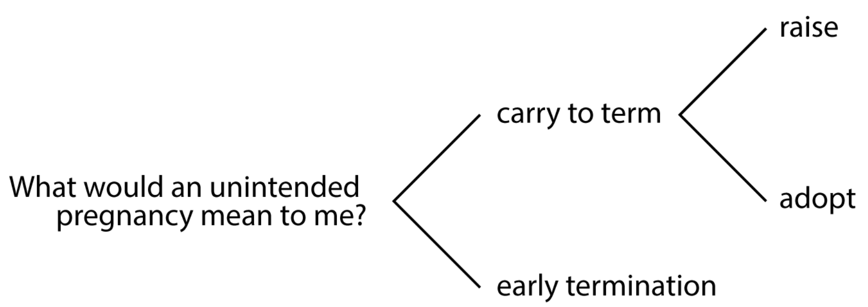


Figure 3 Unintended pregnancy decision tree

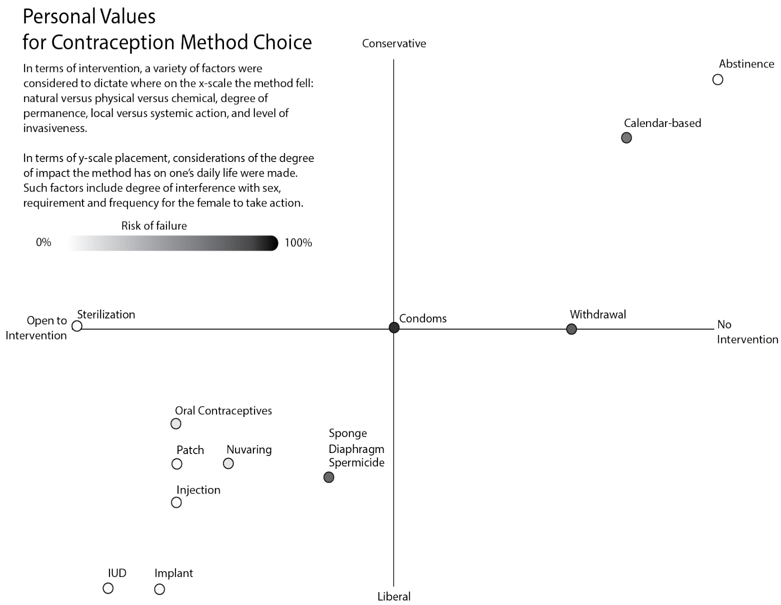


Figure 4 *Displays preliminary mapping of values versus preference of degree of medical intervention*

For example, the choice of contraception method itself is more multi-modal, and may include a variety of variables. Figure 4 shows currently available contraceptive methods mapped on a scale of sexual attitudes from liberal to conservative, a second axis that describes the degree of medical intervention necessary to engage in that method, with a third axis of value displaying risk of failure. Some additional variables that might be considered in the decision space are cost, the physical interaction of the method with the body, and the experience of potentially positive or negative side-effects of the method.

4. Sharing peer experiences

A number of studies cite family, peers and partners as key influencers shaping the adolescent woman's views of sex and contraception. In a qualitative interview-based study of 21 adolescent women, Melo, Peters, Teal, & Guiahi (2015) derived a 4-stage model of decision-making characterized by the following stages: contemplation, preparation, action and maintenance. During this process, the first two stages are characterized by different kinds of information seeking behavior. Melo et al. (2015) found that during the first two stages, which might be characterized as thinking about contraception, and actively seeking information about contraception, adolescents considered the viewpoints of medical professionals, as well as friends, family and sexual partners along with their own personal contraceptive concerns.

In any deliberative decision-making process, peer stories provide important context. Considering deliberation as a *filter* through which a participant might reframe their own ideas of a complex matter, the central experience of deliberation is a peer-to-peer interaction where participants are confronted with and interrogate other opinions. (Fishkin 2008) The resulting dialog is what informs and shapes participants' opinions and provides a richer basis for decision-making. Deliberation results in *considered* judgements, where people have had the chance to consider different opinions and points of view. (Fishkin 2008)

Medical professionals play a key role in the conversation about treatment options. Elwyn et al. (2012) offer a model of shared decision-making that begins with deliberation, followed by a three-step supportive process of choice talk, option talk, and decision talk. Elwyn focuses upon the patient <> physician interaction supported by specific decision support tools as the most effective model for shared decision making. This may hold true for many medical situations. In the context of the contraception choice, however, peer stories can figure prominently in both contraception choice, and contraception continuance. (Melo et al., 2015)

An adolescent engaged in the process of choosing contraception methods might want to hear a range of stories to inform their own viewpoint. Stories could encompass considered information for why a peer decided to choose or not choose a particular method of contraception, stories that might correct common misconceptions (such as return to fertility after using a LARC), stories that share positive or negative consequences of a particular contraception-related experience. Many adolescents gather information from peers as well as medical professionals, and they view this information as holding different kinds of importance. (Melo et al., 2015) Peer information can also be valuable as a means to reduce infection. Roye & Seals (2001) found that information provided by STD-infected peers was effective both when provided in person or by video.

5. Implications for design

Considering the previous points, we find that designing for the situation of the contraception conversation is a richer, more complex endeavor than the presenting of medical options and warning of specific side effects. Adolescent women encounter the contraception conversation at a liminal point in life. What seems to be a revocable decision that can be made upon the basis of medication and side-effects preferences may actually serve as a model for deliberation that can be used in future, more consequential medical decisions. The goals of physicians, patients, and goals for public health are mutually co-affective, and play an important role in how the contemporary doctor-patient conversation is enacted.

There are critical questions that must be addressed during this contraception conversation with the adolescent female. Through the exploration of current DAs, there are various aspects that are currently well-covered—however, something important is missing. The critical piece missing is the cultural weight that this process bears as a landmark for the adolescent woman's health journey. As perhaps the first decision she will have to make regarding her own body, with additional impact on her psychological state, there is a compelling need to provide appropriate support for the weight of this decision-making process.

Designers of shared decision-making tools should consider the various aspects of contraceptive choices as pertains to young female's values. In this experience, it is crucial for females to feel understood when approaching thinking about different methods of contraception, which in turn helps the healthcare professionals better respond to patients' need. A decision-making aid which serves as a platform for storytelling and exchange of information provides a way for females to communicate their feelings and experience empathy from peers. Designers should work in tandem with patients and providers to offer a values-based platform that helps to amplify the voice of the patient in the health care conversation.

Enabling an interactive approach to contraception choice through identification and assessment of personal values on a multi-dimensional map of important variables is a more effective way to navigate this process. Through providing this platform for an adolescent female, the contraception decision-making process becomes both more easily understandable and allows for the female to feel understood and heard by allowing her to map her own values, and share that information with her practitioner. Additionally, supporting deliberation with a story-centered approach that is delivered by mobile phone seems to offer an effective mix of apparent peer-to-peer advice, supporting feelings of personal privacy, and the opportunity to provide prompts to capture viewpoints and reflect the viewpoints back to the user. Early prototypes of this work have been received positively in informal user interviews.

Fundamentally, we believe that the foundational problem of engagement in contraceptive practices is mischaracterized as choice of a contraceptive medication or regimen. The organization of the DAs examined by Wyatt et al., (2014) and the additional 6 aids that we analyzed using Wyatt's framework use a model of rational choice that treats the engagement as an encapsulated event that occurs once. We advocate approaching contraception DAs from a different perspective, supporting periodically revisiting the decision process, engaged consideration through deliberative inquiry into the adolescent woman's values, and supporting a process of ongoing attunement between the patient and the contraceptive regimen.

6. References

Beauchamp, T., & Childress, James F. (2013). Principles of biomedical ethics (7th ed.). New York: Oxford University Press.

Bernstein, A., & Jones, K. M. (2019). *The Economic Effects of Contraceptive Access: A review of the evidence*. A report for the Institute for Women's Policy Research Washington, DC.

Clare, C., Squire, M. B., Alvarez, K., Meisler, J., & Fraser, C. (2018). Barriers to adolescent contraception use and adherence. *International Journal of Adolescent Medicine and Health*, *30*(4). https://doi.org/10.1515/ijamh-2016-0098

Cooper, A., Reimann, R., & Cronin, D. (2007). *About Face 3: The essentials of interaction design*. *Information Visualization* (4th ed., Vol. 3). Indianapolis, Ind: John Wiley & Sons. https://doi.org/10.1057/palgrave.ivs.9500066

Dehlendorf, C., Fox, E., Sobel, L., & Borrero, S. (2016). Patient-Centered Contraceptive Counseling: Evidence to Inform Practice. *Current Obstetrics and Gynecology Reports*, *5*(1), 55–63. https://doi.org/10.1007/s13669-016-0139-1

Dehlendorf, C., Fitzpatrick, J., Steinauer, J., Swiader, L., Grumbach, K., Hall, C., & Kuppermann, M. (2017). Development and field testing of a decision support tool to facilitate shared decision making in contraceptive counseling. *Patient Education and Counseling*, *100*(7), 1374–1381. https://doi.org/10.1016/j.pec.2017.02.009

Downey, M. M., Arteaga, S., Villaseñor, E., & Gomez, A. M. (2017). More Than a Destination: Contraceptive Decision Making as a Journey. *Women's Health Issues*, *27*(5), 539–545. https://doi.org/10.1016/j.whi.2017.03.004

Elwyn, G., Frosch, D., Thomson, R., Joseph-Williams, N., Lloyd, A., Kinnersley, P., … Barry, M. (2012). Shared decision making: A model for clinical practice. *Journal of General Internal Medicine*, *27*, 1361–1367. https://doi.org/10.1007/s11606-012-2077-6

Fisher, T. D., & Hall, R. G. (1988). A Scale for the Comparison of the Sexual Attitudes of Adolescents and Their Parents. *The Journal of Sex Research*, *24*(1), 90–100. https://doi.org/10.1080/00224498809551400

Fishkin, J. S. (2008). Deliberative Democracy. In *The Blackwell Guide to Social and Political Philosophy* (pp. 221–238). Oxford, UK: Blackwell Publishers Ltd. https://doi.org/10.1002/9780470756621.ch10

Hartman, L. B., Monasterio, E., & Hwang, L. Y. (2012). Adolescent Contraception: Review and Guidance for Pediatric Clinicians. Current Problems in Pediatric and Adolescent Health Care, 42(9), 221–263. doi: 10.1016/j.cppeds.2012.05.001

Hendrick, S., & Hendrick, C. (1987). Multidimensionality of Sexual Attitudes. *The Journal of Sex Research*, *23*(4), 502–526. https://doi.org/10.1080/00224498709551387

Hodgkinson, S., Beers, L., Southammakosane, C., & Lewin, A. (2014). Addressing the Mental Health Needs of Pregnant and Parenting Adolescents. *Pediatrics*, *133*(1), 114–122. https://doi.org/10.1542/peds.2013-0927

Janz, N. K., & Becker, M. H. (1984). The Health Belief Model: A decade later. *Health Education Quarterly*, *11*(1), 1–47.

Jardine, O., & Robinson, L. (2013). Patient decision aids – a tool for shared decision-making. InnovAiT: Education and Inspiration for General Practice, 6(4), 248–254. doi: 10.1177/1755738012469357

Kingston, D., Heaman, M., Fell, D., & Chalmers, B. (2012). Comparison of Adolescent, Young Adult, and Adult Women's Maternity Experiences and Practices. *PEDIATRICS*, *129*(5), e1228–e1237. https://doi.org/10.1542/peds.2011-1447

Madden, K., & Kleinlugtenbelt, Y. V. (2017). Cochrane in CORR ®: Decision Aids for People Facing Health Treatment or Screening Decisions. Clinical Orthopaedics and Related Research®, 475(5), 1298–1304. doi: 10.1007/s11999-017-5254-4

Melo, J., Peters, M., Teal, S., & Guiahi, M. (2015). Adolescent and Young Women's Contraceptive Decision-Making Processes: Choosing "The Best Method for Her." *Journal of Pediatric and Adolescent Gynecology*, *28*(4), 224–228. https://doi.org/10.1016/j.jpag.2014.08.001

Mol, A. (2002). *The body multiple: Ontology in medical practice*. Durham & London: Duke University Press.

Mol, A. (2008). *The Logic of Care*. Abingdon, UK: Routledge.

Turner, V. (1970). Betwixt and between: the liminal period in *rites de passage*. In *The Forest of Symbols: Aspects of Ndembu Ritual* (pp. 93–111). Ithaca: Cornell University Press.

Roye, C. F., & Seals, B. (2001). A qualitative assessment of condom use decisions by female adolescents who use hormonal contraception. *The Journal of the Association of Nurses in AIDS Care: JANAC*, *12*(6), 78–87. https://doi.org/10.1016/S1055-3290(06)60186-6

Rubin, S. E., Felsher, M., Korich, F., & Jacobs, A. M. (2016). Urban Adolescents and Young Adults Decision-Making Process around Selection of Intrauterine Contraception. Journal of Pediatric and Adolescent Gynecology, 29(3), 234–239. doi: 10.1016/j.jpag.2015.09.001

Sonfield, A. & Kost, K. (2015) Public Costs from Unintended Pregnancies and the Role of Public Insurance Programs in Paying for Pregnancy-Related Care: National and State Estimates for 2010, *New York:Guttmacher Institute.* Available at http://www.guttmacher.org/pubs/publiccosts-of-UP-2010.pdf.

U.S. Department of Health and Human Services, Health Resources and Services Administration, M. and C. H. B. (2019). The Health and Well-Being of Children: A Portrait of States and the Nation, 2017-2018. Rockville, Maryland: U.S. Department of Health and Human Services

Weisman, C. S., Plichta, S., Nathanson, C. A., Chase, G. A., Ensminger, M. E., & Robinson, J. C. (1991). Adolescent Women's Contraceptive Decision Making. *Journal of Health and Social Behavior*, *32*(2), 130. https://doi.org/10.2307/2137148

Wyatt, K. D., Anderson, R. T., Creedon, D., Montori, V. M., Bachman, J., Erwin, P., & LeBlanc, A. (2014). Women's values in contraceptive choice: a systematic review of relevant attributes included in decision aids. *BMC Women's Health*, *14*(1), 28. https://doi.org/10.1186/1472-6874-14-28.

About the Authors:

Michael Arnold Mages, PhD Assistant Professor, Design, Northeastern University. Michael uses design methods to develop things that facilitate difficult and high-stakes conversations. His work has been used for critical hires, redesign of workplace systems, creation of governmental policy and services.

Janice Lin, PharmD holds a Master of Information Design and a Doctor of Pharmacy from Northeastern University. As a practicing pharmacist, she seeks to develop practices to enhance care and mindfulness.

Anni Xu is currently a student in the Information Design MFA at Northeastern University. Her research seeks to understand how tacit experiences might be visualized.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Improving access to psychotherapy in a digital age: an exploratory design study based on five studio classes

Stéphane VIAL[a]*, Sana BOUDHRAÂ[b]

[a] Université du Québec à Montréal (UQAM), École de design, Chaire Diament
[b] Sana Boudhraâ, Université de Montréal, École de design, Hybridlab
*Corresponding author e-mail: vial.stephane@uqam.ca
doi: https://doi.org/10.21606/drs.2020.376

Abstract: Despite the efforts of governments, psychotherapy remains underused. Drug prescriptions are rising continuously in developed countries. Startups emerged over the last years, offering mostly online therapy services, but they strengthen the divide between the 'online' and the 'offline. To tackle the multifaceted problem of psychotherapy and to avoid 'digital dualism', the question we addressed during three years is: 'What design can do for psychotherapy in a digital age?' From Fall 2016 to Fall 2018, we offered five student cohorts to work on this question in design classes. In this paper, we explain what is the problem with psychotherapy (section 2), how we conducted the five studio classes in order to explore this problem (section 3) and what are the main ideas resulting from this exploration (section 4). Finally we discuss the results both from an educational and research perspective (section 5).

Keywords: psychotherapy; mental health; e-health; design; studio class

1. Introduction

Drug prescriptions in the treatment of mental disorders are rising continuously in developed countries. However, for most common mental disorders such as depression or anxiety, psychotherapy is more effective and longer-lasting than medications. Some governments tried to curb the decades-long increase in antidepressant prescription rates, for instance in the UK with the *Improving Access to Psychological Therapies* program. But psychotherapy still remains underused. More than 300 million people are now living with depression worldwide, and nearly 50% of them do not get treatment (World Health Organization, 2017). If we want to improve the mental health of populations, it is essential to improve access to psychotherapy. In parallel, the emerging field of mobile mental health (Harrison et al., 2011) seems very promising in order to address the treatment gap (Chandrashekar, 2018). Mental health mobile apps are booming (Anthes, 2016) and are widely promoted as an opportunity to expand the availability and quality of mental health treatment (e.g. by the National Institute of Mental Health in the US, the National Health Service in the UK, or the Mental Health Commission of Canada).

Initiated in France in 2016, the research project PSYDIA ("**PSY**chotherapy in the **DI**gital **A**ge") is a project-grounded research (Findeli, 2010) in interaction design and mental health that aims to improve access to psychotherapy through a mobile app. This paper is about the early stage of the project, which tackles this question: To what extent can digital technologies improve access to psychotherapy? How can we improve access to psychotherapy with a mobile app? What design can do for psychotherapy in a digital age?

We tried to address this question with students through five design studio classes. Our aim was not to provide a solution by the output of design student workshops, but to explore a large number of design ideas and to identify the most recurrent and relevant of them in order to guide further research towards meaningful solutions. The five classes have been developed during three academic years between Fall 2016 and Fall 2018: two in a bachelor of design program, three in a master of service design program.

In this paper, we explain what is the problem we wanted to address with students about psychotherapy (section 2), how we conducted the five studio classes in order to explore this problem (section 3), what are the design ideas resulting from this exploration (section 4), and finally we discuss the results both from an educational and research perspective (section 5).

2. Background: the problem with psychotherapy

2.1 Psychotherapy is effective, medication is on the rise

Drug prescriptions in the treatment of mental disorders are rising continuously in developed countries, and psychotherapy is continuing to lose market share to medication. For instance, in the US from 1998 to 2007, among individuals receiving outpatient mental health care, use of only psychotherapy (-5.4%) as well as psychotherapy and psychotropic medication together (-7,9%) declined, while use of only psychotropic medication increased (+13,3 %) (Olfson & Marcus, 2010). Decline is occurring as the evidence base for talking therapy has grown. For most common mental disorders such as depression or anxiety, psychotherapy is more effective and longer-lasting than medications, and is a more cost effective intervention in the long term (American Psychological Association, 2012). Furthermore, if given the choice, people express a 3-times-greater preference for psychotherapy over medications, because of medication side-effects and individual differences (McHugh et al., 2013).

2.2 Unmet psychotherapy needs and mental health facts

Considering this situation, some governments tried to curb the decades-long increase in antidepressant prescription rates, for instance in the UK with the *Improving Access to Psychological Therapies* program conducted by the National Health Service, or in Canada with the *Québec Psychotherapy Program for Mental Disorders* (PQPTM). However, without the support of powerful industrial lobbies like those in the pharmaceutical sector, psychotherapy remains underused. Only in Canada, the cost of covering the unmet psychotherapy needs of Canadians is estimated at $1.24 billion per year (Mental Health Commission of Canada, 2017). In addition, more than 300 million people are now living with depression worldwide, an increase of more than 18% between 2005 and 2015, and nearly 50% of people with depression do not get treatment (World Health Organization, 2017).

2.3 A multifaceted problem with eight major issues

If we want to improve the mental health of populations, it is essential to improve access to psychotherapy. Such a challenge remains very difficult to overcome since the problem is multilevel. We have identified at least eight major issues that make it complicated:

1. **Prices**: the average cost for a regular therapy session is $75-150 (USD) in the US, €40-80 in France, £50-80 in the UK, or $80-130 (CAD) in Quebec. For "top therapists", it can jump to $200-300 in New York City or £150-220 in London.
2. **Health systems**: there are very low health insurance reimbursement rates for therapy; most often, it is not covered by public health systems, or just for a few cases.
3. **Research**: with its various theoretical models of human mind, psychology fails to fully embrace an evidence-based approach, reinforcing the biomedical model in psychiatry.
4. **Marketing**: there is an important influence of direct-to-consumer drug advertising.
5. **Prescription**: it's easier to write a prescription than try to find or help find a therapist.
6. **Ethics**: people feel stigmatised with mental illness and it's hard to fight against that.
7. **Societal trends**: in a digital age where everything goes faster than ever, people want a quick fix, avoiding waiting lines.
8. **Technology**: new hopes come with Big Data, AI or robots for mental health, but coming with new ethical challenges related to data privacy and security.

2.4 Online therapies market

For the last 10 years, an online market for mental health has slowly emerged, especially in telehealth or teletherapy, trying to fix the price and waiting line issues. Beyond the increasing number of mental health apps dedicated to various self-management tools (stress, anxiety, mood, sleep...), a specific approach to psychotherapy has appeared: online therapy services. A range of startups have been founded, mostly in North America, for instance *Breakthrough.com* (USA, 2009) — acquired in 2014 by MDLIVE —, *MyTherapistMatch.com* (USA, 2009), *iCouch.me* (USA, 2010), *Ginger.io* (USA, 2011), *Talkspace.com* (USA, 2012), *BetterHelp.com* (USA, 2013), *Mindstrong.com* (USA, 2013), *Meetual.com* (Canada, 2015), *Foresightmentalhealth.com* (USA, 2017). More recently, in Europe, a new app-based service for meeting doctors through video – *Kry.se* (Sweden, 2015) – launched an online psychology service and is now expanding in European markets such as France (*Livi.fr* is the french version of Kry.se and was launched in 2018). In 2019, as a sign of the growing emerging market in the field, a VC fund investing primarily in mental health was founded in the US *(Whatif.vc)*. His founder, Stephen Hays recently tried to map the mental health startup landscape (Hays, 2020). It's not yet comprehensive, but quite impressive: he could find 717 startups (Figure 1).

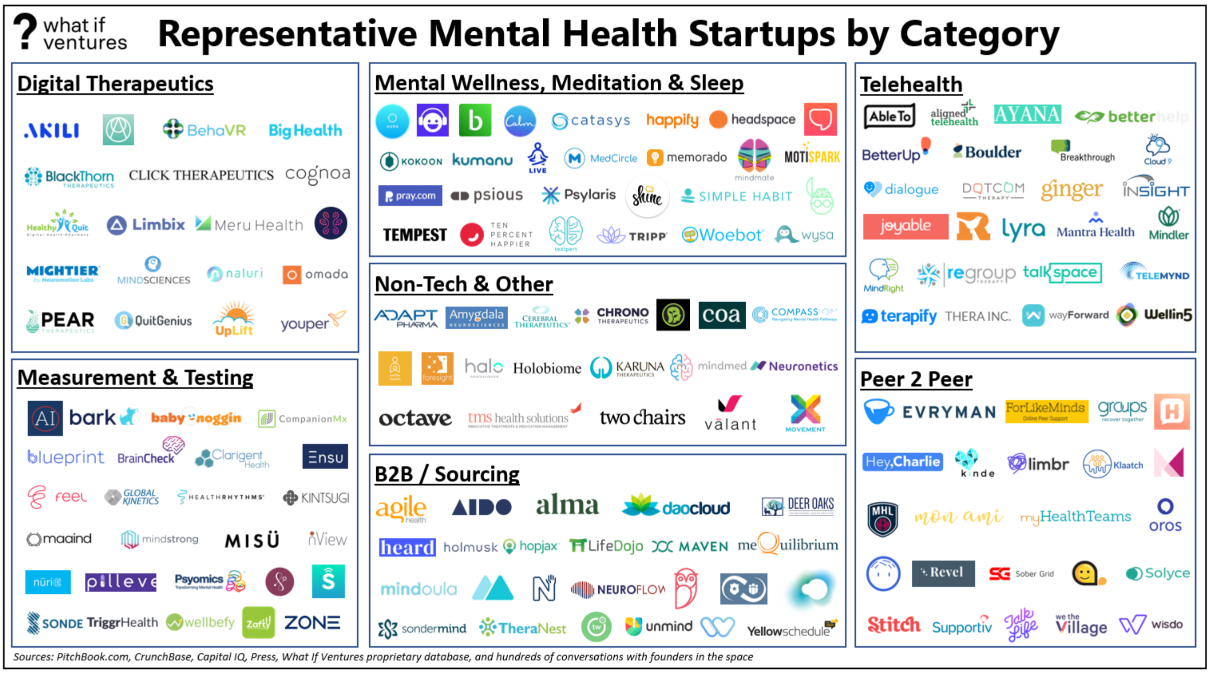


Figure 1 *Mapping the Mental Health Startup Landscape, by Stephen Hays (2020) © What if ventures.*

As we can see in Figure 1, Telehealth is only one area — the one addressed in this paper — of the mental health startup landscape, in which Hays says he found in total 114 startups. Such a landscape would need further research and analysis, but as a preliminary observation, we can mention that most of these startups offer online therapy in opposition to in-office practice — sometimes trying explicitly to put out of fashion face-to-face therapy in their communication. Some of them (e.g. *Talkspace.com*) dictate the therapy prices to therapists (payment is no more under their control) or control access to client records (therapists know patients only by their username and don't have access to their contact information). Others (e.g. *BetterHelp.com*) share data with Facebook about how often a person is going to a session, when he/she booked appointments, his/her approximate location, how long he/her was chatting on the app (Osberg and Mehrotra, 2020). Perhaps because they do not use a codesign approach, many mental health startups are missing a deep understanding of stakeholders needs (patients, therapists, caregivers, health system professionals and many other actors of such a complex field). As well said by Prof. Paul Yock, "the 'move fast and break things' approach that works in tech doesn't translate well to healthcare" (Yock, 2018).

2.5 Beyond the divide: avoiding digital dualism

"Online therapy" is a term that presupposes a divide between the online and the offline, the digital and the physical. Talking about "online therapy" means separating "online therapy" from "offline therapy". Research has shown that "digital dualism", a view of the digital and physical as separate spheres, is a fallacy (Jurgenson, 2012) and that the distinction between the real and the virtual is faulty (Bonenfant, 2011 ; Vial, 2019). If it could make sense at the beginning of the computer era and of the internet in the 1980s and 1990s (Turkle, 1984), today it is no longer possible to separate digital users from non-digital ones: they are the same persons, living an unbroken experience that is partly online, partly offline.

As postphenomenology studies show, technologies always play a mediating role in human experience (Verbeek, 2015) and human perception (Vial, 2019). Psychotherapy is not only a treatment, it is also a user experience, which is always technology-mediated, either it happens online (with screens and interfaces) or offline (with walls and chairs). In this research, we assume that improving access to psychotherapy in a digital age is based on a subtle and creative mix of digital and non-digital solutions. Exploring what design can do for psychotherapy in a digital age means going beyond the merely online therapy approach.

3. Cases: five design studio classes

Ideation is widely recognized as one of the core strengths of any design activity (Brown, 2008; Mulgan, 2014). Designers brainstorm, explore new ideas, expand alternatives. From Fall 2016 to Fall 2018, we conducted an exploratory study through five design studio classes involving 102 students during 3 academic years, making a total of 69 projects delivered within 181 hours of classes (Table 1).

Table 1 Overview of the 5 design studio classes

#	Term	Program	Class duration	Students	Mode	Projects
01	Fall 2016	Bachelor	50 hours	40	in team	12
02	Fall 2016	Master	27 hours	9	individual	9
03	Fall 2017	Master	27 hours	7	in team	2
04	Fall 2018	Bachelor	50 hours	32	individual	32
05	Fall 2018	Master	27 hours	14	individual	14
	Total		**181 hours**	**102 students**		**69 projects**

The expected result was to discover innovative ideas that can address one or several of the eight major issues that have been identified in this research (Section 2.3) and that have been presented to students at the beginning of each class. Especially, we expected ideas about how to experience psychotherapy in a way that is easier, less stigmatizing, less expensive, and more powerful (i.e. able to reach much more people in need).

In this section, we will describe the design activities that were implemented with the students, how they were organized, which stakeholders were involved, what were their goals, and what kind of deliverables were produced. In order to do so, we will refer to Kees Dorst's "descriptive framework" of design (Dorst, 2008), according to which there are four elements in any design activity: the object, the actor, the context and the process.

3.1 Object

The design question presented to the students was the following: what design can do for psychotherapy in a digital age? In order to address this question, students were asked to create an app prototype. Not an app prototype that would be a ready-made operational solution, but that would explore and open possibilities, or push the limits.

The purpose of these classes was both education-oriented and research-oriented.

From an educational perspective, these classes aimed to: 1) approach interaction design through a social design lens thanks to a mental health care topic; 2) develop skills in UX/UI design methods and in the design of qualitative user experiences; 3) offer students the opportunity to contribute to a research project through a design class that is research-driven.

From a research perspective, these classes aimed to: 1) generate a large number of ideas on how to improve access to psychotherapy through a mobile app from the perspective of young connected people; 2) get inspiration in order to guide further research towards meaningful solutions for the design of the Psydia app.

Regarding the object, students were asked to integrate two main requirements:
1) to address one or several of the eight major issues previously identified (Section 2.3); in the last year, for the classes 04 and 05, students were specifically asked to address issues 1 (Prices) and 2 (Health systems) related to financial access to psychotherapy;
2) to take for granted that it is more relevant to mix digital and non-digital solutions than offering merely online services (Section 2.5).

3.2 Context

The five studio classes took place at the University of Nîmes, in Southern France. Two of them were developed within the third and last year of the Bachelor of design program with Concentration in "Design and digital culture", within the main design studio course of the Fall term. The three others were developed within the first year of the Master of design and social innovation program, within the short course "Service design and digital technologies" of the Fall term. In France, a university course can last the whole term or not. In this case, it was not. The duration of each course was quite short (Table 1). For most of students, it was their first course in interaction design.

Regarding the context, the students were asked to imagine that they were working on an innovative project within an incubator or accelerator, as if they were social designers-entrepreneurs who would launch their own business.

3.3 Actors

The class was led most of the time by the lead researcher and professor alone (classes 02, 03, 04, 05), and sometimes in co-teaching with other design instructors (class 01). The design projects were all conducted and executed by students, either individually (02, 04, 05) or in teams (01, 03) (Table 1). For few classes (03, 04, 05), students had to make an interactive prototype and to conduct interviews with potentiel end-users in order to test it. Around 15 persons were invited in class, most of them were random people on the campus such as students or teachers from other departments. In addition, mental health professionals were invited from time to time as counselors, either at the start of the project in order to present their activity and inspire students (Figure 2), or at the end as jury members (Figure 3).

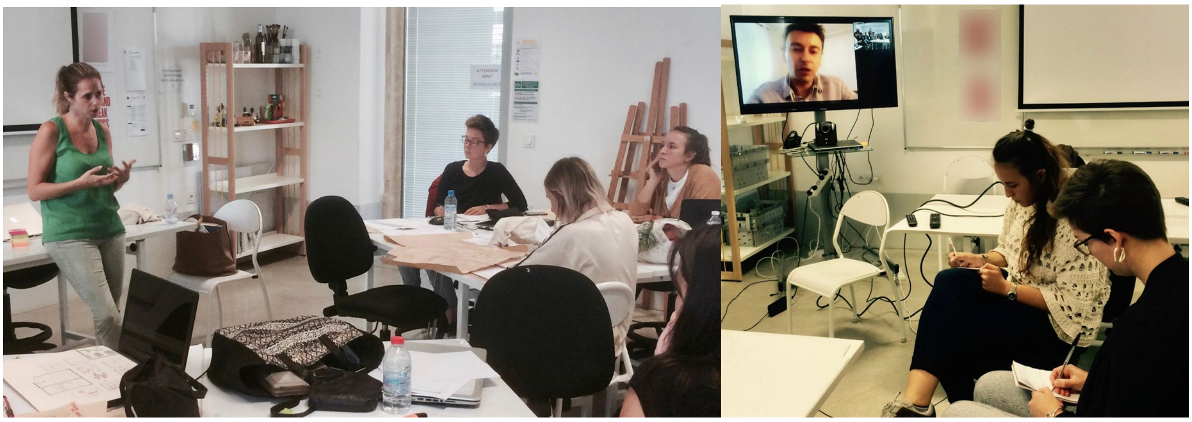


Figure 2 Psychologists presenting (in-person or remotely) their practice to master students (September 15 and 21, 2016).
Psychologist 1 (on the left): Marion Logerot. Psychologist 2 (on screen on the right): Rémy Potier.

Figure 3 Jury session in the bachelor program with a psychologist, a co-teacher and students (November 24, 2016).
Psychologist (on the left): Emmanuelle Toujas. Design co-teacher (both images): Benjamin Servet.

Regarding the actors, students had to explore one or several of the three following options:
1) to connect patients with psychotherapists;
2) to connect patients with patients;
3) to connect psychotherapists with psychotherapists.

3.4. Process

Entitled RESPY for "**RE**de**S**igning **P**s**Y**chotherapy", the project of the two first classes (01, 02) was organized as a classical studio in a service design program, based on a design brief. After a presentation of the problem with psychotherapy (Section 2), including presentations and testimonials from invited psychologists, the students were asked to imagine how to reshape the experience of psychotherapy through an app-based service.

The requested deliverables were quite conventional and in accordance with established practice in service design (Table 2), including personas, customer journey maps, wireframes and graphic mockups (Figure 4).

Table 2 Overview of the deliverables from the 5 design studio classes

#	*Term*	*Program*	*Deliverables*
01	Fall 2016	Bachelor	Personas, journey maps, paper wireframes, mockups, jury presentation
02	Fall 2016	Master	Use cases, personas, paper wireframes, final presentation
03	Fall 2017	Master	Design sprint: journey map, sketch, storyboard, prototype, interviews
04	Fall 2018	Bachelor	Design sprint: journey map, sketch, storyboard, prototype, interviews
05	Fall 2018	Master	Design sprint: journey map, sketch, storyboard, prototype, interviews

Figure 4 Paper wireframe / Screen wireframe / Graphic mockup, by a bachelor student (November, 2016)

Entitled PSYDIA for "**PSY**chotherapy in the **DI**gital **A**ge", the project of the three last classes (03, 04, 05) was organized as a design sprint (Knapp et al., 2016), a five-day process for addressing a long-term goal through design, prototyping and testing through user interviews (Figure 5). In order to adapt the sprint process to each class schedules, it was sometimes shortened with only half a day for each day-step (classes 03 and 05) or extended with several days for each day-step (class 04). It was also adapted so that students can do projects either individually or in teams.

For each class, the long term goal systematically offered to students was the same: “how to give more power to psychotherapy?”. In 2018 (classes 04, 05), it was a bit more specific by focusing on the financial aspects of accessing to psychotherapy: “how to improve access to psychotherapy and how to help people fund it?”. This question of funding was explicitly related to two of the eight major issues: the ones of prices and reimbursement (Section 2.3).

Figure 5 *Master students in a design sprint in class, overview of the 5 steps (October-November, 2017).*
User interview: random user Susana Paixão-Barradas (left) with design student Marylou Planchon (right).

Although the design sprint format sounds like a questionable trend, there is some great value in it both for educational purposes (make students produce something very quickly) and for research purposes (generate a lot of ideas in a short time in order to explore a problem). During these design sprints, students often said they were surprised by themselves with all that they made in only a few days, compared to other classes lasting all the session.

Regarding the process, students had to explore one or several of the 3 following stages:
1) before therapy;
2) during therapy;
3) after therapy (ended).

4. Results

4.1 General overview: very various ideas generated by students

Through the three-years exploration among the five design studio classes, a large range of ideas have been generated by students in order to address our initial question *"What design can do for psychotherapy in a digital age?"*. They are presented as raw data in Appendix 1, where all projects are numbered from P1 (Project 1) to P69 (Project 69). A few general comments can be made at first glance.

Not all students really understood the design question and the two related main requirements (Section 3.1). As an example, we can mention here the My Psy project (P24), which offers just another online therapy service "as usual", with a design that fits more a service for meeting physicians than therapists. Many students had the same commonplace ideas, such as finding a therapist through a map, checking his/her profile and making an appointment (for instance, P11, P25, P27, P43, P47, P64). As an example, we can mention here the Sporty psy project (P27), which is quite well designed for a bachelor student who never took an interaction design class before.

Some students had the same commonplace ideas but enriched them with a more original one, such as a follow-up tool for the therapist (P2); a focus on patient orientation (P5); a patient questionnaire or mood test or symptom description or diagnosis test (P8, P12, P31, P35, P44, P46, P48, P53, P54, P62); a focus on a specific disorder (P9); a focus on a better information on therapy or mental disorder (P34, P38); a focus on a friend recommendation or friend help (P36, P65, P67); or an orientation video call (P61). We can mention here the **E-Psylon** project (P2), that offers clear patient profiles management for the therapist with integrated clinical notes on each patient; or the Perfect Psy project (P61) that offers a video call for the first contact and then bring to see a therapist face-to-face.

In the last year (classes 04 and 05), when they were asked to address financial issues such as prices (issue 1) or health systems support (issue 2) (Section 2.3), some students successfully tried to tackle the complex problem of funding therapies (P29, P33, P35, P46, P49, P57, P65, P66, P67). We can mention here the À vos dons project (P66), which offers patients, in a very poetic way, to pay a bit more each therapy session by adding a kind of tip that goes to a collective nest egg represented as a tree; or the Online therapy project (P46) which offers to match patients with therapists through a symptom description test and offers reimbursements via partnerships with mutual funds.

Finally, a few students came with very original and atypical ideas, sometimes a bit weird, sometimes very relevant. We can mention here: a patient record sharing at the emergency room (P3); an access to psychotherapy for migrants and refugees during their journey (P6); a taxi service to go to the nearest psychotherapy center (P10); a psy speed-dating-like service (P18); a psychotherapy service for LGBT+ (P26); a service aimed to funding your therapy in exchange for service in a non-profit (P33); a service for reducing the cost of psychotherapy by watching commercial videos (P45); a mental health self-management tool (P56); a chatbot (P63); online circles for relatives (P69).

4.2 Synthetic overview: five main categories of ideas

Ideas generated by students can be sorted in five main categories:

Ideas related to ***information, orientation and online support***: everything that helps suffering people understand the complex field of mental health and therapies, trust a therapist, find reliable information, get online help from peers or professionals...

Ideas related to ***search and appointment***: everything for finding a therapist, making an appointment, getting in touch with him/her, which includes typically features such as cartographic search, scheduling, messaging...

1. Ideas related to ***supporting the therapy process***: everything that helps patients keeping engaged in therapy after started, such as mood follow-up, privates notes, video calls between two sessions, and that keeps patients and therapists connected.
2. Ideas related to ***focusing on targeted people***: everything that is dedicated to specific persons and adapted to their needs, such as persons suffering from particular disorders, people with particular identity characteristics, or therapists themselves.
3. Ideas related to ***costs and financial issues***: everything that helps funding and paying your own therapy, including payment process, reimbursements, financial helps, partnerships with employers or insurances.

A total of 63 in 69 projects match with these five categories. Table 3 offers a synthetic overview sorted by these five categories, in order to better understand the most repeated and original ideas and to compare ideas coming from students alone with those from teams.

Table 3 Synthetic overview of students' projects sorted by categories

Category 1: Information, orientation and online support (9 projects)		
Project type (nbr)	Individual (9)	Team (0)
Major issues addressed	Research, Marketing, Ethics	n/a
Common solutions	e.g. online personality tests, articles on mental disorders, friends groups...	n/a
Original solutions	e.g. digital kiosk in the street, ads at physicians office, therapy explorer, daily goals...	n/a
Category 2: Search and appointment (31 projects)		
Project type (nbr)	Individual (23)	Team (8)
Major issues addressed	Prescription, Societal trends	
Common solutions	e.g. find a therapist, therapist profile, appointment management...	e.g. orientation form, find a therapist, therapist profile, appointment management
Original solutions	e.g. mood diary, online diagnosis, online chat, speed-dating-like psy meetups...	e.g. car ride for joining a therapy center, follow-up tool for therapists...
Category 3: Supporting the therapy process (7 projects)		
Project type (nbr)	Individual (7)	Team (0)
Major issues addressed	Prescription, Societal trends, Technology	n/a

Common solutions	e.g. mood diary, private notes, goals to reach, video calls, shared agenda...	n/a
Original solutions	e.g. therapy organizer for patients, communicating with therapist between two sessions, feedback years after...	n/a
Category 4: Focus on targeted people (7 projects)		
Project type (nbr)	Individual (4)	Team (3)
Major issues addressed	Prescription, Ethics, Societal Trends	
Common solutions	e.g. find a therapist for kids...	e.g. online chat, appointment tools...
Original solutions	e.g. refined gender profile for LGBT+, counselling for sportspersons, SEO tools for therapists...	e.g. map of camps for migrants, goals to reach for children with ADHD, chat with mediators for harassed kids at school...
Category 5: Cost and financial issues (9 projects)		
Project type (nbr)	Individual (9)	Team (0)
Major issues addressed	Prices, Health systems, Societal trends	n/a
Common solutions	e.g. collecting money features...	n/a
Original solutions	e.g. reimbursing 50% of sessions through insurance partnership, support from employers...	n/a

Only 6 projects remain uncategorized because of their uniqueness, which are: data sharing for professionals at the emergency room (P3), post-hospitalization patient follow-up (P4), follow-up after therapy is ended (P23), associate psychotherapy to wellbeing practices (P32), becoming a “listener” and getting trained to listen to patients (P59), online counselling through a chatbot (P63). To be noticed: only 14 in 69 projects were managed in teams, all others were conducted individually. This is mostly due to the pedagogical approach since the classes 04 and 05 (46 in 69 projects) were asked to work primarily on an individual basis.

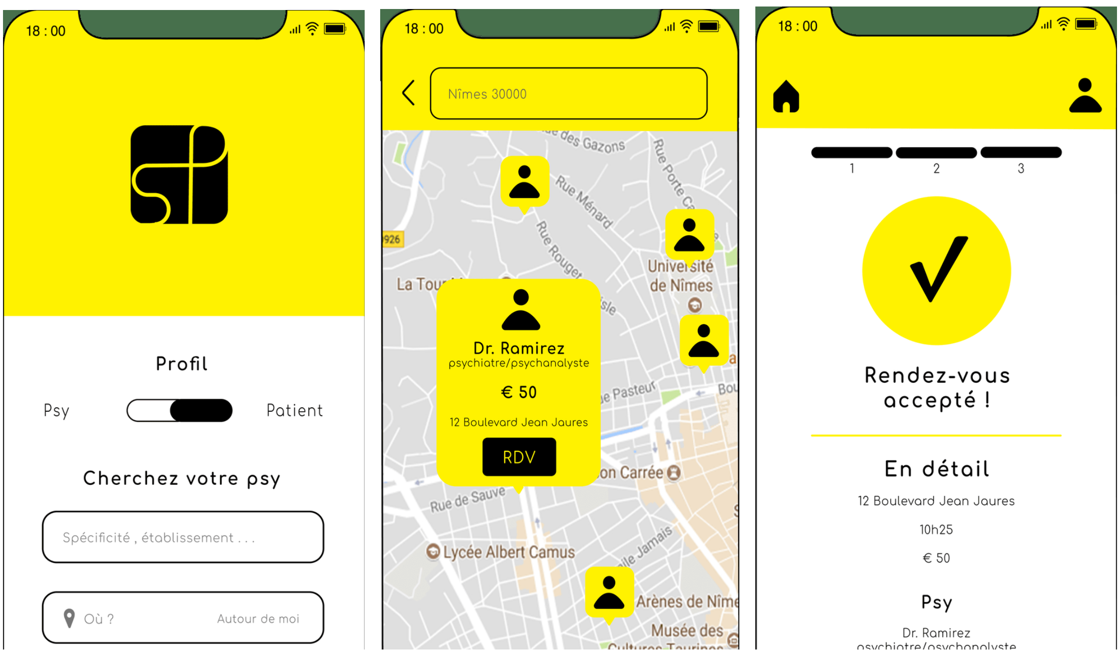
4.3 Four prototype examples

Let’s focus on four examples and comment shortly about concept, relevance, UX/UI design.

Example 1: “Ther’happier” (P35) – Category 5: Cost and financial issues *(screenshots below)*
Concept: An app for matching patients with therapists in partnership with health insurances.
Relevance: Tackling the financial issue; interesting user journey based on an orientation test before matching the patient with a therapist; avoiding digital dualism by considering a large range of practice modes (in-person, at home, by phone, online).
UX/UI design: A rather cold design, closer to the medical world, which needs improvements.

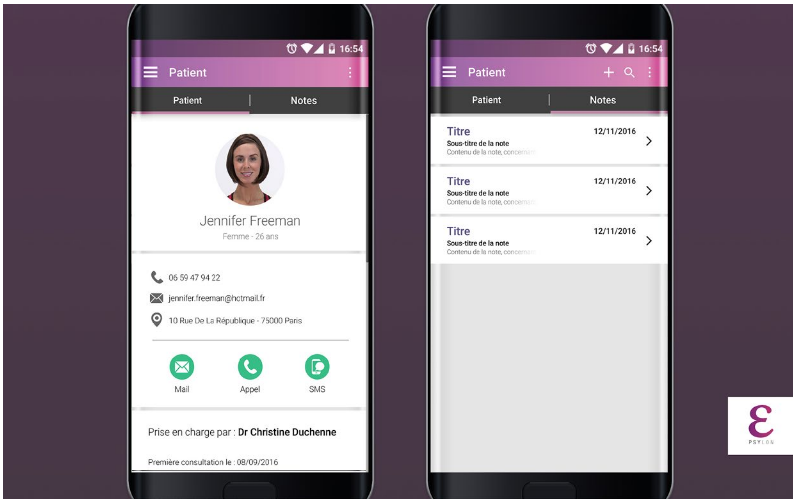
Example 2: "Sporty psy" (P27) – Category 2: Search and appointment *(screenshots below)*

Concept: An app for matching patients with therapists through features such as cartographic search, therapist profile, appointment management.
Relevance: Easy search and experience but no clues about why choosing this therapist.
UX/UI design: Energetic colour and clear layout, but the yellow is not so safe for accessibility.



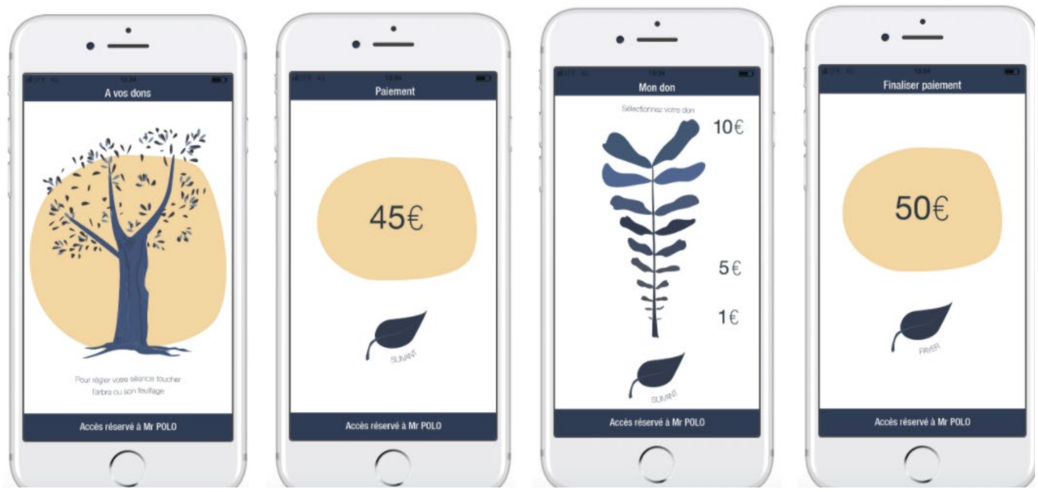
Example 3: "*E-psylon*" (P2) – Category 2: Search and appointment *(screenshots below)*

Concept: An app for matching patients with therapists with a focus on follow-up tools for therapists such as patient records and notes for therapists.
Relevance: The features focused on the therapist perspective were much appreciated by invited clinical psychologist Emmanuelle Toujas during final jury session.
UX/UI design: Clear and usable design, close to real professional quality.



Example 4: "À vos dons" (P66) – Category 5: Cost and financial issues *(screenshots below*

Concept: An app for paying your sessions and adding a tip (represented as a leaf) in order to increase a collective pot (represented as a tree) to be shared with low incomes people
Relevance: Tackling the financial issue with a very innovative and creative idea.
UX/UI design: A subtle and poetic design that gives the act of paying a sensitive dimension.



5. Discussion

This exploratory study is the first step toward a more comprehensive and in-depth research about the question *“What design can do for psychotherapy in a digital age?”*. Conducting the five studio classes in order to address this general question, we aimed to maximize the ideation process among students to better understand both difficulties and opportunities for psychotherapy to be practiced by professionals and adopted by patients through all the possibilities that new technologies offer. In this last section, we would like to discuss a few implications of the study both from educational and research perspectives.

5.1 Educational implications

The results showed that students’ projects are structured around five main categories of ideas : 1) *Information, orientation and online help*; 2) *Search and appointment*; 3) *Supporting the therapy process*; 4) *Focusing on targeted people*; and 5) *Costs and financial issues*. From an educational perspective we explored different pedagogical *instructions and setting* that were variable from a cohort to another. *Instructions* consisted at asking students to avoid digital dualism and to focus on specific issues such as Costs or Ethics. The *setting* concern whether students work individually or in teams, and the course duration depending if sessions were either in a regular course during the semester or in a design sprint format. What we expected from these five studio classes is to discover a big range of multiple and diverse ideas addressing the eight identified issues (Section 2.3). Though, we found out that several ideas are common among different studio projects, and they only address few of the mentioned issues. We think that not all students have understood the design question they were supposed to explore, but also most of the students have answered only to a few issues. This could be one of the consequences of the difficulties students have while trying to understand psychotherapy from its different perspectives, types and practices. In fact, students approached the project being most of the time in the patient’s shoes (they naturally identified with the patient’s posture) and had difficulties to see the bigger picture. That’s why conducting more projects with codesign approach including clinicians and mental health professionals could help avoid these misleading biases and would bring more insightful data. Furthermore, students who worked in teams were more cooperating than codesigning. According to Alexiou (2010), the interactions between the participants lead to the emergence of actions and design ideas that individuals would not have in mind without this interaction. Working along with the therapist would bring students a more comprehensive knowledge about the design problems including situated knowledge from a specific field, which can only thrive in a sharing context (Goffin and Korner, 2011).

5.2 Research implications

First, the bigger challenge is to understand that addressing the question of psychotherapy in the digital age is more complex than just to design a mere digital solution (such as an online therapy service) in order to make it more accessible to all stakeholders. This is why, as mentioned above (Section 2.5), we assume that a psychotherapy is not only a treatment, it is also a user experience. Technologies always play a mediating role in human experience (Verbeek, 2015) and human perception (Vial, 2019). As such, psychotherapy is always technology-mediated, either it happens online (with screens and interfaces) or offline (with walls and chairs). The 69 projects that raised from the 5 studio classes are a kind a proof of that, showing that from a design process' perspective it is more important to think the whole user experience before applying predefined settings ruled by conventional framing of digital uses. All students projects explicit in details how psychotherapy is deeply structured and organized by the technology that mediates the relationship between patients and psychotherapists, at all stages. For us, it is important not only to consider *but to design* the mediating role of technology instead of letting technologies dictate what psychotherapy is in a digital age and how it should be practiced. This would need deeper analysis in order to understand more exactly how this technological mediation makes a contribution to define what a psychotherapy in the digital age could be, which is our global research question.

Second, another interesting research path from this exploration is about ethical dilemmas. A lot of design situations in these 69 projects are related to ethical issues, such as the use of collected data on patients or therapists. For instance, only the Hand-up project (P40) offered to use the app without any signup. This makes questionable all the other projects that systematically require from users to register and generate a lot of personal data about their mental health. For instance, apps that offer an appointment management system will store a history of sessions, which could be a sensitive information for a insurance company or an employer. What if your employer knew that you had 60 appointments with a psychotherapist during the last 2 years? As says Rachel Metz in a recent article published in the *MIT Technology Review* about the *Mindstrong* app, "most of us wouldn't want our employers anywhere near our mental health data, no matter how well protected it may be" (Metz, 2018). Should we or should we not collect mental health data in a digital app designed for psychotherapy? What would we win and what would we lose in each case? This is an example of an ethical dilemma that was approached in this study and, of course, further research on that would be necessary.

Last but not least, this study brought us closer to our research goals, since it shed light on the success of potential paths we could take for further work. In fact, it showed that, through original projects, students were able to create mixed experiences both digital and non-digital, avoiding the traditional digital dualism that most of digital mental health services offer nowadays. This study underlines that it is totally feasible, more realistic and more relevant to design a service that join both spheres, which joins Jurgenson (2012) about the fallacy of separating the digital from the physical.

6. Conclusion

Innovation in health care requires a responsible approach involving all stakeholders. "Digital health products need to appeal not just to individual consumers but to a complicated landscape of stakeholders – from doctors and patients to regulators and insurers" (Yock, 2018). This is why most of digital health startups fail, because "they apply a strategy to healthcare that was developed and refined in the tech sector" (Yock, 2018). For the same reasons, most of mental health startups develop online therapy services without addressing the complex and multifaceted problem of therapy nowadays. The exploratory study that we conducted with 102 students during 3 academic years has resulted in 69 projects offering many inspiring ideas for the future of psychotherapy in the digital age by avoiding the pitfalls of digital dualism. This is due to our theoretical approach, that helped avoid "preconceived ideas about what a solution should look like" (Yock, 2018). However, it was a first step and, in order to fill in the gaps of this study such as the patient-centered tendency of our students, the next step of the research will consist in a series of codesign workshops with clinicians.

Acknowledgements: This article builds on the expertise of several colleagues, designers, clinicians and students who participated in the project at some point between 2016 and 2018, mainly: 1) design students at the University of Nîmes, from the Bachelor of Design program (« Licence Design »), Concentration in "Design and digital culture" (« Design et cultures numériques »), and from the Master of Design program « Design, innovation, société » (DIS), within the short course "Service design and digital technologies"; 2) designers and co-teachers Benjamin Servet and Lilian Chapellon; 3) clinical psychologists Emmanuelle Toujas, Rémy Potier, Marion Logerot, Élodie Charbonnier. We also owe a good deal of thanks to colleagues Marie-Julie Catoir-Brisson, who read and critiqued our earlier draft, and Claudia Déméné, who suggested useful options for the final revised paper.

7. References

Alexiou, K. (2010). Coordination and emergence in design. CoDesign, 6(2), 75–97.

Anthes, E. (2016). Mental health: There's an app for that. Nature, 532(7597), 20–23.

Bonenfant, M. (2011). Les mondes numériques ne sont pas "virtuels" : l'exemple des jeux vidéo en ligne. Revue Des Sciences Sociales, (45), 60–67.

Brown, T. (2008). Design Thinking. Harvard Business Review. June 2018, 84–95.

Chandrashekar, P. (2018). Do mental health mobile apps work : Evidence and recommendations for designing high-efficacy mental health mobile apps. Mhealth, 4(6).

Dorst, K. (2008). Design research: a revolution-waiting-to-happen. Design Studies, 29(1), 4–11.

Findeli, A. (2010). Searching for Design Research Questions : Some Conceptual Clarifications. In R. Chow, W. Jonas, & G. Joost (Eds.), Questions, hypotheses & conjectures : discussions on projects by early stage and senior design researchers, New York: iUniverse, Inc., pp. 286–303.

Goffin, K., & Koners, U. (2011). Tacit knowledge, lessons learnt, and new product development. Journal of Product Innovation Management, 28(2), 300–318.

Harrison, V., Proudfoot, J., Wee, P. P., Parker, G., Pavlovic, D. H., & Manicavasagar, V. (2011). Mobile mental health: review of the emerging field and proof of concept study. Journal of Mental Health (Abingdon, England), 20(6), 509–524.

Hays, S. (2020, January 10). Approaching 1,000 Mental Health Startups in 2020. Retrieved from medium.com/what-if-ventures/approaching-1-000-mental-health-startups-in-2020-d344c822f757

Jurgenson, N. (2012). When Atoms Meet Bits: Social Media, the Mobile Web and Augmented Revolution. Future Internet, 4(1), 83–91.

Knapp, J. et al. (2016). Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days. New York: Simon and Schuster.

McHugh et al. (2013). Patient preference for psychological vs pharmacologic treatment of psychiatric disorders: a meta-analytic review. J Clin Psychiatry, 74(6), 595–602.

Mental Health Commission of Canada (2017). Options for improving access to counselling, psychotherapy and psychological services for mental health problems and illnesses. Ottawa: Howard Chodos. Retrieved from : https://www.mentalhealthcommission.ca/sites/default/files/2017-07/Options_for_improving_access_to_counselling_psychotherapy_and_psychological_services_eng.pdf

Mental Health Commission of Canada (2018). Expanding Access to Psychotherapy: Mapping Lessons Learned from Australia and the United Kingdom to the Canadian Context. Retrieved from: https://www.mentalhealthcommission.ca/English/media/4134

Metz, R. (2018, October 15). The smartphone app that can tell you're depressed before you know it yourself. MIT Technology Review. Retrieved from: www.technologyreview.com/2018/10/15/66443/the-smartphone-app-that-can-tell-youre-depressed-before-you-know-it-yourself/

Mulgan, G. (2014). Design in Public and Social Innovation : what works and what could work better. Londres : Nesta. Retrieved from: www.nesta.org.uk/report/design-in-public-and-social-innovation

Olfson, M. and Marcus, C. (2010). National Trends in Outpatient Psychotherapy. Am J Psychiatry, 167:1456–1463.

Osberg, M. and Mehrotra, D. (2020). The Spooky, Loosely Regulated World of Online Therapy. Jezebel. Retrieved from jezebel.com/the-spooky-loosely-regulated-world-of-online-therapy-1841791137

Turkle, S. (1984). The second self : computers and the human spirit. New York: Simon and Schuster.

Verbeek, P.-P. (2015). Beyond Interaction: A Short Introduction to Mediation Theory. Interactions, 22(3), 26-31.

Vial, S. (2019). Being and the Screen: How the Digital Changes Perception. Published in one volume with A Short Treatise on Design. Cambridge (Mass.): The MIT Press.

World Health Organization (2017). "Depression: let's talk". Retrieved from: www.who.int/news-room/detail/30-03-2017--depression-let-s-talk

Yock, P. (2018, October 17). Why do digital health startups keep failing? Fastcompany. Retrieved from https://www.fastcompany.com/90251795/why-do-digital-health-startups-keep-failing

About the Authors:

Stéphane Vial is a Professor at the School of Design at the University of Quebec in Montreal (UQAM), where he is the Chairholder of the UQAM Research Chair in Design for e-Mental Health (Diament). Previously, he was an Associate Professor at the University of Nîmes.

Sana Boudhraâ is an expert in codesign approach and project-based pedagogy in the design studio. She is a Ph.D. candidate at the Faculty of Environmental Design, University of Montreal (UdeM) and a member of the design research laboratory Hybridlab (UdeM).

Appendix

List of the all ideas generated through the 69 projects

NB. For classes 04 and 05, prototypes are interactive and still available online (project name is clickable).

#	Projet name	Main idea	Main features in the app
Class 01 (Bachelor) - Teams			
P1	Cognitivo	improving social inclusion of children with ADHD	goals to reach, events, chat
P2	E-psylon	matching patients with therapists with a focus on follow-up tool for therapists	find a therapist, therapist profile, appointment management, notes for therapist
P3	Hopiccop	better tracking patient records and data sharing for professionals at the emergency room	single shared record with multi-users access
P4	Psychologues	patient follow-up after hospitalization that leads to start a psychotherapy	online record, find a therapist, appointment management
P5	Psyclik	matching patients with therapists with a focus on patient orientation	orientation questionnaire, find a therapist, therapist profile, appointment management, payment by app, online record
P6	RISM	making psychotherapy accessible to migrants during their journey	network of migrants, online record, map of refugee camps, appointment management
P7	TRUST	fighting against harassment at school	online chat and counselling between children & mediators, sharable child record, recommended therapist, appointment
P8	Adopte un psy	matching patients with therapists with a focus on guiding the patient	find a therapist through a questionnaire, therapist profile
P9	Mobipsy	matching patients with therapists with a focus on psychological follow-up (for agoraphobia)	find a therapist by specialty, appointment management
P10	Psygo (A)	find a psychotherapy center and go there through a dedicated taxi service	map of psychotherapy centers, appointment management, choose a car ride
P11	Helpsy	matching patients with therapists	find a therapist, appointment management, recommendations
P12	Happsy	matching patients with specialized therapists	find a therapist by specialty and therapy type through a questionnaire, manage appointments, diary, subscription

Class 02 (Master) - Individuals			
P13	Éléphant	therapy organizer in order to save and remember everything	therapy timeline including appointments, goals to reach, private notes, image sharing
P14	I=US	help people go and meet a therapist, fight against stigma	virtual psy to help define the problem, online chat, audio and video calls
P15	Pourquoi pas toi ?	breaking the taboo of therapy through a better information	digital kiosk in the street to inform people and get an appointment with a therapist
P16	MDT	helping therapists in organizing client records and clinical notes	list of difficult cases, patient profile, comments about patients from other therapist, peer sharing
P17	GoPsy	helping people forget about drugs and go see a psychotherapist	ads at physicians office, online chat before appointment, first session
P18	Speedy Psy	helping meet therapists face-to-face through psy meetups	choose therapists online, check profiles, go to meetup
P19	Amoi	toning down psychotherapy with tools	appointment management, mood diary, private notes, media sharing, exercises, chats
P20	Entre deux	communicating with therapist between two sessions	video call and chat with limited time levels (from 5 min to 25 minutes)
P21	AB	offering a therapy organizer for patients	check-up, appointments, mood diary, chat, comment sessions, find a therapist for a friend, feedback years after
Class 03 (Master) - Teams			
P22	Start my therapy	getting information and choosing the right therapist	find a therapist, types of therapies explained, therapist profile, appointment management, itinerary
P23	Feel free	follow-up after therapy is ended	progression visualization, rate your experience, sharing with relatives
Class 04 (Bachelor) - Individuals			
P24	My Psy	meeting a therapist through video	find a therapist, therapist profile, appointment management, video call
P25	Psydia	matching patients with therapists	find a therapist, appointment management, notifications
P26	Help'em all	psychotherapy service for LGBT+	specific patient profile (gender data...), find a therapist, messages, payment
P27	Sporty psy	matching patients with therapists	find a therapist, therapist profile, appointment management

P28	Thér'happy	matching patients with therapists	find a therapist, appointment management, mood diary
P29	Psycodia	matching patients with therapists and reimbursing 50% of sessions	reimbursement through insurance partnerships, mood diary, online diagnosis and related therapists recommended
P30	Hériss'	getting in touch with therapists without stress	find a therapist, therapist profile, patient's availability, request to selected therapists
P31	Test-it	online personality tests and related counselling	library of tests by categories, results and suggestions
P32	Happy & good	associate psychotherapy to wellbeing practices such as meditation	therapist profile, wellbeing care counselling, appointment management, discounts
P33	Théra'Service	fund your therapy in exchange for service in an association	localize associations, associations profile and contact, list of available services/missions
P34	Explorapie	matching patient with appropriate therapists through information about various therapy types	list of therapies, therapies presentation page with text, video, testimonials, list of therapist by therapy type
P35	Ther'happier	matching patients with therapists in partnership with mutual funds	orientation test, find a therapist, various consultation modes (in-office, video...), manage appointment, reimbursements
P36	Proksya	matching patients with therapists through a friend recommendation	symptom description, related therapists, therapist profile, chat, appointment management
P37	Psymatch	matching patients with therapists	patient profile, symptom description, find a therapist, appointment management, rate therapist, follow-up tool
P38	Psyko.more	resources on mental disorders and matching patients with therapists	articles on mental disorders, books to read, counselling, find a therapist
P39	Let's meet	patient orientation in order to match with an appropriate therapist	short personality test, access to selected talking groups for meet-ups
P40	Hand-up	chatting with psychologists without user registration	patient orientation, information on mental disorders, appointment management
P41	Théramis	invite a friend and recommend him/her a therapist	questionnaire on your friend, diagnosis hypothesis, find an appropriate therapist, therapist profile, invite your friend

P42	PsyForSport	psychotherapy counselling for professional sportspersons	patient profile, health information, specialized therapists, appointment management
P43	H Psy	matching patients with therapists	find a therapist, therapist profile, appointment management
P44	PsyForMe	matching patients with therapists through a mood test	patient profile, mood test, related therapists offered
P45	Psyou	reduce the cost of psychotherapy by watching commercial videos	habits and hobbies form, related videos, real time nest egg, find a therapist, therapist profile, appointment management
P46	Online therapy	matching patients with therapists for online therapy in partnership with mutual funds	symptom description, find a therapist, appointment management, video calls, online payments, reimbursements
P47	Psygo (B)	matching patients with therapists	find a therapist, therapist profile
P48	VisioPsy	matching patients with therapists through a quizz	patient orientation quizz, recommended related therapists, find a therapist, appointments, video calls, PayPass payment
P49	Olimpsy	book activities and hobbies and points for funding your therapy	find hobbies and activities, pay for it, get session points, choose therapist, pay with points
P50	iTalk	inform patients and match them with similar patients for discussing	patient profile and information, patient posts, online chat
P51	Oupsy	matching patients with therapists and follow-up tools	find a therapist, therapist profile, nest egg, shared diary, meditation exercises, messages, audio files, mood test
P52	Child therapy	find the best therapist for your kid	patient profile, find a therapist, appointment management
P53	Advisor	matching patients with therapists and managing sessions	diagnosis test, online chat counselling, patient profiles, find a therapist
P54	Theraqui	matching patients with therapists through a quizz	online quizz, therapist recommendation, find a therapist, manage appointment, discount code for first session
P55	Speak'n Read	share your experience or read experiences from other people	friends groups, donate, read messages, post messages, contact therapist...
Class 05 (Master) - Individuals			
P56	Danteo	content for mental health self-management and therapy follow-up	daily goals, food and sleep resources, articles, videos, audios, therapist notes and advices, messages

P57	Help Work	support from employers to fund first therapy session	check employer support, find a psychologist, therapist profile, call, resources to read
P58	N'autre psy	Therapy management tools for therapists	shared agenda, messages from patients, appointments
P59	Si tu tends l'oreille	become a listener, get trained, listen to patients	find partner therapists to get trained, chats with patients, appointment management
P60	Adopte un psy	find the best therapist	find a therapist, messages, appointment management, first session for free in video call, rate video call
P61	Perfect Psy	matching patients with therapists through an orientation video call	immediate first meeting with a counsellor through video, related recommended and rated therapies, appointments
P62	My Psy	matching patients with therapists through an online diagnosis	quizz, diagnosis hypothesis, related recommended therapists, therapist profile, messages, online subscription
P63	Ysia	online counselling through a chatbot	chat, find a therapist, AI-enabled online conversation
P64	Feel better	matching patients with therapists	therapists list, therapist profile, therapy subscriptions, appointment management
P65	Oreilles de proximité	matching patients with therapists through a friend recommendation	invitation from a friend who offers a package of sessions, find a therapist, therapy follow-up tools (goals, co-funders...)
P66	À vos dons	add a tip to your session price and increase the collective nest egg	online payment, tips adding option, check the total of available donations, collective funding
P67	PsyCo	co-funding your therapy through monthly donations from friends	find a therapist, therapist profile, manage appointments, co-funding link, visualize amounts for next sessions
P68	PsyView	therapist profile generator and SEO tools	therapist profile generator, choosing search engines and directories
P69	Mon Cercle	understanding and improving mental disorders of relatives through online circles	find and join a circle, chat online with circle members during circle online opening times, goals to reach

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Enhancing the Student Learning Experience through Engagement with Community: A Transdisciplinary and Collaborative Approach to WIL

Petra PEROLINI[a]*, Naomi HAY[a]

[a] Griffith University, Australia
*Corresponding author e-mail: p.perolini@griffith.edu.au
doi: https://doi.org/10.21606/drs.2020.276

Abstract: [Withheld] is a transdisciplinary work-integrated learning (WIL) design studio unit at [Withheld]. The studio has worked on a broad spectrum of community engagement projects from its inception in 2014. Design staff mentor students in a scaffolded WIL environment allowing for authentic engagement with community, industry, government and not-for-profit groups for an enhanced student learning experience. As such, collaborative approaches to live projects are examined for potential benefits to learning and teaching, student engagement, and to the wider community. This paper provides an overview of the studio, outlines the team development phase and participant involvement, highlights two highly successful community projects undertaken in 2016 and 2018, and unpacks assessment results, course evaluations, and student and client feedback.

Keywords: work integrated learning; community engagement; transdisciplinary collaboration; socially and environmentally responsible design

1. Introduction

The LiveSpace Studio is an interdisciplinary and collaborative Work Integrated Learning studio established in the design department of Griffith University in 2014, supported by a Griffith University learning and teaching grant to explore student learning on real-world projects in a campus workshop setting. LiveSpace projects provide opportunities for students to work on real projects within the broader community, where they are challenged beyond the limitations of a typical studio environment. Students are provided with opportunities to engage with projects from initial client briefs, early conceptualisation, design development, prototyping, documentation, construction and project administration under the guidance of industry experts and academic staff. (Hay et al., 2015). Working on projects outside of a classroom environment, students are able to gain insight into the complexity of the whole of design process and the interaction of designers, clients, consultants, trades, community and stakeholders in a continuous feedback loop In working with community on tangible projects, students are further provided with insights into the benefits such design interventions can have within the community itself. (Hay et al., 2015) Students across the design disciplines explore spatial design, urban design, and retrofitting projects with a strong focus upon materials reuse, repurposing, retrofitting and design for disassembly and modification, providing students with an advanced level of knowledge in sustainable design that will equip them with essential skills in a rapidly changing world. The selection of projects, framed within the context of socially and environmentally responsible design further encourage students to develop an inherent ethical framework, recognising the importance and responsibility of their role as future design practitioners. As Carleklev and Sterte (2013) contend, teaching sustainability to students

Is not simply about providing relevant information but is "foremost about training students to meet the challenges of tomorrow," which in the context of design means shifting "the focus from material, form and function towards systems, correlation and time as well as about developing an attitude and behaviour towards a more sustainable future." (p.1454) Further, drawing from the theories of Donald Schon (1985), "reflection-in-action" is embedded in the program as an iterative process, allowing for a circular approach to experimentation, innovation and learning from mistakes (p.27). The projects reviewed in this paper therefore reflect an approach to redirecting design practice through pedagogy, interdisciplinarity, connection with community, and reflective forms of practice (Hay, et al., 2015). Underpinning the program is a commitment to engaging students with ethical and sustainable practice in design and the mentorship of socially responsible emerging design practitioners within the community.

2. The Benefit of WIL Programs

The importance of Work Integrated Learning (WIL) programs in developing graduate employability skills and an ability to understand the interconnections between theory, practice and life experience has been widely observed (e.g. Cooper, Orrell, & Bowden, 2010). The Australian Government commissioned *2017 Good Practice Report -Work Integrated Learning (WIL)* identifies that effective, successful student learning in WIL programs is "both a process and end-orientated concept encompassing a range of approaches, practices and strategies that integrate theory within the practice of work" (Sachs, Rowe, & Wilson, 2017, p.28). Good practice in WIL aims to provide high-quality student learning experience, improve graduate employability, develop active citizenship, enhance university standards and profiles, and provide mutually beneficial relationships with industry and community (Sachs, et al., 2017, p.28). The benefits of such practice have been increasingly embraced by Australian universities, with many including Curtin University, Swinburn University of Technology, University of Wollongong, Deakin University, Macquarie University incorporating WIL as part of their whole of organisation strategic plan. Some of these institutions focus upon student employability, some on developing industry and community links with the university, and others on enhancing the student learning experience (Sachs et al., 2017, p.13).

In design education, the benefits of WIL are significant, with the relationship between institutions, industry and community critical not only for the development of student skills, but also as a mode of integration, innovation, research and reflexive practices, bringing innovation and positive change to all parties (Camacho & Alexandre, 2019). Designers operate within a complex network of actors with competing interests and agendas. The importance of learning the intricacies of negotiating relationships between the designer, the client, consultants, trades, regulators and the community *in situ* cannot be underestimated. Cuff (1992) contends that design schools regularly separate the "primary professional activity of design from its context," whereby "what is learned in the laboratory (read: studio) is valuable basic knowledge that bears little direct relevance for the way we act in the environment (read: practice)" (P.66). Lawson and Dorst (2009) agree, contending that situated learning is of particular relevance to design which itself is an "intrinsically situated activity" (P.280). Therefore, the best place to educate design students for practice is within practice itself (Lawson & Dorst, 2009, p.214). Situated learning can be viewed as a "highly social, even anthropological" mode of learning, highly relevant to the way in which designers learn from and through projects, beyond the more simplistic view of "learning as doing," where learning takes place best not in the formal classroom but in the context in which it is to be applied (Lawson & Dorst, 2009, p.280).

There are multiple examples of art and design schools globally embracing such situated learning practices over the past decade. One such example, 'The Design Agency Project', located at the Edinburgh College of Art was established in 2008 within the BA (Hons) Graphic Design Program. Each year, senior year graphic design students establish multiple design agencies, and interview and appoint junior students within their design teams. The projects undertaken are profit generating commercial projects, with industry experts appointed as mentors. The project is experimental and evolving in nature and therefore not tied to specific employability criteria, funding criteria, or "pedagogical imperatives," allowing for a fluid creative process (Sharman & Patterson, 2013, pp.1803-4). Upon completion of the four-year degree, students have concurrently undertaken three years of work experience (Sharman & Patterson, 2013, p.1788). Inspired directly by this model, Nottingham Trent University formed 'The Consortium' in 2013, applying the concept to students of product design students who were academically strong, yet lacked confidence to secure work placements themselves (Watkins & Clarke, 2018, p.147) 'The Consortium' was designed as a "safe risk-free space within the University to engage in entrepreneurship and enterprise," using facilities of the business start-up incubator 'The Hive,' whilst securing funding, support and existing projects from the European Regional Development Funding enterprise 'Future Factory' over three consecutive years (Watkins & Clarke, 2018, p.147). Whist currently on hold, the authors (and facilitators) contend the project could easily be restarted, having offered strong opportunities for students unable to gain placement, and enhanced skills in entrepreneurship, networking and leadership. However, a concern raised by the authors was the initial program had not appropriately provided an authentic "experience or environment that mimicked working in larger organisations." (Watkins & Clarke, 2018, p.149)

In Australia, The University of Western Sydney' professional design studio, 'The Rabbit Hole' aims to provide a "unique learning environment, incorporating participatory design methods and a work integrated learning framework that facilitates situated learning experiences, where live projects with real-world outcomes bridge the gap between academia, community and industry." (Edwards-Vandenhoek & Sandbach, 2013, p. 1538). The program runs as a year-long capstone course of the four year Bachelor of Design Degree. The teaching team, students (primarily graphic design) clients, industry, alumni, work together on live projects, with graduates encouraged to maintain close links with the studio upon graduation. Projects are sourced both internally at UWS and within the local community, with working budgets, real timeframes, and clients (Edwards-Vandenhoek & Sandbach, 2013, p. 1540). The aim is to provide an environment for "responsible, inspired, work-ready emergent designers with an understanding of how their actions can positively impact change in their communities, and the world at large." (Edwards-Vandenhoek & Sandbach, 2013, p. 1552). Programs such as these reflect new modes of learning and teaching emphasising work readiness and employability, collaboration, real world experience and the interconnection of theory and practice (praxis). Further, in times of growing global challenges and complexity, the need to engage in transformative models of learning and teaching in design becomes increasingly important. Rooj and Frank (2016) contend that design educators need to facilitate co-creation skills development in the face of global challenges of sustainability which no stakeholder can tackle alone. We are therefore in need of trained design professionals who co-create in transdisciplinary environments with community to develop "plans and policies for sustainable and just" built environments (P.477). Fry (2009) contends that design intelligence is critical to informing education and practice and must occupy a larger frame, with the designer as a redirective practitioner taking on a leading role in the initiation of sustainable projects with viable ideas and practical solutions (p.13, p.172). Barnett (2004) adds that to design a curriculum for "supercomplexity" in times of uncertainty, the process must be imaginative, high risk and transformative, engaging students in a process of forming their own responses to challenges faced, making "interventions in an already pre-structured world" (p.257).

WIL programs adopting radical and transformative curricular have the potential to be instrumental in addressing uncertain futures through new modes of interventionary design thinking in the co-creation of sustainable built environments. Engaging students in the authentic learning experience in the classroom is no easy task. Educational theorists have explored the effect on student engagement of authenticity – the alignment between classroom activities and goals that are personally meaningful to the student, that matter to the community outside of the classroom, or which reflect ways of thinking within an established domain (Shaffer, 2004). In providing learning and teaching environments that are both ''risky" and "transformative" (Barnett, 2004, p.257) carefully constructed WIL programmes can provide avenues for the co-creation of knowledge meaningful and beneficial to the student, industry, and to the wider community.

3. LiveSpace: An Experimental Learning Environment

Much of the literature on WIL programmes focuses upon a "singleton model" (Orrell, 2011, p.10) with students from singular disciplines working in industry placements. However, design problems, described as "wicked problems" by Rittel and Webber (1973, pp.155-169) are a complex negotiation of multiple actors, perspectives and conflicting interests. Transdisciplinary learning can help to break down perceptions of predefined boundaries between design disciplines thereby opening a path towards making further sense of complexity in ever changing global scenarios (Hay et al., 2015). Rooj and Frank (2016) contend that transdisciplinary teaching is still relatively rare, experimental, and lacking a strong theoretical underpinning (p. 483). LiveSpace aims to address these limitations through the provision of a cohort-based, transdisciplinary, simulated professional design studio in the classroom and workshops, which can potentially also present an opportunity to “transform what constitutes...occupational practice” (Billett, 2014, p. 100). Students across studio majors of Interior and Spatial Design, Product and Industrial Design, Graphics and Visual Communication Design and Visualisation and Immersive Design work together in teams, alongside industry experts, consultant’s government, community, business representatives and not for profit organisations to see projects through to completion. In creating an “experimental learning environment” (Shaffer, 2004) LiveSpace aims to prepare graduates for future work practices, as well as engendering a disposition to lifelong learning and social justice. The LiveSpace program further aims to prepare graduates to be leaders in the design field by becoming knowledgeable and skilled transdisciplinary designers and design researchers, effective communicators and team members, innovative and creative critical thinkers and strategists, and socially responsible practitioners in their communities with a focus upon:

- Enhanced collaboration with community, regional ,and industry partners. By bringing authentic, real world design projects into a learning studio the project provides an opportunity for students to learn *in situ* and provides local organisations, not-for-profits and community-based groups with an opportunity for greater engagement with university students and researchers.
- Enhanced employability skills of students through structured, practice-based WIL experience: greater confidence, risk taking, critical reflection, self-evaluation, learning from mistakes and adaptation of theory and practice to workable solutions.
- Improved quality of the student experience through participation in socially and environmentally responsibly focused community-based projects and research, whilst exploring new thinking in sustainable design, construction practices and technologies: design for disassembly, modification, transportability, re-use, re-purposing and recycling are design strategies that can be sustainable and provide competitive advantage in a rapidly changing industry. In doing so the studio aims to address a major concern shared among leading institutions in design research and pedagogy; that of a lack of critique of un-sustainable industry practice (Fry, 2009).
- Providing a scaffolded learning environment for students to connect theory and practice (praxis), allowing smoother transition into the workplace and for industry to test future practices.

3.1 Project Sourcing, Development and Team Formation

LiveSpace projects are selected with an ethical design practice, social justice, and sustainability focus including community projects, non-for- profit projects and local and regional government projects. The majority of projects fall within 100 kilometres of Brisbane to optimise the capacity for *in situ* collaboration on projects from project conception to completion. A number of projects have been undertaken in remote rural areas and inter-state, in which case the project team has travelled to conduct research on the ground, undertake community consultation, attend client briefings and complete comprehensive site analysis. The project is then followed through to completion in the studio, with video conferencing utilised in lieu of face-to-face meetings on site. Projects costs are typically covered by the university, funded in-kind by client/community, or funded through modest grants to cover purchase of materials for prototyping and travel and accommodation costs. Many projects are brought directly to the studio, with external partners interested in working with students making contact with the course convenor directly. Other projects are sourced word-of-mouth through the multiple industry, government and community networks maintained by the design staff team. After an initial briefing, the studio convenor meets with the stakeholders to discuss an approach, expected outcome, level of engagement of the University and any possible limitations.

LiveSpace is open to 3rd year design students from four majors; Interior and Spatial Design, Product and Industrial Design, Graphics and Visual Communication Design and Visualisation and Immersive Design. Whilst there is no minimum Grade Point Average (GPA) requirement, students must have demonstrated required competencies in the completion of their 2nd year design major studies. Enrolment numbers have consistently been at capacity (25-30 students) since the studio's formation in 2014. Typically, three to four projects are offered in one semester, all of varying complexities and time durations. At the commencement of the semester, enrolled students are briefed on available projects and provided with the opportunity to meet potential clients face-to-face for initial project briefings in in week one where possible, or via video conferencing. In the initial ideation phase, multiple proposals are conceptualised and presented to clients/stakeholders, either individually by students on smaller projects, or in small working groups. Concepts and return briefs are submitted to the client for consideration and a single concept is selected for further development.

A skills audit is then undertaken with the students, and project teams are formed based upon levels of skills, interdisciplinary mix, and project preferences. Whilst student project preferences are always considered, experience has demonstrated that the success of a team depends upon achieving a balanced mix of skills, diverse interests, and a cohesive and collaborative mix of participants. The course convenor also identifies specific project needs, the needs of student learners, and any time and scheduling limitations. Collaboration and teamwork are standard practice for most professional design activities, even for the smallest projects. This collaborative design process invites input from a variety of stakeholders and laypeople and brings together divergent thinking around common goals, vision and approaches agreed upon through a consensus. Community-based design, participatory design or design of public interest, is critical in the development of LiveSpace projects. Typically, one team consists of four to five students. The teams are required to select a team leader, maintain an online progress blog, and attend a minimum of three hour-long weekly studio sessions at the university, where a tutor will be appointed as mentor. Students are further required to work on the projects individually for an additional ten hours per week minimum outside of the formal contact time. Peer evaluations required from each team member are submitted in weeks four, eight and twelve. Students are asked to evaluate their peers on dependability, quality of contribution, accuracy and quality of completed tasks, and overall commitment and contribution to team progress. The tutor consults individually with each team member to provide feedback and a summary of the evaluations received. The purpose of the evaluations is two-fold. They facilitate the identification of potential problems within the team dynamic early in the project, providing tutors the opportunity to address this in a timely way, and are incorporated into the student's final grade as a self/peer assessment component. Team leaders also take on responsibility of informing the convenor and tutors of the project progress, team dynamics and any potential issues, along with maintaining the team progress blog and obtaining approvals from the course convenor for any occurring expenses for travel and purchase of consumables.

Where possible, the ultimate aim is for students to work on a project from conception to construction documentation, administration and completion, though this is not always possible during the period of student enrolment on larger projects. LiveSpace has been running for six years and completed over 32 projects to date. Some projects were conceptual, others required students to produce digital or physical solutions, and nearly all resulted in making prototypes of systems or objects in the workshops. Six spatial design projects were taken from conception through to full construction - a regional art gallery, a student lounge and four community spaces. In each case, students were responsible for the conception, design development, and production of complete construction documentation, specifications and schedules packages, along with continued project administration. Learning through first-hand experiences with clients and stakeholders whilst receiving continuous feedback throughout the process is critical to student's sense of preparedness as graduate designers ready to join a highly competitive industry. In gaining valuable experience working on live projects in the LiveSpace studio, students are better prepared for practice by acquiring effective specialised and transferable skills required for transition from classroom to industry.

Table 1 LiveSpace Selected Projects 2014 to 2019

Projects	**Client**	**Type**	**Duration**	**Year Comm**	**Year Completed**	**Completion Status**
Charleville Gallery	Murweh Shire Council	Design and Construct	5 semesters	2014	2018	Construction Completed
Charleville Streetscape	Murweh Shire Council	Design	2 semesters	2014	2015	Proposal under Consideration
Adeline House	Sisters of Mercy	Design and Construct	2 semesters	2015	2016	Concept
Reverse Garbage	Recycling Non for Profit	Design and Construct	1 semester	2015	2015	Under Consideration

Bills Bar Woodford	Woodford Folks Festival	Design and Construct	1 semester	2015	2015	Construction Completed
Sidewalk Bar Woodford	Woodford Folks Festival	Design and Construct	1 semester	2016	2016	Construction Completed
Compass Connection Cafe	Compass Connection	Prototype	1 semester	2016	2016	Prototype Completed
Commonwealth Games Seating	Gold Coast City Council	Design and Prototype	2 semesters	2017	2018	Prototypes Completed
Endeavour Learning and Lifestyle Centre	Endeavour Foundation	New Typologies	1 semester	2018	2018	Typologies for new Lifestyle Centres Completed
Goanna Lounge -sticky space	Griffith University	Design and Construct	1 semester	2019	2019	Construction Commences early 2020

4. Community Engaged Projects

The following section outlines two projects that demonstrate Livespace success by working closely with stakeholders and the community. The Compass Connections Café, completed in 2016 and the Endeavour Foundation's Learning and Lifestyle Centre completed in 2018, generated positive and supportive responses from clients, community and industry partners. The projects were specifically designed to give students opportunities to become industry ready through experiential learning, offer valuable opportunities for learning through reflection-in-action (Schon, 1985, p.27), enrich student learning experience, and increase employability skills.

4.1 Compass Connection Café

The Connection Café is Compass Institute Initiative's newest social enterprise in Nambour, Queensland. The coffee shop offers a full food and drinks menu operating from Monday to Friday. The primary goal of the café is to provide people with disabilities with real work experience and flexible employment opportunities. In 2016 the recently opened café planned an extension to provide the local community and employees with a shared 'usable' outdoor environment utilising the grassed areas surrounding the main building. The plan sought to provide the local community with more open room for gatherings, activities and community meetings whilst facilitating a more meaningful relationship between Compass Connection's workers and the broader community. Though only newly opened the café was already a local favourite for breakfast and lunch due to the friendly staff, excellent service, quality of the food and relaxed atmosphere. Compass Connections asked [Withheld] to provide a future vision of how to develop the adjacent area to the café to provide the local community with an engaging and interactive outdoor seating environment. One of the primary challenges was a lack of funding, resulting in a decision to source as many materials as possible for the seating through charity-based tip-shops and salvage yards free of charge. A small university-based grant allowed students to purchase additional materials needed for prototyping.

Table 2 Project Process - Compass Connections Café

Compass Connections Café Project	**Project Process**
Site briefing August 2016	The first briefing on-site in August 2016 allowed students to meet with Compass Connection's representatives and employees whilst obtaining valuable site information and a thorough project briefing.
Teams formation and virtual meetings	Three five-member transdisciplinary teams commenced conceptualisation of the project collaboratively. The Compass project relied upon flexibility in communication and collaboration, as site visits were limited due to distance. Meetings therefore often occurred through video conferencing. Students further conducted mixed methods research through a series of interviews and focus groups with Compass Connection employees and café staff.
Concept proposals and design process August - October 2016	Initial concepts were introduced to stakeholders at a symposium held in the studio. Subsequently, the concepts were reviewed and shortlisted to proceed into the final design phase involving prototyping the outdoor seating designs. After sourcing materials appropriate for their conceptual design responses, student teams developed technical specifications and construction drawings for their prototypes.
Challenges and limitations	Teams faced many challenges as they engaged in a process of making-as-learning, determining the limitations of recycled materials as they are often fraught with complexity and contradictions. Initial limitations included issues of matching the functional and aesthetic design intent with availability, affordability and appropriateness of materials from salvage yards. A further reoccurring issue was high toxicity levels in available treated timbers, which were therefore deemed inappropriate as a material for the furniture. Students were supported by tutoring staff and skilled workshop technicians, with many of the activities centred around sorting, dismantling and assessing the condition and constraints of the materials.
Final prototype presentations October 2016	The final four prototypes were presented to the client and community representatives at a symposium in October 2016. The overall feedback received from all stakeholders was positive. The benefits seen by the community were a strong indication of the impact of this project, particularly in the inclusive strategy of public engagement that offered significant opportunities for participation. The involvement of the community also allowed for cost and time savings whilst the participatory process underpinned sustained community interest in the project.

Figure 1 Compass Connections Café - LiveSpace students working on prototypes using campus workshops, image by author.

Upon completion, the furniture elements were seen as central show pieces at the opening of the new Compass Connection Café community space in early 2017. The furniture pieces provided the building blocks for community engagement throughout the process and as such, they were not only functional, but became ongoing conversation pieces. The community partnership encouraged and engaged students as learner/makers, who were not only recognised for their skills and knowledge but were encouraged to take on design leadership roles during the development and implementation phase. As the feedback (Table 5) reflects, the project has successfully demonstrated that by adopting practices of making-as-learning, teaching-by-doing, engaging with community, and encouraging networking and mentoring on live projects is highly beneficial to the student learning experience.

Figure 2 *Compass Connections Café prototype of outdoor table made from recycled materials by LiveSpace students, image by author.*

4.2 Endeavour Foundation Learning and Lifestyle Centre

The Endeavour Foundation's Learning and Lifestyle Centre (LLC) is a centre-based program where clients take part in a range of flexible learning programs, recreation and social activities. Learning and Lifestyle services follow a person-centred support model, helping people with intellectual disabilities to develop independence, confidence, self-esteem and social interaction skills. Centres promote individualised programs to develop personalised plans to meet clients' goals and aspirations, whilst striving to work together to build the confidence needed to achieve them. There are currently over thirty-five Learning and Lifestyle centres in Queensland and a limited number of additional centres throughout Australia (C. Beaumont, personal communication, March 12, 2017). In 2018, the Endeavour Foundation was seeking to improve their Learning and Lifestyle centres to make them inclusive, welcoming, modern, and flexible state of the art facilities where clients and families feel supported, encouraged and inspired. The Endeavour Foundation and LiveSpace worked in partnership on future typologies for their Learning and Lifestyle centres.

Figure 3 *Endeavour Foundation Learning and Lifestyle -Brisbane Centre. LiveSpace site visit, March 2018. Image supplied by Endeavour Foundation www. https://www.endeavour.com.au/services/learning/learning-lifestyle*

Table 3 *Project Process - Endeavour Foundation Learning and Lifestyle Centre*

Endeavour Foundation Project	**Project Process**
Client briefing March 2018	1. The client identified the following areas for consideration in student proposals: 2. Break out rooms for educational purposes 3. Open planning for multipurpose activities 4. Art room for specific art programs 5. Office space 6. Chill out/relaxation rooms 7. Core activities that are either leisure based or skill development 8. Kitchen for general use and meal preparation 9. Facilities including ambulant access and showers
Project scope and directions	Following the briefing, LiveSpace students commenced designing new Learning and Lifestyle Centre typologies to promote inclusivity for an intellectually impaired client base through supportive, aesthetically pleasing, vibrant, functional, safe and flexible centres which encourage learning and independence. The poorly designed and ineffective existing centres received continued criticism from clients, carers and staff. New design typologies were modelled upon an existing Endeavour Centre space in Ipswich, Queensland. Although the ideas were specifically tailored to a specific space, the proposed typologies were aimed at informing new future visions for all of Endeavours' Learning and Lifestyle centres across Australia.

Research phase	Students visited a smaller LLC in Coopers Plains, Brisbane to obtain valuable information on operation, activities, function and aesthetics. An interview with management and staff confirmed that clients, carers and staff all agreed that urgent improvements were necessary to make the centre more inclusive and vibrant for their clients. Teams identified several educational typologies and grouped them into four main areas; formal learning spaces, informal learning spaces, spaces which offer support, and workshops. The purpose of this exercise was for stakeholders and students to discuss and select which combination of typologies would best represent the ideal future learning and lifestyle spaces.

Identified Learning Spaces for Learning and Lifestyle Centres

Learning spaces	**Type 1**	**Type 2**	**Type 3**
Formal Learning Spaces	Traditional Classrooms	Seminar rooms	Flexible Classrooms
Informal Learning Spaces	Study lounges	Group Learning	Library/ Resources
Support Learning Spaces	Outdoor Spaces	Café/ Canteen	Mixed use lounge
Workshops	Computer Labs	Craft Rooms	Tech Workshops

Design process April-May 2018	As the Endeavour Foundation was interested in receiving as many typologies as feasible, thirty-five students worked individually on the conceptual design process. During a classroom critique in week six, students presented their concept typologies to the class and tutors. Twelve concepts were shortlisted to be developed further in teams.
Final presentations June 2018	12 Groups presented their final concepts to Endeavour Foundation Representatives in a symposium held on campus in June 2018

Figure 4 Endeavour Foundation Learning and Lifestyle Centre Typology project. Concept Symposium with 3rd year Design Students and the Endeavour Foundation client, May 2018, image by author.

Stakeholders commented on the selected designs as being innovative and dynamic, whilst promoting inclusivity and bringing a new approach to concepts of learning for people with intellectual disabilities. Key strategies employed by the twelve concepts emphasised making the centres more effective by observing three key elements; access, participation and learning. Student project research also highlighted the need for active client participation throughout the process. A clear theme identified from interviews with the stakeholders was for layouts and design requirements to go beyond the minimum standards for educational premises and the Australia Building Code. This approach was considered by all to be essential for successful operational and inclusive learning centres. The winning proposal successfully blends exterior and interior activities and proposes an internal streetscape design, where clients acquire important life skills such operating an ATM, participating in social interactions in the café or in the corridor (street), and tending to an internal garden, whilst also offering a number of formal and informal teaching spaces, offices and ancillary spaces. The concepts presented provided the client with potential redirections for their future learning and lifestyle centres and will form part of a wider discussion in planning to generate new ideas for designs and to stimulate discussions and debate.

Figure 5 *Endeavour Foundation Learning and Lifestyle Centre Typology. Final Design Symposium, selected student proposal, May 2018, image by author.*

5. Assessment, Feedback and Recommendations

In six years of operation, LiveSpace studio has initiated spatial design, urban design, retrofitting and exhibition projects in collaboration with community, government, industry and not-for-profit organisations. LiveSpace studio is also currently working with the university on internal projects, developing innovative sticky campus spaces. LiveSpace projects are taught as part of the Design degree at Griffith University which aims to educate future designers as reflective practitioners capable of tackling complex, or "wicked" problems (Rittel and Webber, 1973) through design praxis and learning-through-making. Learning outcomes aim to produce knowledge workers and makers with an understanding of design as a means of social change (Fry, 2009; Wood, 2007). This approach is in line with a shift toward critical thinking and transdisciplinary research and practice in progressive design programs around the world. Each year, feedback is gathered from students, the course convenor and stakeholders. The data presented here is drawn from the projects previously outlined and is significant in that it has resulted in adjustments to the course where necessary. Participants in the feedback process were overwhelmingly positive and supportive of the program.

Table 4 Feedback for Learning and Lifestyle Centres Project

Endeavour Learning and Lifestyle Centre Project	**Feedback**
Course Convenor	It was amazing to see our students in action with our new industry partner proposing original and clever design concepts and solutions. The school places great importance on our industry collaborations and offers a well-rounded learning experience to students. In this case, the ability for our students to bring their ideas and solutions to industry has been an invaluable experience for them and has also deepened their understanding of designs ability to promote inclusiveness.
Client	Working with LiveSpace students has been a very rewarding experience over the semester. I have been lucky enough to have been working with different groups on a variety of typologies over 12 weeks. It is always great to work with young creative minds who have great energy proposing new ideas and new ways of tackling problems. The project has been challenging and we went along on a journey with students, asking them to really push the boundaries. And they did. Some of the proposals are exciting, new and challenge the current approaches of learning spaces for people with intellectual disabilities. Our aim is to find new innovative ways to build our future centres. The 12 proposals received will be included in this process.
Community	I have an adult son with special needs who attends the Coopers Plains centre. The staff is wonderful but unfortunately the centres need urgent improvement. The emotional wellbeing is so important to people with mental disabilities and friendly, vibrant, well designed and light and bright spaces are needed to support their various needs. As a parent, I was delighted to hear that Endeavour is investing in new design typologies for future learning and lifestyle centres. I had the pleasure of being interviewed by LiveSpace students and was impressed by the in-depth research they undertook to really try and understand the needs of the users.

Client	I have learned so much working with students. The project was challenging. Students found the initial site visits to our centres confronting at first. Many had never met someone with an intellectual disability. Communication and groundwork were key in this project. We had weekly Skype meetings and we also arranged four site visits. In the end we received many detailed and creative new ways of thinking about how to design a learning and lifestyle centre. The typologies will now be used to drive the discussions forward.
Student	This course provided me with a great WIL experience. I really enjoyed working on a live project. There was more accountability and I think I worked better knowing that my proposal has the potential to be selected to initiate some real change in the lives of the people using these centres.
Student	This course was a reality check. I was thrown in the deep end and I knew that all the knowledge and skills learned in theory and studio courses were skills that are actually required on real life projects, but I never knew that at the time. Featuring this project in my portfolio helped me in a recent interview.
Student	This internship was an eye-opener. Working on real projects gave me a good insight into what is required as a graduate. I was really driven and highly motivated working on this project. Alongside LiveSpace, I also undertook an industry placement. I was able to use the design process I learned at work too.

Table 5 Feedback for Compass Connection Project

Compass Connections Project	**Feedback**
Course Tutor	This project presented some challenges. The site was a two-hour drive away which meant that we needed to plan our initial site visit well. We ended up having to drive up a second time to record missed measurements and to conduct further interviews with staff and the community. Another challenge was sourcing appropriate recycled materials and accelerating the ideation phase in the design process. Students were used working on ideating for a number of weeks on studio projects. This time we allowed one weeks. A lack of joinery detailing, and workshop skills meant a further delay. Although students had obtained the necessary workshop inductions prior to the commencement of the project, they lacked decision making skills and technical skills. At the end, the finished prototypes were heavier and larger than anticipated, and we had to hire a truck to get them delivered on site. As [Withheld] had a small school-based grant, we were able to fund the delivery using those funds.

Client	Working with LiveSpace was a great experience. As we had no budget for a designer, we were very grateful to be working with LiveSpace. Not only did the students present some very creative prototypes, they also pushed the brief beyond our expectations and offered additional ideas on how we can engage better with the community.
Community	These young designers are looking at the social impacts design can provide to initiate change. And social change is exactly what we as a community push for. The Compass café is already getting support from the local community but any help from creative minds on how to give more exposure to the café is welcomed. The final designs really could make a huge difference bringing more local patronage which translates into Compass being able to offer more traineeships for these young adults with intellectual impairments.
Student	I never felt ready to step into professional practice. This course was as close to getting an experience as possible while still at uni. It gave me sufficient exposure to all my practical concerns, and I now feel a little more prepared.
Student	Coming from a studio-learning environment, I was confident in the design process and the aesthetics on space and presenting to clients, but this course introduced me to the consideration of working with limitations. I was able to obtain quotes on all the joinery I had designed and documented. I was able to meet with the cabinet maker, discuss the designs, get feedback on the construction and material use and do some additional work experience with the joiner. Learning by doing was a highly motivating experience.
Student	What was new to me was that building with recycled or salvaged content is more difficult than building with new material. I found it challenging to find the materials and then propose unconventional construction techniques. There were a lot of discussions with builders and tradies, tossing ideas and starting from scratch.
Student	LiveSpace was fun. I really enjoyed working and learning with students from other cohorts. I would like to see a permanent LiveSpace studio where we have our desk and can work over the week with a studio director available.

Student grades are allocated based upon project team performance with a peer review component accounting for fifty percent of the semester grade. The remaining fifty percent is individually awarded for project journals. Results have indicated that students work extremely well in the course, are highly motivated, and are actively involved in the design process, leading to higher-level learning outcomes. Further, the course organisation with a strong emphasis on teams, mentoring by staff, and building relationships with external stakeholders has resulted in increased student ownership of learning outcomes. While the initial response to LiveSpace has been overwhelmingly supportive, adjustments to the program continue as data received from assessments and course evaluations is analysed each year. One change under consideration for 2020 is to cap the student intake based upon GPAs. This would ensure students have accomplished the necessary academic success required in experiential learning and confirms a level of commitment, dedication and self-direction; all qualities that matter not only for the success of LiveSpace projects, but also for future employers. A further change under consideration is to limit student intake. Large cohorts of over twenty-five students have presented significant challenges in the management of the course, with students occasionally failing to receive full support from tutors whilst working on complex design projects with developing skills and knowledge. Smaller cohorts would ensure a more personalised approach, further engaging students in deep learning, whilst providing high-quality feedback and ensuring consistency and excellence in project outcomes.

5.1 Discussion and Recommendations

While a significant part of the course evaluation discussed here is based on feedback provided by students, clients, community and teaching staff, they are significant and have resulted in adjustments to the program. The overall feedback from all participants has been positive and supportive and indicates that the course is providing industry workplace opportunities for students, so they can transform their learning experiences into practice knowledge. One indication of the positive impact of the course is that stakeholder demand sometimes can't be accommodated due to timeframes or because we often can only accommodate one single larger project. Data available for sequencing, timings and duration of recent projects are currently being analysed and evaluated and early results indicate that future development of the program will require furthering relationships with industry partners and identifying funding possibilities. Future collaboration with design programs at other institutions and education scholars at Griffith will also help LiveSpace to build a solid framework for further evaluating learning outcomes. LiveSpace fulfils a need for a safe learning environment for students to explore sustainable design practices and innovative methods of design processes through hands-on, experiential learning. As noted, this opportunity is limited in current tertiary-level education, and as such LiveSpace will provide a model for other institutions. LiveSpace aims to address a major concern in design disciplines; that of a lack of critique of un-sustainable industry practice and the essential move towards new modes of thinking to enable students to become effective future practitioners.

Acknowledgements: We would like to acknowledge contributions from Dr Peter Hall and Dr Beck Davis of a previously published paper which has been referenced throughout this paper - Hay, N., Perolini, P., Davis, B., & Hall, P. (2015). Socially and Environmentally Responsible Design Process: A Cross Disciplinary Approach. In Popovic, V., Blackler, A., Luh, D.B., Nimkulrat,N., Kraal, B.,& Nagai,Y. (Eds.). IASDR2015 Interplay Proceedings, pp. 898-912. Brisbane, Australia, QUT.

6. References

Barnett, R. (2004). Learning for an unknown future. *Higher Education Research & Development,* 23(3), 247–260. https://doi.org/10.1080/0729436042000235382

Billett, S. (2014). *Mimetic learning at work : Learning in the circumstances of practice*, 1-21. Retrieved from https://ebookcentral-proquest-com.libraryproxy.griffith.edu.au

Camacho, B., & Alexandre, R. (2019). Design Education. University-industry collaboration, a case study, *The Design Journal,* 22(1), 1317-1332. https://doi.org/10.1080/14606925.2019.1594958

Carleklev, S., & Sterte, M. (2013). Pedagogy for teaching design: with an emphasis on sustainable design. In Reitan, J.B., Lloyd, P., Bohemia, E., Nielsen, L.M.,Digranes,I.,Lutnaes, E.(Eds.). DRS CUMULUS 2013 Design Learning for Tomorrow: Proceedings from 2nd International Conference for Design Education Researchers Design Learning for Tomorrow, pp. 1453–1467. Oslo, Norway, ABM-media.

Cooper, L., Orrell, J., & Bowden, M. (2010). *Work integrated learning : A guide to effective practice*. Retrieved from https://ebookcentral-proquest-com.libraryproxy.griffith.edu.au

Cuff, D. (1992). *Architecture: The Story of Practice.* Cambridge and London, U.K: The MIT Press.

Edwards-Vandenhoek, S., & Sandbach, K. (2013). Down the Rabbit Hole: a situated approach to design education that facilitates socially responsible emergent designers. In Reitan, J.B., Lloyd, P., Bohemia, E., Nielsen, L.M.,Digranes,I.,Lutnaes,E.(Eds.). DRS CUMULUS 2013 Design Learning for Tomorrow: Proceedings from 2nd International Conference for Design Education Researchers Design Learning for Tomorrow, pp. 1537–1554. Oslo, Norway, ABM-media.

Fry, T. (2009). *Design Futuring: Sustainability, Ethics and New Practice.* Sydney, Australia: University of New South Wales Press.

Hay, N., Perolini, P., Davis, B., & Hall, P. (2015). Socially and Environmentally Responsible Design Process: A Cross Disciplinary Approach. In Popovic, V., Blackler, A., Luh, D.B., Nimkulrat,N., Kraal, B.,& Nagai,Y. (Eds.). *IASDR2015 Interplay Proceedings*, pp. 898-912. Brisbane, Australia, QUT.

Lawson, B., & Dorst, K. (2009). *Design Expertise.* Oxford, UK: Routledge.

Orrell, J. (2011). *Good Practice Report: Work-Integrated Learning.* Sydney, Australia: Australian Learning and Teaching Council. Retrieved from http://hdl.voced.edu.au/10707/213987

Rittel, H.W.J., & Webber, M.M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences,* 4, 155-169. https://doi.org/10/1007/BF01405730

Rooij, R., & Frank, A. (2016). Educating spatial planners for the age of co-creation: The need to risk community, science and practice involvement in planning programmes and curricula. *Planning, Practice & Research,* 31(5), 473–485. https://doi.org/10.1080/02697459.2016.1222120

Sachs, J., Rowe, A., & Wilson, M. (2017). *Good Practice Report: Work-Integrated Learning.* Canberra, Australia: Australian Government Department of Education and Training. Retrieved from https://ltr.edu.au/resources/WIL_Report.pdf

Schön, D. (1982). *The reflective practitioner: How professionals think in action.* New York, U.S.A.: Basic Books.

Schön, D. (1985). *The design studio: An exploration of its traditions and potentials.* London, U.K.: RIBA Building Industry Trust.

Shaffer, D .W., (2004). Pedagogical Praxis: The Professions as Models for Post-industrial Education. *Teachers College Record*, 106(7), 1401-1421.Retrieved from https://www.tcrecord.org/content.asp?contentid=11577

Sharman, I. J., & Patterson, Z. (2013). 'Not two weeks in a place tidying-up the paper drawer' – an employability agenda case study. In Reitan, J.B., Lloyd, P., Bohemia, E., Nielsen, L.M.,Digranes,I.,Lutnaes,E.(Eds.). DRS CUMULUS 2013 Design Learning for Tomorrow: Proceedings from 2nd International Conference for Design Education Researchers Design Learning for Tomorrow, pp. 1787–1805. Oslo, Norway, ABM-media.

Watkins, M., & Clarke, P., (2018). The consortium: an innovative approach to employability. Proceedings of the 20th International Conference on Engineering and Product Design Education, pp. 146-150. Dyson School of Engineering, Imperial College, London.

Wood, J. (2007). *Design for Micro-utopias: Making the unthinkable possible*. London, U.K.: Rutledge.

About the Authors:

Petra Perolini is the Program Convenor of the Design Major Interior and Spatial Design and the Program Leader of the Bachelor of Design at the Queensland College of Art, Griffith University. Petra has a practice background in commercial interior design, design futures and urban and regional planning. She has worked on projects, which support social inclusion and community housing. Her projects respond to present and future needs in progressive ways, addressing current and pressing social and environmental issues that affect city living globally today.

Naomi Hay is a multi-disciplinary designer and sessional lecturer in the Design Department at Queensland College of Art Griffith University. She is completing a PhD with a research focus investigating the role of design in strengthening resilience of vulnerable communities towards sustainable futures. As an educator Naomi is committed to the development of re-directive, ethical design practice, with a focus upon connecting students to real world projects involving industry partners, regional councils, and not for profit groups.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Transforming a Public School: A Case Study of Tongji-Huangpu School of Design and Innovation and Its Search for Synergy

Yubei GONG[a]*, Yongqi LOU[a]

[a] Tongji University, China, People's Republic of
*Corresponding author e-mail: grace_912@hotmail.com
doi: https://doi.org/10.21606/drs.2020.291

Abstract: In response to the changes of technological and sociological landscape, education policies and experiments are emerging globally. Tongji-Huangpu School of Design and Innovation (THDI) is a newly reformed educational institution in China. It operates in the Chinese public education system and is designed to model 21st-century learning practices by applying a design thinking (DT) methodology and problem/project-based learning (PBL) pedagogy. This case study gives an overview of the school, outlines the practice of the past 27 months since its establishment and elaborates the tensions during transition phases. Synergy, the concept of the whole being greater than the sum of its parts, is identified as the goal of reducing tensions, and three design initiatives have been implemented for improving the collaboration among high school and college teachers. The school reform is the first of its kind in China and it hopes to shed light on the design and education research.

Keywords: design thinking; pbl pedagogy; school reform; synergy

1. Introduction

Education has gone through several reforms in the past century. This started with replacing the classical education of the type offered to royalty and wealthy people with modern education that became more practical and civilian. Gradually, human capital theory that explained the economic value of a worker's experience and skill was put forward by economists like T. W. Schultz (1963), who further developed the notion of education as investment in human capital rather than consumption. Since then, education has reflected the national will and administrative power. With the development of globalization and the civil rights movement, however, education inequality has been criticized, and global organizations like the Organization for Economic Co-operation and Development (OECD) and United Nations Educational, Scientific and Cultural Organization (UNESCO) have started to play an important role in setting up educational goals. In recent years, education reforms have become fierce with the demand from the top and the bottom for change. People have never been more anxious than they are now, fearing that jobs will be filled by intelligent robots. New education policies, schools, curricula, and pedagogies are emerging as an antidote to the assembly-line production that formerly characterized the school system. Among these, problem/project-based learning (PBL); social emotional learning (SEL); STEM and entrepreneurship education (Zhou & Tang, 2018; Zupan & Nabergoj, 2012); and design thinking (DT) have become the buzzwords of the day. As the representative of this education reform, High-Tech High (HTH)[1] in the US just won the WISE Prize for Education[2], the world-class education reward, and spread its PBL philosophy and practice around the world.

The education innovations and reforms have had a great influence in China. Recently, China has even led educational innovation in the field of artificial intelligence (AI) by incorporating AI into public K–12 education[3]. This is one of the strategies that the state has adopted to fulfill its aims of transforming "Made in China" to "Created in China," which was stated in the 13th National Five-Year Plan. Various education measures have been carried out to cultivate the future generation such that it will be more critical and creative. In 2003, the Law of the People's Republic of China on the Promotion of Private Education was executed, which broke down the situation of the state-run public education system and offered the private and international school choices for families. In 2017, the National Entrance Exam reform was implemented on an experimental basis in a couple provinces to encourage students' comprehensive competence development. However, the situation in China is similar to that in the United States, where most of the education initiatives are seen in extracurricular activities rather than core subjects (Mehta & Fine, 2019). To transform the core of the traditional school system, new Chinese schools emerged (see Table 1). It should be noted that international schools and courses have sprung up, but they are not categorized as new Chinese schools in this article. Rather, to be considered new Chinese schools, the schools must be based in China, have Chinese founders, and have curricula that were originally created in China.

---

1 Developed by a coalition of San Diego civic leaders and educators, High Tech High opened in September 2000 as a small public charter school with plans to serve approximately 450 students. HTH has evolved into an integrated network of sixteen charter schools serving approximately 5,350 students in grades K-12 across four campuses. The HTH organization also includes a comprehensive adult learning environment including a Teacher Credentialing Program and the High-Tech High Graduate School of Education, offering professional development opportunities serving national and international educators.
High Tech High is guided by four connected design principles—equity, personalization, authentic work, and collaborative design—that set aspirational goals and create a foundation for understanding our approach. See https://www.hightechhigh.org/about-us/

2 Wise Prize for education established in 2011 is the first distinction of its kind to recognize an individual or team for an outstanding, world-class contribution to education. See https://www.wise-qatar.org/wise-works/wise-prize-for-education/

Table 1 Chinese Schools Founded in the Past Three Years

School Name	Ownership	Year of First Student Enrollment	Initiator/ Founder	First Campus Location	Academic System
Agilearning	Private	2019	Zhijuan MA	Beijing	Pre-K–12
Moonshoot Academy	Private	2018	Jason WANG	Beijing	G9–12
ETU School	Private	2017	Yinuo LI	Guangzhou	Pre-K–12
Tongji-Huangpu High School of Design and Innovation	Public	2017	Yongqi LOU	Shanghai	G9-12
Yungu School	Private	2017	Jack MA	Hangzhou	Pre-K–12

These newly established Chinese schools are the pioneers of an education reform that aims to make a revolutionary change instead of simply tinkering with the traditional rote testing school system. Among them, Tongji-Huangpu High School of Design and Innovation is the only public high school. It is intended to innovate in the public school system with design thinking and pave an alternative way of learning and teaching for more public schools. The dynamics of the change involves discrete agencies, agents, and conditions; this requires a synergism of the forces (learners, educators and the system) working together for a common goal that can exceed the original goals via focused efforts.

2. Overview of Tongji-Huangpu High School of Design and Innovation

> The central theme of design is the conception and planning of the artificial. Design provides the thought that guides the making of all products, whether by individual craftsmanship or mass-production techniques. These include the following: (1) material objects; (2) verbal and visual communication; (3) organized activities and services; and (4) complex systems or environments for living, playing, working, and learning. Virtually all definitions of design today are variations of this theme, each intended to draw out a different aspect or emphasize different possibilities of its meaning in accordance with different (usually tacit) theoretical or philosophical assumptions (Buchanan, 1995, p. 82).

2.1 Challenges and approaches

When Tongji-Huangpu High School of Design and Innovation enrolled its first group of 48 students in Shanghai in the fall of 2017, it was the first of its kind—a public secondary high school purposefully designed around the core principles of design-thinking in China, although design thinking had been applied to K–12 education for more than 10 years in the United States (Roth, 2017). Through collaboration with the local education bureau, the school sought to create a model for teaching and learning that would combine the merits of both traditional rote test learning and the PBL way of learning. The core challenge is to find a Doctrine-of-the-Mean between the two ways of learning within the state-run public education system. This philosophical goal of maintaining balance and harmony to a state of constant equilibrium (Legge, 1893, Chapter I, Para. 5) is rooted in the Chinese culture and people's mindset and will be easily accepted by educators and learners. Another challenge was transforming an old school to a preferred condition. Tongji-Huangpu High School of Design and Innovation is a new school in an old campus. For its new characteristics, it adopts a way of teaching and learning that is strongly aligned with 21th-century practice. In terms of being old, the high school took over everything from the old school except the name. Instead of building a brand-new school, the high school is exploring the possibilities of making changes within the public education system with design-thinking. In practice, transforming the school includes the design of a leadership structure, a professional development community, curricular structures, an assessment framework, the supporting infrastructure and more. The success of the school transformation is not only the completion of each building block but also the building of organic relationships among them.

The approach to achieving the "Doctrine of the Mean" can be seem from the school schedule, where 60% of the school time is allotted for subject matter courses and 40% for PBL courses. The 60% mode is for meeting all the requirements for high school students set by the National Ministry of Education, including passing all the standardized exams. It is taught by high school teachers or subject teachers. In this article, the two terms are used to refer to the teachers from the high school. The 40% mode, curated by the college team, is employed to break the disciplinary boundaries and features via open-ended learning chains that can fuse new knowledge and experiences through a problem- and project- based curriculum. This 40% mode is also called PBL courses and taught by teachers, researchers and postgraduates from the college. The two modes go in parallel at the beginning, but the key to their success is found in the interdisciplinary synergy of the two modes.

Choosing problem and project-based learning as the teaching pedagogy is based on a school goal of cultivating students to be future leaders in diverse areas. This requires the students to master a depth of knowledge and have various capabilities that can cope with increasingly complicated real-world problems. A three-dimensional (3D), T-shaped framework and knowledge cube was proposed by the initiator, Prof. LOU (Figure 1). The framework was developed from the T-shape concept (Leonard, 1995), which emphasizes the importance of both vertical and horizontal knowledge and skills. The metaphor of a thumbtack best describes the T-shape's capability. Only if the two work together can a thumbtack be pushed into a wall (Lou & Ma, 2015). Lou and Ma (2015) further emphasized that the "connection part" of the vertical and horizontal is crucial, and people who are strong at the connection part can be trained through applying "depth of knowledge" to solving real-world problems. Apart from problem-based learning and project-based learning under the rubric of PBL, which forms a global norm (Mohd-Yusof, Graaff, & Kolmos, 2016), another seven PBLs are proposed at the high school (Lou, 2018)[4]. The nine PBLs work together as a manifesto of the teaching and learning philosophy, promoting the interweaving and linking of "vertical" and

4 Passion-, personnel-, process-, participation-, practice-, prevision-, and peer-based learning

“horizontal” capacities.

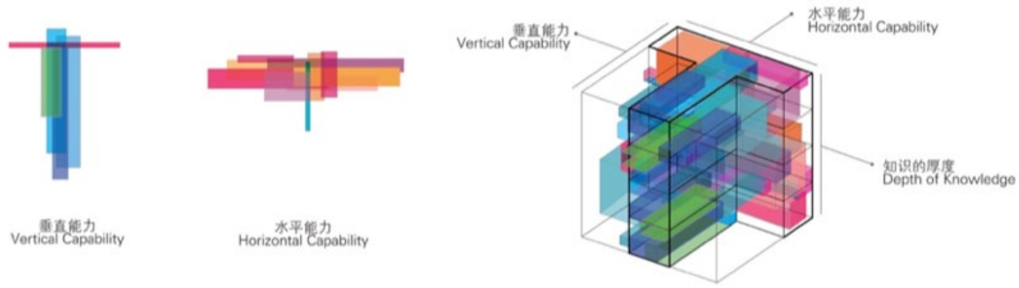


Figure 1 Relationship between the T-shape and knowledge cube (LOU, 2012).

2.2 Consensus and infrastructure building

The school goal was initially narrowly defined, but the consensus that design thinking as a teaching and learning catalyst and design-driven innovation education as the school guiding ideology will better prepare students to face the complex technological and sociological challenge of tomorrow than rote learning does. The district education bureau was determined to take the risk; thus, it quickly selected a school for the experiment and allocated special funding. The school principal was attracted by the vision; thus, she left her previous school and joined forces with the new school. Parents and students bravely joined the experiment. Many gave up an acceptance by a “key school” with a high reputation and chose the new school. Several teachers from the previous school left, but most remained, regardless of the high uncertainty ahead. The school vision brought the stakeholders together.

With the shared goal and government funding, the school infrastructure has been developing along with the development of the school activity. The school campus and classroom have been redesigned to fulfill the educational goal of a student-centered school that enables social interaction (Dewey, 1916), open and flexible communication and collaboration, and a happy and safe learning environment (Figure 2). The school space encourages students and teachers to organize and create an environment that serves their learning purpose. Therefore, students are no longer passive receivers, and teachers have to change their role from “dictator” to facilitator (Figure 3).

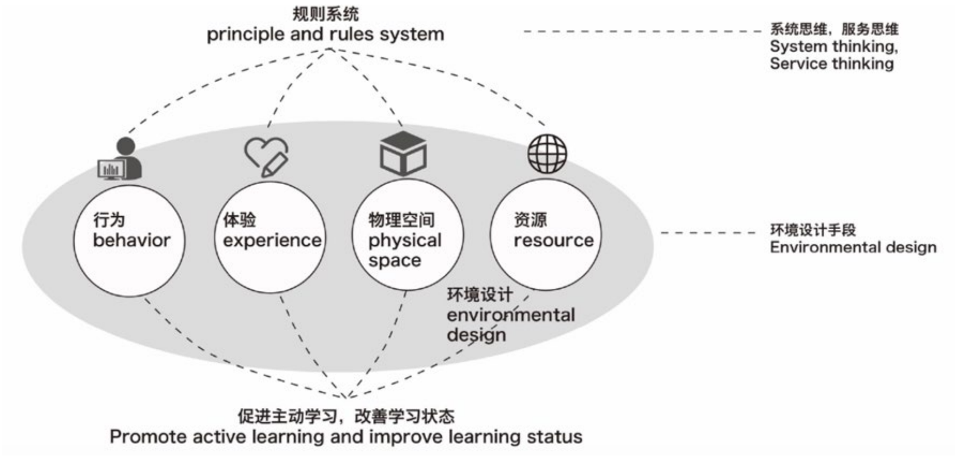


Figure 2 *Environmental design principle and rule system (Ran XUN, thesis proposal under the supervision of Prof. LOU, 2017).*

Figure 3 *Classroom before (left) and after (right) the school reform at Tongji-Huangpu High School of Design and Innovation.*

From a wider perspective, the school should be open to the social community and share resources with other parts of the community. For example, the school will build cooperation with the museums, galleries, and hotels in the community. And the community can access to the resource and space of the school. Ultimately, the walls of the school are no longer a barrier to being part of the wider community and community is integrated as a part of the school for teaching and learning (Figure 4).

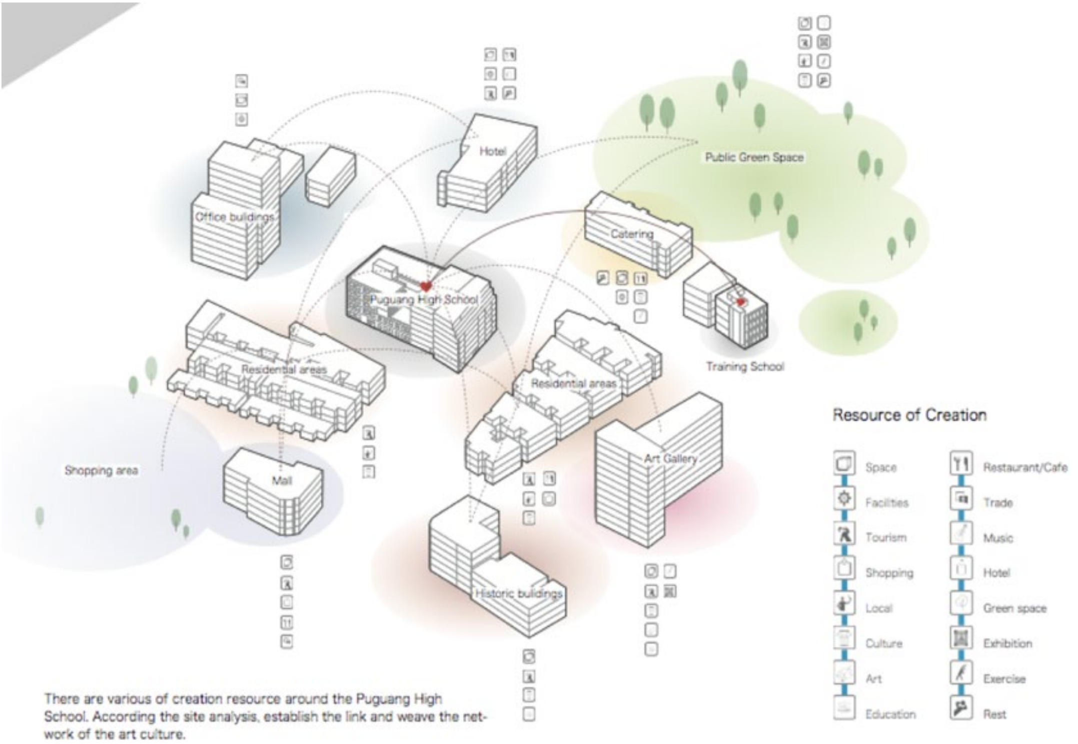


Figure 4 Tongji-Huangpu High School of Design and Innovation and the neighborhood community (Yiting WU, college studio work, 2017).

2.3 A college and high school partnership

The collaboration between the design college and high school advances mutual interests. The college conducts teaching and research activities at the high school and applies the findings to help transform the school. The high school teachers learn from working with the college teachers, and students gain access to rich resources from the college. As a result, they co-design the school and the related studio curricula at college. This partnership enables the design to expand beyond the traditional arts and craftsmanship and shift the paradigm to solve strategic and holistic problems (Lou, 2017). It also explores the possibility that design-driven innovation education can be extended to younger students at high school.

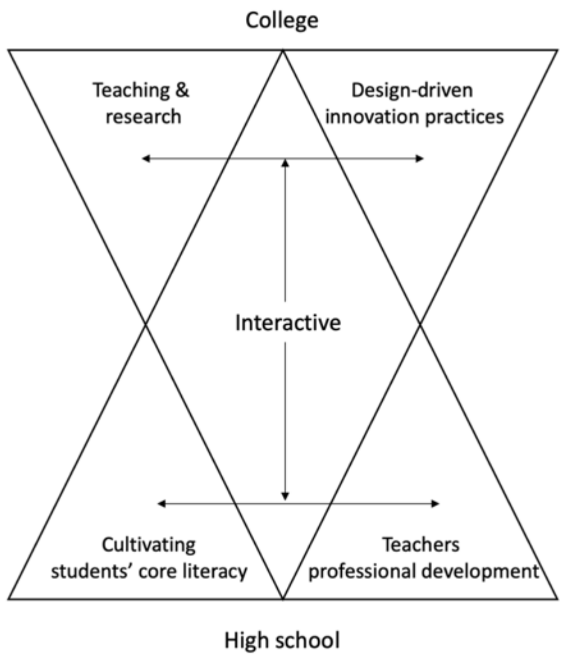


Figure 5 Partnership between the college and high school.

3. School in transition and increased tensions

Pendergast et al. (2005) proposed a three-phase model of the general sequence in which reforming schools attend to particular core component changes in their reform initiatives after the distillation of the massive amount of data.

- **Initiation phase** that typically occupies the first year or two;
- **Development phase** that typically consumes the next two to five years; and
- **Consolidation phase** that can last over a further five to ten years. (Pendergast et al., 2005, p. 64)

An agenda as ambitious as transforming a school does not come without its share of tensions and failures. The school reform has been in progress for 27 months, and tensions have emerged at different phases. These are itemized below.

3.1 Phase 1: culture shock

The initiation phase was the first year, between the fall of 2017 and 2018, when the school just resumed its admission and teaching after suspension for a year. The school campus had been partially redesigned to support the new curriculum. The PBL team was led by a Finnish design educator. Basic teacher training had been conducted to align the understanding of the school vision and design thinking methodology. Students were exciting and anticipating a brand-new learning experience. During this phase, the subject teachers who participated in the PBL course played the role of spectators and babysitters. They observed and took part in the PBL only to maintain class order. As Figure 6 depicts, the high school and college teachers who are in charge of the PBL course stayed in their zones, with limited collaboration.

Figure 6 Typical scene of the PBL course during phase 1.

Tension soon emerged in the initiation phase. This phenomenon was similar to the culture shock people experience when they move to a cultural environment that is different from what they are used to. The PBL course embraces an open, transparent, democratic, and non-competitive environment. This is partly because the PBL curriculum lead is from Finland; tesought . The curriculum lead was strongly against competition and tried to create an experience-oriented and a failure-friendly way of learning.

In contrast to the Finnish way of learning, China is a highly competitive society. Efficiency and efficacy take priority across industries. The high school teachers described the PBL course as a utopia and expressed their concern for the learning outcome. They worried that the students took the advantage of the PBL course to have fun and in the end the students wasted their time without learning anything at school.

In addition to the cultural differences between China and Finland, there are also culture differences between college and high school. At the college level, students and teachers have great autonomy, and their interests are not tied together. However, the interests of high school teachers are closely related to students' academic performance. Hence, high school teachers engage in rote memorization for the sake of efficiency. In sum, the same group of students mean differently for high teachers and PBL course teachers and therefore are taught differently.

3.2 Phase 2: competitors and conflicts

The development phase occurred from the second year on. After one year of observation, several high school teachers took initiatives to experiment with interdisciplinary teaching in the PBL course. Later, a task force made up of high school subject teachers was built. A couple of high school teachers started to apply the PBL pedagogy and design thinking methodology for teaching subject matter during the 60% mode. Several courses in the PBL mode settled as module courses in the PBL curriculum. From this semester on, the high school sported a full-time staff of four, including one design educator, one game designer, and two curriculum specialists. Members of the curriculum development team meet with subject teachers daily and took ownership for the PBL curriculum refinement. The school started to attract increasing attention from the public and gained a reputation as the Chinese version of High-Tech High School in the U.S.A.

After the culture shock period, high school teachers start to fight for their interests. The 60% and 40% occurred in parallel, and hence, become competitors; this led to the deviation from the vision that both modes were organically synergized. The competition of the two modes can be seen from different perspectives. For one thing, high school and PBL teachers were competing for limited time. High school teachers faced an ever-changing slate of rules and regulations and struggled to coordinate with other subjects. However, the school reform phased out block scheduling, which allotted about 40% of school time to do PBL practice without lowering the national standards for subject matters. Moreover, reaching a better PBL outcome usually required extra time after school. The scramble for time led to high dissatisfaction among the high school teachers. For another thing, high school and PBL course teachers fought for the control of students. In the PBL course, students can easily engage with interesting topics or materials and feel relaxed, without experiencing exam pressure. In contrast, students find the subject textbooks boring and are very passive in learning. One high school teacher complained, "students have no interest and energy in the traditional subject class after taking PBL courses."

Competition is due to the conflict of interests, which can be resolved as the two modes are synergized. Bigger conflicts come from institutional rigidity. How much autonomy can high school teachers have? How much freedom can high school teachers employ to teach at their pace rather than busily coping with various inspections and tests from the district, province, and state? The ideal of the PBL curriculum is the synergism of the high school syllabus across disciplines and practicing the content in a problem- and project-driven way of learning. It requires subject teachers to take on identities as designers rather than content experts who are only charged with delivering information to students. Similarly, how much autonomy can high school students have? How can they be evaluated as whole persons rather than exam machines? Unlike students at international and private schools, who can choose the Gaokao (national college entrance exam) or to study abroad, THDI students take the Gaokao, in which the test score means everything. As the Gaokao approaches, high school teachers and students become anxious and can hardly concentrate on the PBL courses in the senior grade. Although they believe in the vision of the school, they prefer to increase their scores through practicing the content on paper repeatedly to be on the safe side.

After 27 months, the school is still at the early stage of transition. The competition between subject courses and PBL courses and emerging conflicts are the inevitable result of socio-political processes involving different stakeholders, classrooms, schools, locales, and even national factors. Quick reaction to the conflicts and intensive action maintained over years are required.

4. Efforts at synergy

4.1 Toolkit development

Although Tongji-Huangpu High School of Design and Innovation is a new school, the high school teachers are all from traditional high schools. They've got used to the chalk-and-talk way of teaching and got great pressure to learn and try PBL pedagogy without enough guidance and support. In some degree, the school reform adds extra burden to them rather than helping them reduce their burden. Therefore, first and for most, let the subject teachers benefit from applying design thinking and PBL in their teaching that can help increase students' interest in learning and turn them from passive learners to be active learners. It will therefore make teaching easier for high school teachers.

The roadmap begins with a single subject and gradually will develop toolkits, protocols, and other resources to support cross-discipline collaboration. These tools aim to help subject teachers solve their teaching pain

points. The college team chose Chinese and chemistry as the starting points; these are two subjects teachers are willing to make changes to in their classroom, but they have not done so because they do not know where to start. For Chinese, writing has been problematic for both students and teachers. The subject teachers pointed out the main points of difficulty in writing as how to structure an essay and how to make the elements of model essays visible for imitation. The college team created a template after rounds of communication with subject teachers and iterated them after gaining students' feedback.

For chemistry, the periodic table of elements is the entryway to the subject, but this is too abstract and boring. The college team helped turn the rote learning into a personalized way of learning by creating a toolkit to connect the elements to students' daily life story (figure 7).

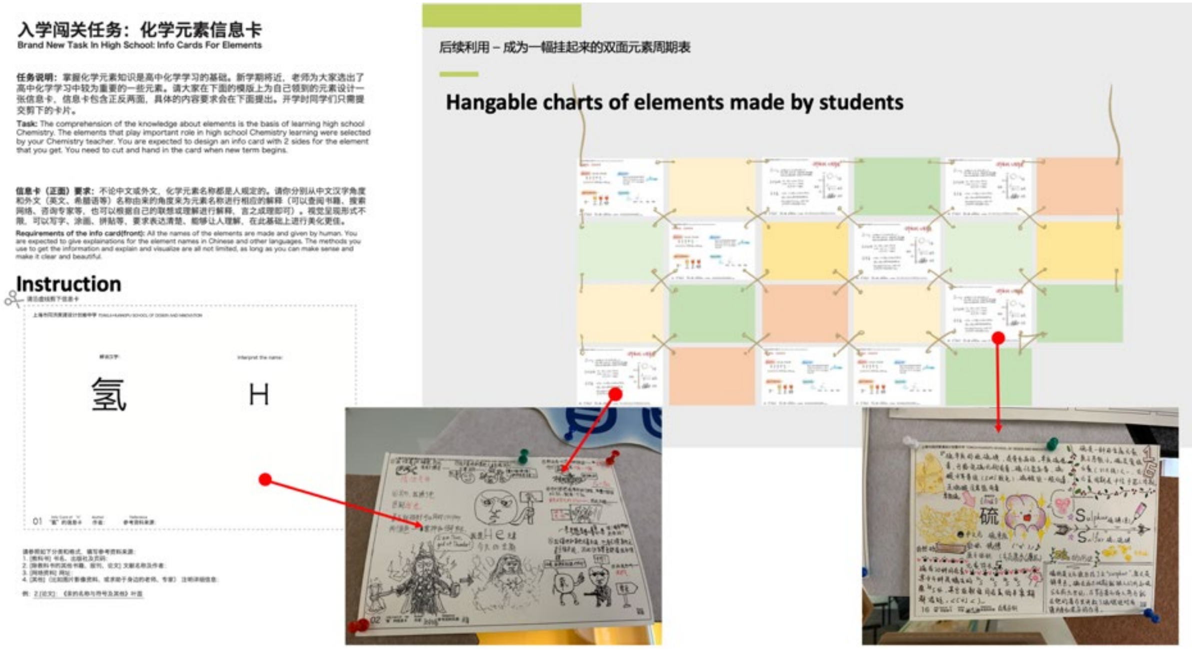


Figure 7 Periodic table of elements assignment for students (Ying LIU, toolkit development for her master research, 2019).

These tools assist the subject teachers to turn a rote learning into a more interactive and fun learning process and shift their attitude of treating the PBL course teachers as competitors to teaching partners.

4.2 Collaboration and learning from doing

Traditionally, the teaching profession has been an isolating one. Accountable for the performance of the students in their classrooms and on the standardized tests, teachers rarely have time for professional development, much less collaboration. Moreover, they do not have the opportunity to engage in a process of design, iteration, and reflection. The pace at which they must move to cover all the required standards is just too fast. By introducing an internally collaborative project, the PBL team sought to change the experience of traditional teachers, and in so doing, build internal capacity at the school.

In the fall of 2018, a program called Student-Initiated Project Program (SIPP) was conducted for three months. After one year of PBL courses, students were given the space to conduct an inquiry independently, with the teachers as facilitators. Going through the design process, students learned the basics of conducting design research and shifted their attitude from a results-driven one to learning from doing.

In addition to building student autonomy and research capability, another original intention was to train the high school teachers through the project process. A high school teacher and PBL course teacher were assigned. Before and after every class, both parties shared their observations and points of confusion and prepared the resources for the next class. After three months of participation, the high school teachers had become familiar with the design research process, learned to develop a toolkit for a specific purpose, and started to shift their identity. However, only a small group of high school teachers took part in the Student-Initiated Project Program (SIPP), and making it accessible to more teachers will take time.

4.3 Teaching and learning service design

Service design is an emerging practice in education. It takes a holistic view of all the related actors, their interactions, and supporting materials and infrastructures (Interaction Design Foundation, n.d.), and it requires a collaborative approach to customer needs and the competencies and capabilities of service providers (Kuzmina & Bhamra, 2014). A service design approach explores the relationship among various actors and identifies the interaction touch points, assisting the high school to navigate uncertainty during the transition.

After immersion in the school classroom for a year, the college team depicted different users' personas, working scenarios, and needs, offering teaching and learning services with a data platform. This data platform helped school administrators, teachers, students, and parents collaborate with resources beyond the school. Figures 8 is one sample of the service design.

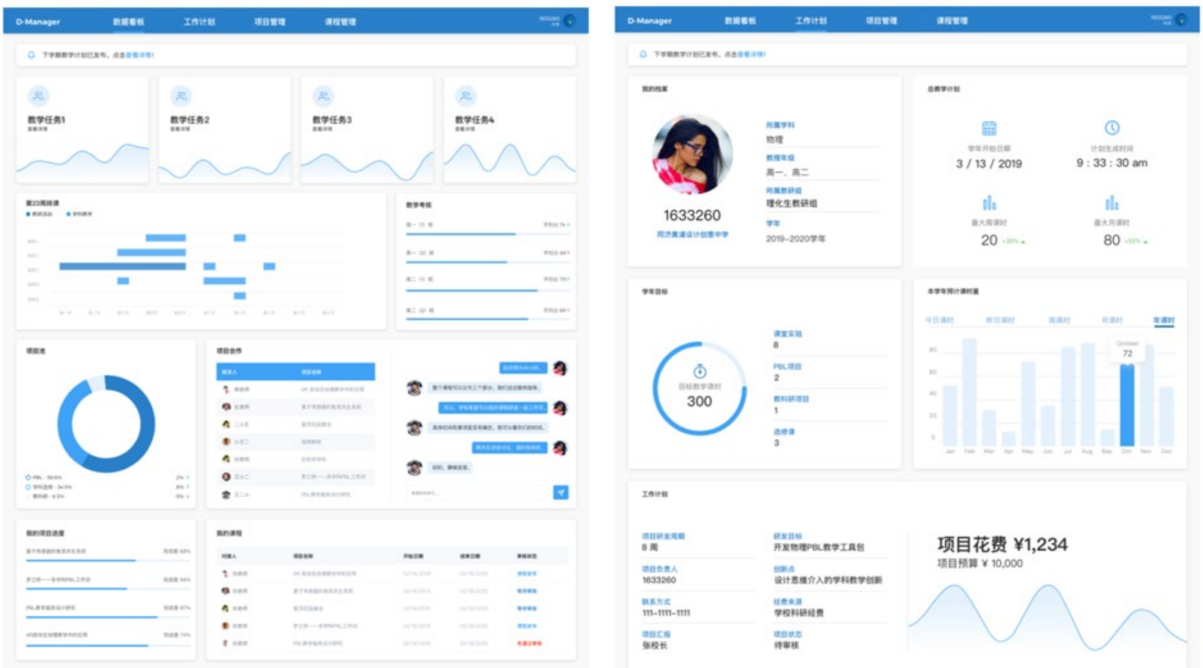


Figure 8 Data board and work plan (Yuetong ZHAO, 2019).

5. Conclusion

Through the development of the PBL curriculum, we can see that the school reform sought to achieve more than a mere exchange of resources among the college and high school. By synergizing the traditional exam-oriented learning, PBL pedagogy, and design thinking methodology, it expected to create something new and valuable—a whole that would be greater than the sum of the individual parts.

Currently, the school is in the second phase of reform, focusing on the teachers and the development of systems that engage them in realizing the vision. In essence, it is crucial to make the reform an integral element of the school culture. This can be difficult and frustrating, and the corrosive effects of resistance, cynicism, and burnout expressed by some staff can be anticipated. As Michael Fullan (2001) reminded us after his study of numerous education reforms, the change process is not linear, but rather, it is a continuous, interactive journey full of uncertainties, turmoil, and resistances. Apart from the creation of toolkits for the teachers, initiatives of collaboration culture building, and the development of a learning service platform, a sustainable model of innovation should be further explored. This dictates an extremely different relationship between the school administration and the frontline teachers.

The school reform has faced constraints from the beginning, and it still has to comply with the rules governing any urban public school. State syllabuses heavily restrict what can be taught, and standardized tests determine how the material must be presented. Given the unusual pedagogical model and public context in which it operates, the high school experiment is itself a precious lesson for both education and design research.

6. References

Schultz, T. W. (1963). *Economic Value of Education.* Columbia University Press, New York.

Methta, J., & Fine, S. (2019). *In Search of Deeper Learning: The Quest to Remake the American High School.* Harvard University Press, Boston.

Chen, P., & Huang, R. (2017). Design Thinking: from the Maker Moverment to the Cultivation of Innovation Ability. *China Educational Technology.* 9, 6-21.

Zhou, J.B., Tang, X. (2018). Research on the Path of the Application of Design Thinking to Promote Entrepreneurship Education Development in New Era. *Heilongjiang Researches on Higher Education.* 4, 113-117.

Zupan, B., Nabergoj, A.S. (2012). Developing Design Thinking Skills in Entrepreneurship Education. Leading Innovation Through Design: *Proceedings from the DMI 2012 International Design Management Research Conference,* 525-535. https://tinyurl.com/s6z78e5

Legge, J.(1893). *The Doctrine of the Mean.* Retrieved from http://www.nothingistic.org/library/confucius/mean/

Lou, Y. (2017). The Expanding Scope and Paradigm Shift of Design. **Time+Architecture.** 1, 11-15.

Buchanan, R. (1995). Myth and maturity: toward a new order in the decade of design. In Margolin, Victor & Buchanan (Eds.), *A Design Issues Reader,* (PP. 75-88). Cambridge, Mass: MIT Press.

Roth, B. (2017). *Forward. Taking Design Thinking to School: How the Technology of Design Can Transform Teachers, Learners, and Classrooms.* New York, NY: Routledge.

Dorothy, L. (1995). *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation.* Harvard Business School Press.

Lou, Y. & Ma, J. (2015). A 3D 'T-shaped' Design Education Framework. In E. G. Carayannis, G. Bast, & D. F. Campbell (Eds.), *Arts, Research, Innovation, and Society*, (PP. 287-294). Cham: Springer.

Lou, Y. (2018). A Design-Driven 3D T-Shape Innovative Education at High Schools. *Elementary and High School Principals,* 248, 31-36.

Mohd-Yusof, K., Graaff, E.D. , & Kolmos, A. (2016). IJEE Guest Editorial: PBL Across Cultures. *International Journal of Engineering Education*, 32(1). 305-307.

Dewey, J. (1916). *Democracy and Education.* http://www.stephenhicks.org/wp-content/uploads/2011/09/dewey_john-poe.pdf

Pendergast, D. et al. (2005). *Developing Lifelong Learners in the Middle Years of Schooling, Ministerial Council on Education, Employment, Training, and Youth Affairs (MCEETYA)* Report. https://www.researchgate.net/publication/257142583_Developing_Lifelong_Learners_in_the_Middle_Years_of_Schooling

KUZMINA, K. and BHAMRA, T.A. (2014). Positioning service design as transformational approach in education for sustainable development (ESD). IN: *ServDes14 Conference,* Lancaster, UK, 9-11th April.

Service Design. (n.d.). https://www.interaction-design.org/literature/topics/service-design

Zhao, Y.T.(2019).*Service design research on teaching system of problem-based learning for Tongji-Huangpu School of Design and Innovation* (unpublished master's thesis). College of Design and Innovation, Tongji University, Shanghai.

Fullan, M. (2001). *The New Meaning of Educational Change* (3rd Edition). New York: Teachers College Press.

About the Authors:

Yubei GONG is an ethnographer, a design researcher and educator. Currently, she is a Ph.D. candidate at the College of Design and Innovation at Tongji University with a focus on design for education activism.

Yongqi LOU is dean and professor of the College of Design and Innovation at Tongji University. He is a leading figure in sustainable interdisciplinary design education, research, and practice and a pioneer in China for design-driven innovation education.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

The Graduate Professional Portfolio as “synergy tool”: navigating the complex role of portfolios in future-focused design education

Deanna METH[a]*, Melanie FINGER[a]*, Dean BROUGH[a]*

[a] Queensland University of Technology, Australia
*Corresponding author e-mail: deanna.meth@qut.edu.au
doi: https://doi.org/10.21606/drs.2020.317

Abstract: Development of a new design curriculum at Queensland University of Technology prompted a study to revisit the nature and purpose of portfolios. Always integral to design disciplines, more widely there has been rapid growth of portfolio use for student learning, assessment and showcase, with technological advancements adding impetus for these to move online. This aligns to pedagogic shifts linked to authentic learning, graduate employability, and fostering twenty-first century graduate capabilities such as collaboration and communication. Research findings conceptualise a Graduate Professional Portfolio as a living, digital “universal archive” for students’ storage, presentation of, and reflection on design processes and outputs, and a space for collaboration and showcasing selected work to peers and employers. The Behance online platform is proposed as suitable for these purposes. The study has relevance across the higher education sector where designing such learning activities with suitable flexibility for individual students’ developmental needs has proved complex.

Keywords: design education; employability; portfolio; behance

1. Introduction

Design education today faces a wide range of competing demands from stakeholders, including students, academics, employers and professional and accrediting bodies. As a fundamental part of developing a new Bachelor of Design curriculum at Queensland University of Technology (QUT), Australia, there was a need to examine such expectations and societal needs more closely, with the acknowledgement that courses will be of little value if graduating students are unable to gain the skills, knowledge and capabilities deemed necessary to practice as designers in the future.

Development of the new future-focused degree commenced in late 2017, with delivery to the first new cohort commencing in February 2019. The degree offers specialisation in seven design disciplines, namely: Architecture; Interior Architecture; Landscape Architecture; Fashion; Industrial Design; Interaction Design and Visual Communication, and central to these are innovative studio based and theoretical disciplinary learning opportunities. Responding to future design needs articulated by stakeholders and sector-wide research evidence, the degree has a suite of four new transdisciplinary, collaborative and industry-linked Impact Lab units at its core, and scaffolded across the three years of study. In addition to providing direct access for students to work with community and industry partners, the Impact Labs provide a framework for students to develop a Graduate Professional Portfolio containing key elements related to their design process, outputs and reflection, and it is within this setting that the research problem was formulated.

Recognising the complex requirements of portfolios in design disciplines, as well as the multiple modes of portfolio outputs in existence, the aim of this action research study, conducted as a collaboration between academics, student partners and a learning designer, was to explore the purpose and shape such a Graduate Professional Portfolio might take. Additionally, a way to resolve the tensions implicit in each disciplinary area already having their own portfolio practices was sought. It was seen as critical not to duplicate or contradict these, but rather use the Impact Labs as a way to enhance additional designerly capabilities such as collaboration, impact, and working with partners, and thereby further enhance graduates' profiles. A feasible concept for how this may be achieved has emerged from the research, with broad applicability across design education, and the wider education sector. It takes notions of students' portfolios to a realm more closely linked to widely voiced requests for greater synergy between education and real-world contexts.

There is value to be gained in taking time to explore the background to portfolios as a pedagogic tool in higher education and design in particular, so this forms the focus of the opening portion of the paper, and linked to this, the specific context in which the research has been undertaken is elaborated upon. This sets the scene for presenting the research questions, following which the research approach is outlined. Results are presented as a set of propositions reflecting the key findings of the work, prior to concluding the paper with a brief discussion and closing points, including areas for future research.

2. Background and context

This research in action is situated in a higher education environment in flux, where contested narratives around societal expectations and the purpose of universities abound. A heightened focus on graduate skills and employability has led the global higher education sector to consider more deeply its role in preparing students for life and work beyond the university, and equipping them with the skills of adaptability and the ability to cope with constant change (Ashwin et al., 2015, p. 353; FYA, 2015; Mackh, 2018, p. 223). Skills felt to be necessary in today's "twenty-first century" graduates include problem-solving, communication, self-management, teamwork, interdisciplinary collaboration and understanding the importance of lifelong learning and ongoing professional and personal development (Cabau, 2017, p. 142; Mackh, 2018, p. 222).

Ashwin et al., (2015) note that active and experiential methodologies have been observed to facilitate in this process, whereby structured opportunities might be built within students' learning and assessment for them to develop such skills. Within experiential methodologies, where students have the opportunity to learn through real-world scenarios and commonly with connections to industry and community partners, there has been a growth in authentic learning and assessment. This brings into alignment learning outcomes with industry expectations, where from a constructivist educational point of view, students' competence is seen as "situational and personal" and linked to more meaningful contexts of performance (Ashford-Rowe, Herrington & Brown, 2014, p. 206).

Within this context, there is a need to acknowledge the complexity of students' skills acquisition, learning and development and the many "scattered" elements thereof, and the need to support students to undertake "personalised learning journeys" that will help them best establish themselves for their futures (Pegrum, 2017, p. v.). Students should be able to readily identify and articulate where and what skills they are acquiring, with the added ability to self-evaluate and reflect on this.

2.1 Portfolios in higher education

Extending the discussion above related to authenticity in learning and students' skills development, portfolios in higher education have been noted as eliciting different learning outcomes to more traditional forms of assessment, such as essays and exams (Jones 2010, p. 293). Crowther (2012, p. 229) defines a portfolio as "a collection or collation of achievements, artefacts, creative works or examples of competencies, usually for the purpose of demonstrating a person's capabilities in a specific field of endeavour".

Ashford-Rowe et al., (2014) note the affordances brought to authentic learning and assessment through digital developments and emerging technologies, and arising from these, Hallam and Creagh (2010) describe the evolution of portfolios from non-digital paper-based into online spaces, heralding the advent of the e- (electronic-) portfolio. Web 2.0 technological developments have recently sparked a further shift from bespoke e-portfolio systems (often institutionally owned, and generally restricted to the course environment) to a wide range of online platforms where students will own the space, and often open to the world beyond the university (ibid.).

Noting the e-portfolio as a direct response to universities needing to better prepare students for lifelong learning and employment, Cabau (2017) delineates three main categories of portfolio in higher education:

- Learning/developmental/reflection/formative/working
- Assessment
- Professional/formal/presentation/representation/career employment

Importantly, Jones (2010) makes the point that in using the portfolio as an innovative learning and assessment tool for quality, authentic learning, "collegial dialogue about practice is fostered and a bridge is built between the discourse of academia and the discourse of practice" (p. 309). This point tallies well with the statement by Cabau (2017) who notes the opportunity of e-portfolios as a 'synergy tool' straddling higher education and the real world (p. 144) – the point from which the title of this paper is derived.

2.2 Portfolios in design education

Moving into the realm of design education more specifically, Crowther (2012) documents the historical use of portfolios in design and creative industries disciplines, noting the shifts towards multiple purposes. Returning to the importance of the 'fidelity' of assessment tools to real-world settings being authenticated (Ashford-Rowe, 2014, p. 209) and notions of synergy, in the instance of design, Orr and Shreeve (2018) note the ongoing interplay and negotiation between the university and the design and creative sectors (p. 44).

It has long been the case that students and practitioners of design disciplines such as the architectures, fashion and visual arts maintain a body of work as evidence of their skills and practice in portfolio form, traditionally paper-based or as tangible media. This aspect of portfolio creation remains integral to design disciplines as evidence of a designer's professional capabilities and practice. In relation to digital and online advancements highlighted earlier, the 2013 Design Institute of Australia large-scale research publication (Robertson, 2013) also details the shifting focus of design disciplines and rapid growth in multimedia, web, and technology design fields of employment and the importance of socially connected, networked and digitally agile graduates. This is further endorsed in large-scale research undertaken by the Foundation for Young Australians (2015) and supports the move of some portfolio outputs into digital spaces.

If one key aim of design education is to aid students in gaining synergy between the spaces where they are learning and spaces where they will work as future professionals, the question then arises as to what becomes of the traditional portfolio and its contents, some of which need to, and should remain personal to the emerging designer alone? In a large-scale study which investigated necessary skills sets for practising designers in Australia, Doloswala (2013) notes that "portfolios developed through education and employment [should] represent a demonstration of capabilities, technical skills, knowledge and creativity" (p. 417). Acknowledging the multiple intents of education and employment, this issue is addressed within the research, in particular to guard against "throwing the baby out with the bathwater" and destroying what is fundamental to design disciplines and quality design education. What therefore is the difference between the erstwhile traditional portfolio, and any future-focused output? What might a portfolio of a future-focused design graduate look like and encompass? To set the scene for asking and answering these questions, discussion now moves to the specific context and rationale for this research.

2.3 Research context

In 2019 a new undergraduate curriculum commenced in the School of Design at QUT across seven disciplinary areas of study, namely: Architecture; Interior Architecture; Landscape Architecture; Fashion; Industrial Design; Interaction Design and Visual Communication. Whilst some readers may interpret these as belonging to a wider defined group of disciplines, for example, also including the Built Environment (as in Savage, Davis & Miller, 2010), for the purposes of this research, it is this set of disciplines to which the term 'design' refers. This does not negate the fact that the research findings may be equally applied to other allied disciplines and professions, such as Engineering, Urban Planning, Law and Business, four areas with which the Bachelor of Design, recognising changing employer needs, now offers a suite of double degree options.

As with its previous iteration, the new course provides students with innovative studio based and theoretical learning opportunities. However, taking on board the shifting higher education and practice landscape described above, and feedback from both internal (students, staff) external (alumni, employers, practitioners) stakeholders, it has been enhanced through the addition of a series of four transdisciplinary 'Impact Lab' units delivered across all year levels of the undergraduate program. In keeping with institutional strategic imperatives of "real world learning" opportunities underpinning students' educations, the Impact Labs, which sequentially address the themes of place, people, planet and purpose, are a direct pedagogic response to the gap identified in design education of students' application of skills and knowledge to "real problems and contexts". This includes engagement with broader and more open-ended external client briefs, adapting to collaborative workplace practices and working in interdisciplinary teams (Doloswala, 2013, p. 418), areas also identified as lacking in sufficient authentic assessment opportunities (ibid. p. 420). Through the Impact Labs, students from all study areas participate in problem-based, collaborative learning and idea generation alongside community and industry partners.

Implicit in these units is a developmental approach where students have the support and space to fully reflect on and articulate skills gained, scaffolded across the three years of their degree. In a bid to ensure authenticity of learning outcomes and assessment, there is an explicit focus on students building networks and individual narratives of "impact" as designers, as well as each student developing a Graduate Professional Portfolio as an assessable learning outcome. As discussed above, this is an overt attempt to offer an opportunity to develop a future-focused portfolio thus deliberately introducing real-world synergy.

2.4 Formulating the research questions

Whilst the Graduate Professional Portfolio was a purposeful introduction as an entity within the new course due to clear drivers described above, less thought was given in the early stages of course development as to the shape and nature of such an entity. In commencing more rigorous curriculum and learning design, an urgent imperative therefore arose for deeper consideration of how it might be seen to function and interact across the whole course. Specifically, research questions included:

1. What is the current status of and thinking around portfolios in design education?
2. What is the role and nature of a Graduate Professional Portfolio in the Bachelor of Design degree?
3. How might this work where the portfolios are being developed from within a transdisciplinary space, whilst discipline-focused portfolios (e.g. for an architect or fashion designer) are simultaneously arising from design studio work?
4. Might they be one and the same thing where connectivity with discipline-specific requirements of a portfolio are also honoured?

On deeper reflection, readers may also note the implied expectations and complexities within the words "graduate", "professional" and "portfolio" which intimate moving beyond notions of a simple "portfolio". This knotty problem brought impetus and weight to the case for undertaking a detailed piece of research. The section following outlines the research approach taken to address these questions.

3. Research approach

3.1 Curriculum development as action research

This work has been undertaken using an action research approach to curriculum development. Researchers note the suitability of this mode of research in situations where a change or implementation is desired (O'Leary, 2010; Cohen, Manion & Morrison, 2011). In keeping with definitions of action research (ibid.), this research was grounded in the practical situation described above, involved stakeholders as collaborators (students, staff and practicing designers), and had the aim of having a direct impact on professional practice, in this instance, specifically related to the design disciplines. As an "experiential learning approach to change" (O'Leary, 2010, p. 150) the research presented here forms one part of a cyclical process of identifying a problem, collaboratively researching the situation, planning for and undertaking proposed action, evaluating this and reflecting on and preparing for further possible action.

Gibbs et al., (2017) highlight the importance of informed pedagogic practices in higher education and the growth of action research activities to contribute towards this effort (p. 4). Meth et al. (2020) detail this across a range of curriculum development activities at QUT, including in the School of Design, where ensuring a scholarly evidence base to all aspects of curricular development has been essential. In particular, the findings of Robertson (2013) regarding the changing focus of design disciplines and employers' needs of graduates have shaped developmental conversations. Noted as a common oversight in action research taking place within the normal guise of institutional work (Gibbs et al., 2017, p. 9) to bring greater transparency and ensure adherence to standards of ethical research, approval was gained from the institution for this work prior to commencement.

3.2 Co-creation and the student voice

As a significant part of the research approach, acknowledging the proven value of working with student partners in curriculum development (Cook-Sather, Bovill & Felten, 2014, pp. ix-x) where increased rigour and deeper understandings might be gained, it was seen as critical to do so here for co-production of any potential solutions.

Seven student partners were employed from across all design disciplines to undertake primary research data collection and work collaboratively with academics and a learning designer. The productive nature of such a three-way curriculum development relationship has been elaborated upon by Fitzgerald et al. (2019). Additionally, student partners brought their disciplinary expertise and experiences as students who themselves were on the cusp of graduating and developing their own portfolios, as well as a window to fellow student voices school-wide.

3.3 Research methods

As part of an action research cycle in progress, and drawing on the main research questions above, research data were gathered through:

- desk-based literature and web-based searches
- informal conversations between design academic staff, students and their peers
- semi-formal interviews with design practitioners and employers of designers.

The main method for considering and analysing the data, was through a series of intensive co-production workshops, where academic collaborators, student partners and a learning designer brought together shared knowledges in order to progressively develop and propose a workable model of a feasible way forwards. This needed to be appropriate to the contexts of all seven discipline areas in the degree.

At the outset of the work, and to better situate solutions proposed, part of early conversations centred around defining intrinsic designerly capabilities, those less tangible aspects which in addition to "harder" design skills and knowledge one would expect graduates of design to possess. Unsurprisingly, many of these are not dissimilar to themes presented in this paper. This offers a potential topic for deeper exploration elsewhere, and is set to one side for the purposes of this paper, where the focus is the design portfolio.

4. Results

Data from the literature review on current thinking related to portfolios in higher education has been presented within the Background and Context section above, and mirrors closely the views gleaned from conversations with students and practitioners. Results discussed here relate to the latter questions posed on what constitutes a Graduate Professional Portfolio and how might it be seen to work in a design degree. These have been clustered within a suite of points which highlight what the authors believe to be the dominant findings.

4.1 For truly authentic learning and assessment, there cannot be a single prescribed portfolio format for design students – an online element is crucial.

In striving for unanimity on a portfolio platform to use within the Impact Labs across all seven disciplines, one key set of research data collected was on the range of ways in which designers present portfolios. Table 1 below presents the findings from this exercise. Readers should note that this list is merely representative rather than exhaustive.

Table 1 Preferred forms and digital platforms for capturing, storing and showcasing design work across design disciplines included in the study.

Disciplinary area	Output form or digital platform	Comments
Architecture	Physical and pdf portfolio of work + digital presence (Instagram/Behance)	Whilst mixed messages were received on portfolio modes, the architecture disciplines were unanimous in the need for physical (paper) portfolios of work.
Landscape Architecture	Physical print + digital presence (website/Instagram/LinkedIn)	
Interior Architecture	Physical and pdf portfolio of work + digital presence (Instagram/Behance)	
Fashion	Physical print + digital (website/ Instagram)	Website often includes an online shop component; Instagram follows designers' process and evolution of work; print as a physical "lookbook"
Industrial Design	Website/Instagram/LinkedIn	Something to compete in market; Instagram is used for styling and aesthetic appeal; most have LinkedIn as well for connections
Interaction Design	Predominantly digital: interactive pdfs/ website/Behance/LinkedIn	Behance utilised to house portfolio; LinkedIn holds profile and connections
Visual Communication	Physical print with visual diaries + Digital (Instagram/ Behance/ LinkedIn/Wix/Squarespace)	No set template as output is part of your professional image. Behance as bare minimum

Findings above evidence that the seven disciplinary design areas already have ways of constructing portfolios and personal profiles. Furthermore, there was little unanimity across the seven design-related disciplines on a single mode of portfolio, and also a question of potential duplication and cross-purposes by the Impact Lab units, potentially in direct conflict with the disciplines.

Given the results gathered, if truly striving for authenticity, the question was then posed as to why then we might seek to impose any rigid portfolio structure on students as emerging design professionals? Considering synergy between design students and the world of work, the point was made that different pieces of work and angles would be needed for different audiences i.e. portfolios should be audience and employer specific.

It was clear from the exercise undertaken that no definitive format should exist for designer portfolios and that there could therefore be no singular model for a Graduate Professional Portfolio. Background research undertaken on the PebblePad and Mahara online portfolio systems and a fairly restrictive bespoke institutional portfolio platform deemed them unsuitable for the purposes required. Hallam and Creagh (2010) note that moving beyond institutionally-specified and often institutionally owned e-portfolio products which may be restrictive, Web 2.0 developments have allowed for portfolio models which bring "dynamic and unguided" innovative spaces, often user-owned and with a higher chance of stakeholder engagement, as well as opportunities for social networking and collaboration (p. 189).

These were difficult messages for the curriculum development team to hear since it had been assumed during course design that a single solution for a portfolio model would be defined. What was evident was the ongoing need for designers to be able to draw on a combination of portfolio outputs, and Baron (2009) endorses this view, noting that they may be in both digital and analogue modes as findings have suggested.

A solution to this conundrum came through the in-depth examination of what each of the platforms had to offer, as well as discussion on what the foundation needed to be for all forms of evidence offered in these various formats. The concept of a "universal archive" was thus developed, which should have the capacity to target and draw from content and sections as required for specific audiences, be it for course assessment, a job application or collaboration with other designers. The space should also have the ability to keep reflections and process information private to the individual owner, should they wish to do so.

4.2 A "universal archive" is needed to capture the multiple elements that will be needed for portfolios in action.

The research team decided on Behance (behance.net), part of the Adobe Creative Cloud suite of applications as a universal archive space which offers the most flexibility for being able to do this. In addition to being an online space which is easy to use and free to access, Behance offers a way to foster many of the future-focused skills asked of designers, but with capacity for staying true to the Impact Lab educational model developed, including:

- offering privacy settings so that projects and sub-spaces may remain private to users as desired, fulfilling the need to also be a developmental tool;
- being owned by the student in perpetuity and fulfilling the skills need related to sustaining lifelong learning and ongoing professional and personal development;
- providing a holistic space where work and reflections from any curricular or extra-curricular, and work activities may be captured;
- allowing users to submit work in teams, fulfilling the need for collaborative online spaces;
- allows other users to "like" your work, offering interaction and verification
- providing links to employment opportunities, as employers scout these sites; and
- having the capacity for users to link their account to other social media platforms,

> connecting designers' profiles worldwide - it is socially connected and networked and therefore a good way for students to form networks, access workplaces and bring the synergy desired to their educational experiences.

These additional features which bring flexibility and are easy to use, have been noted by Chaudhuri (2017) as key to platforms where lifelong learning and individual ownership thereof are desired (p. 16).

Looking within the universal archive, research revealed a common core of elements that should be present. These are not dissimilar to those components noted by Doloswala (2013) of capabilities, technical skills, knowledge and creativity (p.417), but also stretch to those aspects listed in Crowther (2012) where one's creative process and design products are present, with additional opportunities to house self-assessments and promote self-understanding through reflective pieces. One additional theme that emerged strongly from the research as an important element of the portfolio which partially fits the theme of creativity, is the need for a portfolio to also reflect a designers' individuality and for students to establish their own personal branding through profiles and position statements as well as their chosen "look and feel". This chimes well with employer messages received.

Some elements may remain personal and hidden from view whilst others may be formative or summative pieces open to specific audiences for specific purposes e.g. assessment or external profile raising. Within such a conceptual model, potential tensions with disciplinary area portfolios are resolved, as any and all digital content may also be housed in the Behance archive, and merely deployed appropriately to specific units of study at specific times, or link out to content stored elsewhere.

Related to the topic of linking out, and networked graduates, whilst student partners initially scoffed at the notion of LinkedIn (linkedin.com) as a social media platform, they all admitted to having live LinkedIn professional profiles. There was general agreement across views gathered, that whilst LinkedIn was not a space for showcasing design work, it was a key way for creating networks, being found, and linking out to other spaces where one's work might be. It was therefore deemed to be a useful tool when coupled with Behance.

4.3 Students should form good archival habits from the outset of their degree, with multiple opportunities given to evidence their professional capabilities, and the agility to navigate these.

The point was made that students need to be guided through the process of developing their portfolios in order for it to become habit-forming for them as emerging professionals. This requires support, clear learning expectations, and learning outcomes aligned with assessments within Impact Labs and other design units across the life of the degree. Additionally, as lifelong learners who are self-managed, students should seek to sustain such a living space in an ongoing way where they are able to show how their design processes and work have evolved over time.

Recognising the volume of work they will ultimately collect, to guard against feeling overwhelmed by content in the archival space, Baron (2009), broaching the issue of the ‘multiple portfolio’ problem describes the following concepts which help to manage the content and deploy it appropriately: “duplicating, dispersing, dividing, doubling and developing.” These key concepts encapsulate well the notions surfaced by this research that students will need to be able to easily create and showcase new portfolios and bodies of work in multiple ways, drawing on a central archive of their work. Upon reaching the final Impact Lab related to “purpose”, design students should then be able to extract and tailor a set of different portfolios for different employment opportunities identified, and potentially as a range of outputs (digital and physical). This employer-focused output is the final professional-oriented portfolio category listed by Cabau (2017) and discussed earlier. By this stage, students have worked through portfolios as developmental tools for learning, reflection and assessment, and the balance of purpose shifts outwards beyond the university.

5. Discussion and conclusion

This research has presented a new, transferable model for consideration in the use of portfolios by design educators. Recognising the diversity of requirements now asked of portfolios in design (no longer a folder of drawings only), the authors believe that there cannot be one type of Graduate Professional Portfolio. Rather, this is a conceptual entity that describes a living, evolving and multifaceted archival space, preferably linked to other online spaces from which selected portfolios, or portfolio elements may be drawn. To return to the complex expectations inferred in the concept, “Graduate” denotes something that students have when they leave university, “Professional” is in the sense that it provides a direct link to their chosen professional network/s following graduation, and “Portfolio” is because it encapsulates all possible requirements that may be asked of any portfolio at different stages of their careers and for different audiences.

> “Preparing young people for the new future of work is an issue of national importance” (FYA, 2015, p. 3)

Behance has been selected following in depth research of requirements specific to one context, and we propose that whilst in this instance it has been deemed to be most appropriate, in other contexts this may be less about using the same platform, and more about the concept itself. It may also be the case that students schooled in habit-forming archiving of their collective works are themselves able to move away from the Behance platform as appropriate.

5.1 Additional considerations

It should not be assumed that all students wish, or are ready to face the “real world” by opening their portfolios for scrutiny. Orr and Shreeve (2018) note the critical role that art and design schools must play in combining educational and professional spaces, where they might “offer protection from the world whilst at the same time preparing students to be part of the world” (p. 44). Achieving synergy may be a slower process for some, or even achieved by different means. So whilst evidence points to the need for designers to have some online presence, in the undergraduate learning environment, it is not possible or appropriate to force students to have online profiles and participate in sites with social networking elements. There are privacy options in Behance, but alternatives need to be offered to students who wish to retain their privacy from online spaces, for example to develop an anonymous ‘persona’ which can be deleted later, or submit pdf versions of similar content. The former was offered as an option to all students in the course. Quality assurance implications of hosting student work in spaces not owned by the university also need ongoing consideration. It is suggested that issues such as ownership, be that intellectual property with external partners or students’ individual versus group work, are fully considered within the design and typical quality management processes of the course and encompassing units of study.

Another important point arising from research discussions is that the journey as an emerging design professional starts when students join the university. It is the case for some design disciplines such as Landscape Architecture, that many undergraduate students are already employed in professional practices across the city well before they graduate. This necessitates early considerations of this area within design education, not as a single-touch experience which may be easily forgotten but as a developmental process which should commence at the start of students’ studies and threaded across the degree.

5.2 Concluding points

This work has introduced new data to an area with which most universities are currently grappling (Chaudhuri & Cabau, 2017), forging new ground in both design education and online portfolios, with the potential to shift sector-wide thinking on these aspects.

2019 has seen the implementation of this portfolio model to over 600 students at a first year level, working in interdisciplinary teams across all seven disciplines on authentic design problems together with community and industry partners. In acknowledgement of new ground successfully forged, the work has recently received a Vice-Chancellor’s Award for Excellence in the Contribution to Student Learning and Research.

In keeping with the cyclical nature of action research, future work will focus on connectivity between design discipline areas and their use of portfolios, capturing and evaluating student and staff feedback on the implementation of this concept as the degree is progressively rolled out, and as part of this, examining the changing nature and focus of students’ portfolio spaces as they progress through their degrees.

Acknowledgements: The authors with to thank: student partners for course design who undertook background research and were integral to conversations in developing this model: Eleni Fuller-Weimar, Osman Garelnabi, Steven O’Hanlon-Rose, Kiara Quig, April Steedman, Sean Wanna, Emma Wright; other stakeholders who engaged willingly in conversations, including academics, practitioners and employers.

6. References

Ashford-Rowe, K., Herrington, J., & Brown, C. (2014). Establishing the critical elements that determine authentic assessment. *Assessment & Evaluation in Higher Education*, 39(2), 205-222. https://doi.org/10.1080/02602938.2013.819566

Ashwin, P., Boud, D., Coate, K., Hallett, F., Keane, E., Krause, K., … & Tooher, M. (2015). *Reflective teaching in higher education*. London, England: Bloomsbury Academic.

Baron, C. (2009). *Designing a Digital Portfolio (2nd edition).* Berkeley, California: New Riders.

Cabau, B. (2017). E-portfolio as a tool to respond higher education ambitions and societal expectations. In T. Chaudhuri, & B. Cabau (Eds.), *E-Portfolios in Higher Education: A Multidisciplinary Approach* (pp. 21-34). Singapore: Springer Nature. https://doi.org/10.1007/978-981-10-3803-7_10

Chaudhuri, T. (2017). (De)Constructing student e-portfolios in five questions: experiences from a community of practice. In: T. Chaudhuri, & B. Cabau (Eds.), *E-Portfolios in Higher Education: A Multidisciplinary Approach* (pp. 3-20). Singapore: Springer Nature. https://doi.org/10.1007/978-981-10-3803-7_10

Chaudhuri, T. and Cabau, B. (Eds.), *E-Portfolios in Higher Education: A Multidisciplinary Approach*. Singapore: Springer Nature. https://doi.org/10.1007/978-981-10-3803-7_10

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education (7th edition)*. Abingdon, England: Routledge.

Cook-Sather, A., Bovill, C., & Felten, P. (2014). *Engaging students as partners in learning and teaching*. San Francisco, California: Jossey-Bass.

Crowther, P. (2012). Portfolio review. In: H. H. Askland, M. J. Ostwald, & A. Williams (Eds). *Assessing Creativity: Supporting Learning in Architecture and Design* (pp. 229-240). Sydney, Australia: Australian Government Office for Learning and Teaching (OLT).

Doloswala, K.N., Thompson, D., & Toner, P. (2013). Digital based media design: the innovative contribution of design graduates from vocational and higher education sectors. *International Journal of Technology and Design Education*, 23, 409-423. https://doi.org/10.1007/s10798-011-9186-0

Fitzgerald, F., Huijser, H., Meth, D., & Neilan, K. (2019). Student-staff partnerships in academic development: The course design studio as a model for sustainable course-wide impact. *International Journal for Academic Development.* https://doi.org/10.1080/1360144X.2019.1631170

Foundation for Young Australians (FYA) (2015). *The new work order: Ensuring young Australians have skills and experience for the jobs of the future, not the past*. https://www.fya.org.au/report/new-work-order/ (Accessed 15 December 2019).

Gibbs, P., Cartney, P., Wilkinson, K., Parkinson, J., Cunningham, S., James-Reynolds, C., … & Pitt, A. (2017). Literature review on the use of action research in higher education. *Educational Action Research*, 25(1), 3-22. https://doi.org/10.1080/09650792.2015.1124046

Hallam, G., & Creagh, T. (2010). E-portfolio use by university students in Australia: A review of the Australian e-portfolio project. *Higher Education Research & Development*, 29(2), 179–193.

Jones, E. (2010). A professional practice portfolio for quality learning. *Higher Education Quarterly*, 64(3), 292–312.

Mackh, B.N. (2018). *Higher Education by design: best practices for curricular planning and instruction*. New York: Routledge.

Meth, D., Russell, H. R., Fitzgerald, R., & Huijser, H. (2020). Enabling scholarship of teaching and learning activities across a curriculum design framework: a lever for faculty engagement. In R. Plews, & M. Amos (Eds.), *Evidence-Based Faculty Development Through the Scholarship of Teaching and Learning (SoTL)* (pp. 347-364). Hershey, PA: IGI Global. doi:10.4018/978-1-7998-2212-7.ch018

O'Leary, Z. (2010). *The essential guide to doing your research project*. London, England: Sage.

Orr, S., & Shreeve, A. (2018). *Art and design pedagogy in higher education: knowledge, values and ambiguity in the creative curriculum*. Abingdon, England: Routledge.

Pegrum, M. (2017). Promoting diversity through e-portfolios. In: T.Chaudhuri & B.Cabau (Eds.) *E-Portfolios in Higher Education: A Multidisciplinary Approach*. Singapore: Springer Nature, pp. v-viii . https://doi.org/10.1007/978-981-10-3803-7_10

Pegrum, M., & Oakley, G. (2017). The changing landscape of e-portfolios: reflections on 5 years of implmenting e-portfolios in pre-service teacher education. In: T. Chaudhuri & B. Cabau (Eds.) *E-Portfolios in Higher Education: A Multidisciplinary Approach* (pp.21-34). Singapore: Springer Nature. https://doi.org/10.1007/978-981-10-3803-7_10

Robertson, D. (2013). *Australian design 2013: Issues and concerns in the design professions.* Melbourne, Australia: Design Institute of Australia PN034 (Issue B). https://www.design.org.au/documents/item/127 (Accessed 17 July, 2019).

Savage, S.M., Davis, R.M., & Miller, E. (2010) Professional education in built environment and design. Sydney: Australian Learning and Teaching Council. https://eprints.qut.edu.au/31328/ (Accessed 13 November, 2019).

About the Authors:

Deanna Meth (PFHEA, Senior Lecturer, Curriculum & Learning Design) has experience leading strategic projects and research spanning higher education policy, curriculum development and student engagement. Her current work focuses on developing digitally-enabled transdisciplinary, authentic curricula in Creative Industries disciplines.

Melanie Finger (QUT lecturer Transdisciplinary Design) has a key role in the School of Design connecting academia with industry, creating job opportunities and fostering long-term partnerships. Working with student partners she develops design curricula, pioneering online portfolio development in the School of Design.

Dean Brough (QUT Academic Director Design) has a wealth of experience in design practice and tertiary education contexts. His creative practice has been exhibited at numerous prestigious design venues both nationally and internationally receiving a *Design Institute of Australia* award.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Exploring transdisciplinary learning and lifelong training in visual communication design education

Jesvin Puay-Hwa YEO[a]*, Chua-Tee TEO[a]

[a] Nanyang Technological University, Singapore
*Corresponding author e-mail: jesvinyeo@ntu.edu.sg
doi: https://doi.org/10.21606/drs.2020.143

Abstract: The paper seeks to discuss how visual communication design education could be improved by incorporating transdisciplinary learning within design curriculum and providing lifelong training to professional designers and design educators. A review of literature indicates that design education needs to be adapted to allow future designers to solve the gradually complex design problems and work in non-design industries. In fact, design education needs to extend design knowledge to non-design disciplines to enable more people to generate innovation to work-related problems. On this basis, it is recommended that design education should offer graphic designers the opportunity to master skills and knowledge of other disciplines, such as marketing and technology. New design courses should be formulated to meet the unique requirements of teaching applied design in a wider context and for broader audiences. Further research is needed to identify other factors that could strengthen the integration of design skills with non-design knowledge.

Keywords: visual communication design; transdisciplinary learning; lifelong training; design education

1. Introduction

With increasing numbers of students opting for art and design programmes, art and design faculties in universities have expanded rapidly with a growing number of both graduate and postgraduate programmes in the last decade (Denicolo et al., 2010; Staley & Trinkle, 2011). Accordingly, design education has moved beyond the teaching of practical design skills towards equipping students with exploration skills that enable them to instigate relevant design issues and examine research related to their personal formative practices as creative individuals (Yeo et al., 2017).

This shift from vocational skills training to an emphasis on research being integral to courses has indicated a transformation in design in higher education. In visual communication design education, design practices are becoming more reflective and multidisciplinary. Designers no longer simply visualise or apply their creativity, but are involved with, or even lead a team to identify and solve more significant challenges that cannot be addressed by designers alone (Sanders & Stappers, 2012). Therefore, besides providing future designers with space "to ask more of the right questions, [they need to] come up with better hypotheses [and] design effective experiments" (Brown, 2012, p. 20) to solve the gradually complex design problems in the world. How can design education be advanced to meet the demands of the ever-evolving industry? Can transdisciplinary learning be cultivated and lifelong training be promoted in this way?

Grounded on Friedman's (2002, 2003) thorough elucidation of the historical development and challenges of designing the university-level design curriculum, this paper seeks to fill the gaps in the literature by exploring transdisciplinary learning and lifelong training as ways to meet the demands of the ever-evolving industry. However, due to the high complexity of curriculum planning, this paper does not intend to provide a definitive evaluation of the concept but to discuss potential ways of adaptation.

2. Overview of undergraduate education in visual communication

2.1 What is visual communication design?

Visual communication design has been subjected to various definitions and interpretations and has often been used interchangeably with graphic design and graphic communication. McCoy (1998) described visual communication design as a spontaneous reaction to the growing needs of commercial communication during the industrial revolution. Technological advancement changes visual communication design in tandem. It broadly encompasses art and design, with specialities ranging from editorial design, packaging design and branding design to motion graphics and digital design. Visual communication design, made up of two components of design process and the creative output, is about creating meaning and expression that will be broadcasted to the public (Swanson, 1998). To graphic professionals, the objective of visual communication design is to create meaningful imagery through a variety of visual technologies and to either communicate ideas and messages or to persuade and entertain the audiences (Meggs, 2005).

2.2 Origins of undergraduate education in visual communication design

The term visual communication design was unheard-of at the turn of the twentieth century and was born out of commercial urgency and needs. Thus, much of the knowledge and skills pertaining to its domain were gathered through trial and error or by on-the-job training (Siu, 2009). Intuition and common sense were often the tools of the field, used in assessing and grading design works. It was also called upon to solve communication problems, in connecting businesses with customers using messages and images (McCoy, 1998). In the 1920s, the Bauhaus school of thought—its foundation of which still models most undergraduate design programs—spawned a revolutionary approach to design education. This model focused “on abstraction and experimentation, and the rejection of accepted traditional formulas” (McCoy, 1998, p. 5). Subsequently, practitioners and students tended to reference published solutions found in graphic design periodicals, magazines and competition annuals, as points of departure that lauded examples of creativity and flashes of intuition, which all apparently captured the Big Idea of the times. In the creative industry, Big Idea means “fresh and provoking ideas that hold a viewer’s attention” (Engel, 2010) of which, however, there is no mode or formula to it. As McCoy insightfully framed, “the Big Idea’s reliance on personal intuition and creativity makes it difficult to formalise a codified educational method; just as educational success is limited to the level of brilliance in both teacher and student” (p. 6).

Presently, most conventional undergraduate programs still do train their students within scopes of practical design fundamentals, leaving graduate and postgraduate programs to fill the niche of providing the much-needed in-depth theory and research. This has been long observed by McCoy (1998), who noted that many students have graduated with advanced typography and computer skills, while they are not usually educated with lifelong, self-directed learning. However, changing taxonomies have since been generating demands for graphic designers to come equipped with cognitive theories and perceptual processes (Winn, 2002a), and to create creative outputs that are relevant and engaging. Winn (2002b) interestingly noted that conventional training is insufficient for today’s multifaceted education. Design education as such should move beyond vocational training and towards ‘intellectual pursuit’ requiring ‘philosophical fluency’ (Heller, 2006) and that it should be a journey that transcends disciplinary boundaries to develop innovative invention and explore regeneration further (Blevis et al., 2015). This appropriately garners current attention to changes in undergraduate education in visual communication.

2.3 The changing face of undergraduate education in visual communication design

Friedman (2003) stated that the evolution of design education was “a consequence of the new needs and demands of the nascent knowledge economy” (p. 244) and any knowledge-based economy values the focus on ideas and innovation (Brown et al., 2010). Commercially driven design outcomes may be fine but these are not always sustainable, as the industry will have moved beyond recognising the familiar, to constant innovations based on design and creative explorations (Liedtka et al., 2013). Designers have to become professionals who are competent to provide solutions to complex issues of today’s world (Friedman, 2003). The thrust of visual communication education is, therefore, to raise the professional stature of graphic designers from the vocation of “commercial artist” by incorporating “hybrid concepts harvested from literature, sociology, and even architecture” (Heller, 2006, p. 10). We have to better prepare students for a greater challenging creative field as the industry will continue to evolve in terms of business developments and strategies, and designers will have to become more responsive than before to contribute to innovation (The Partnership for 21st Century Skills, 2015).

Previously, how a graphic designer created a project might best be described as enigmatic. The renowned graphic designer Stefan Sagmeister's design process was thus described cryptically, as first identifying the design issues, encompassing the topic to seize its secret, then breaking, reforming and returning the secret in a visual form (Moore, 2007). This arcane description fails any potentially useful classroom or studio reinterpretation. For current design practices in visual communication to be helpful, it could be defined in a six-step procedure: 1. identifying and defining the project's objectives; 2. exploring concepts fully; 3. refining feasible concepts in details; 4. executing and modelling of the concepts; 5. communicating the finished design to clients; and 6. final refinement and production (Aspelund, 2015). From an educational perspective, this structured design process would be particularly suited to a knowledge-based economy. Structured design processes provide methodical and critical steps in creative developments that would produce unique concepts. In contrast, formal design processes are client-centred, and outcome-focused, involving merely visual decorations of client's messages (Forlizzi & Lebbon, 2006).

Practical theories and principles involving colour, perception, and symbolism taught in design schools provide useful foundations upon which critical design methodologies can be built. Circumstantially, when any emphasis of design aesthetics outweighs the expression of meaningful visual communication, a student may tend towards mere graphical adorning of information, instead of cultivating potentials to instigate social change. A later movement significant in enforcing the professional standing of design recognised the authorship of exemplary designers in producing creative works, that went beyond the client's brief. This might likely propel the same potential conditions universally, as would the education of a graphic designer be changed from "a decorator of messages to an agent of influence on the social implications of delivering a visual dialogue" (Forlizzi & Lebbon, 2006, p. 52).

3. The need for change in visual communication education

The above sections provide an overview of visual communication design, the origin and development of visual communication education. Detailed inquiries into the design process can include the participatory, contextual, and other subsets of user-centred design (Bennett, 2006). The broader adoption of user-oriented solutions and new approaches towards problem-solving in graphic design have become increasingly prevalent in the field of visual communication (e.g. Frascara & Noël, 2012; Norman, 2004; Sanders & Chan; 2007). Fresh perspectives particular to graphic design also affect the design processes. Current trends in the field of visual communication draw from the social and ethical liabilities of designers, designing for cross-cultural contexts, and human-centred design, which all prioritise the people they design for, as primary intent to the design process. The quality of the creative output largely depends on the particular attributes of the design processes undertaken. The discipline of design might emerge to become the quintessential 21st-century profession, an essential form-giving that creates meanings, a synthesis of art, technology, and a blending of social sciences. Educational perspectives have to be reformed, as 21st-century designers need more than design skills to succeed in this ever-changing landscape.

3.1 Transdisciplinary learning

In the knowledge-based economy, designers with transdisciplinary, or interdisciplinary, skill sets are much needed in the future. In fact, the role of the designer has transcended the stage of mere brainstorming of ideas for a brand, product and/or service to create strategic edges to transforming systems, experiences and organisations (DesignSingapore Council, 2019). Furthermore, designers have been invited to be involved with other businesses to identify more significant challenges and produce more meaningful solutions that cannot be addressed by designers or executives alone (Sanders & Stappers, 2012). Along with the same notion, Norman (2010) stated that designers need to learn from and collaborate with likeminded statisticians to develop new and appropriate methods (p. 4). Therefore, it is inevitable to cultivate transdisciplinary learning within design education, and the following presents three plausible ways:

Expanding the knowledge boundaries

Riding the light wave of technology, many businesses have moved their operations online. For example, in the current banking environment customers can pay their bills online or engage with an operator virtually in 24-hours banking services. In fact, the healthcare industry has tapped on design knowledge for unique creative approaches to meet their goals of “increasing patient engagement; strengthening doctor-patient relations; and changing patients’ behaviour” (FuseLab Creative UI/UX Design agency, 2017). Therefore, as suggested by Friedman (2003), besides “preserving existing knowledge” through providing extensive training in design disciplines, design education should “create new knowledge” by equipping students with knowledge in non-design disciplines, including marketing, medicine and technology, as this would provide a space for the students to develop and explore novel and useful solutions based on their interdisciplinary experiences. Visual communication design, as a practical discipline, often produces tacit knowledge. With the combination of knowledge from other disciplines, the thought process may allow students to uncover unpredicted outcome in the middle of a design inquiry, become aware of it, analyse its effect and respond by making changes to their design process. For instance, Rust and colleagues (2007) stated that the integration of tacit and research skills allowed designers to contribute knowledge to both the design and the natural sciences. Also, designers are known to discover new ideas by linking various understanding together, as well as dealing with known and newly discovered variables and limitations through designing (Schön, 1987). The study of Singh and colleagues (2018) that invited design educators to envision futures of design education has demonstrated that future curricula will integrate ways of learning and knowing that develop from multiple disciplines. The possessing of new knowledge and combining with essential design knowledge will allow future designers to work in other non-design industries. It appears that the discipline of design can become more helpful in advancing economies around the world.

Developing design-led thinking for the future economy

To further promote transdisciplinary platforms, design education should reform their curriculum by not just including transdisciplinary learning but also enrol non-design students. According to the British Design Council (2018), around 2.5 million working people use design skills in their day-to-day tasks. In addition, average workers with design skills seem more valuable compared with workers without these skills because apparently design skills can help workers to drive higher productivity, generating innovation to work-related problems through creative thinking and problem-solving skills (Design Council, 2018). However, this may post challenges for design educators as we may already have a difficult time teaching our Millennial design students (Kincade, 2019). Yet the modern way of design has changed and gone beyond the discipline of design, and we, design educators must be more open-minded than before. So instead of offering existing courses to both design and non-design students, new design courses must be tailored to meet the unique requirements of teaching applied design in a wider context and for broader audiences (Norman, 2010).

Extending the scope of the internship

Besides, reforming the skills curriculum framework for design must be aligned with the needs of the future economy. Transdisciplinary learning can also be cultivated through real-life experiences. Currently, a high percentage of design students serve as interns in the design- and creative-related industries. These exposures have introduced students to advance design practices and allowed them to build networks with industry practitioners and future employers (Kolko, 2005). However, to better contribute to today's globalised societies, as affirmed by Norman (2010), new kinds of designers are needed, in particular, one who can work across specialities and understand human needs, business, and technology. Design education can strengthen their industry-higher education relationship by encouraging design students to do their internship in other industries. For instance, design student Stenlund (2018) mentions that she has gained valuable work experience through interning at Laerdal Global Health. Besides having the opportunity to apply her design skills to real work experiences, she was introduced to more holistic and systemic thinking where patients were the centre of designing. Experience as such can play a critical part in design practices, as it empowers students to answer the question of 'How can design contribute to the society and how does it relate?' particularly with regards to the relationship between design practice and contextual learning in society. Correspondingly, people in non-design fields could be educated and exposed to the value of design when design students participate in internship in these non-design industries.

3.2 Promoting lifelong training in design

To contribute holistically to the knowledge economy, current professional visual communication designers need to be upskilled to meet the demand and transformation of the industry. As stated by Davis (2008), traditional knowledge in design has its limitations and must be reconsidered in this rapidly changing environment. Also, designers who have worked for more than five years may find themselves in a senior role where they are needed for management, communication and problem-solving in order to perform their tasks more satisfactorily. According to the study by Dziobczenski and Person (2017), which investigated the required skill set of graphic designers through the analysis of 1,406 job advertisements from the United Kingdom, graphic designers are required to lead, manage, and organise design and development processes. The associate skill set included "client relationship skills" and "interpersonal (teamwork) skills" where designers have to communicate and work as a team member with internal and external associates. Also, to effectively present their ideas and handle multiple projects and deadlines, "proficient presentation and communication skills" and "project planning and administration skills" are must-have skills for graphic designers. In addition to the skills mentioned above, senior graphic designers will require "team management skills" to lead projects and coach junior team members.

In both aspects, therefore, design education should provide continuing training for design professionals. Additional to advanced design skills such as must-know knowledge of the principles of digital typography and user experience (UX) design, other relevant courses, including problem-solving, strategic, analytical and communication skills, should be offered to allow designers to think expansively and to provide solutions from different perspectives. For example, Chow and Jonas (2008) propagated the use of integrated knowledge and communication platform, such as creating an interface that combined design and processes of analysis, projection and synthesis, to produce innovative artefacts and new knowledge.

Also, with the increase of awareness and concern to our environmental and social issues, learning collaborative skills and knowledge of humanities, such as theology, philosophy, ethics, and literature, can allow designers to establish the significance of human expression and to classify, map and observe the origination of concepts, human, things and occurrences (Archer, 1995, p. 8). Brown (2012) remarked that traditional design processes needed to be changed to solve the gradually complex design problems in the world. Design education can incorporate collaborative projects that address societal and contextual values in newly designed upskilling courses. This would help to strengthen social values that can be conveyed through designs, to encourage reflection on human experiences and to make value judgments of worth (e.g. Frascara & Noël, 2012; Sanders & Stappers; 2012), as well as to engage with others who are more experienced in particular subject matters, while identifying the needs of target audiences or broadening their understanding of the norms, values and practices related to the social issues identified (e.g. Bennett, 2006; Brown, 2009; Caruso & Frankel, 2010; Chick, 2012; Norman, 2004).

For a more sustainable system, design education must also look inward to promote lifelong training as design faulty has to upgrade consistently to impart knowledge that is relevant to the future economy (Steinert, 2017). Friedman (2003, p. 246) pointed out that "few design teachers genuinely represent [the] design profession" as they do not have active careers in the industry. Therefore, allowing design faculties to go on a temporary placement in the industry as a designer may enable them to relearn how to engage effectively and holistically with others. They would then be able to negotiate desirable and meaningful outcomes in the design enterprise and thus make relevant contributions to the context of society.

4. Conclusion

It has been established from the above that integration of various knowledge and upskilling have become critical in design education, for visual communication designers to have an edge on others in the competitive industries. "Design is changing as a professional field and a discipline" (Friedman, 2002, p. 53), and the economy of the future is complex and offers more challenging problems than ever. Yet, this calls for an opportunity for design education not only to serve as a bridge to strengthen the link with the industries, but also to equip future designers with knowledge and skills that transcend disciplines, and more importantly to nurture thinking designers who can lead frontiers of innovation with insightful and relevant transdisciplinary practice. Currently, the paper has conducted an initial review of the educational literature; therefore, the variance and bias of choosing specific ways for advancing design education are inevitable. Future studies may like to engage participants, relevant designers and industries in empirical research to examine whether transdisciplinary or interdisciplinary learning and lifelong training can indeed help to advance design education, as well as to establish ways of how non-design knowledge can be integrated and taught in design related disciplines.

The paper has posited that visual communication design education could be reformed by incorporating transdisciplinary learning within design curriculum and providing lifelong training to both professional designers and design educators, for them to grow as critical, analytical and independent design thinkers. According to Brown (2009), design thinkers are likely to be compassionate and self-learners. Design education, therefore, must provide a platform that allows the students to grow as design thinkers – through mastering skills of marketing, analytical thinking, technology and communication, exploring the boundaries of design knowledge through responsive and collaborative design creations, and consistently acquiring knowledge to upgrade themselves and inquiry about society and the world. As a result, design education can extend its reach in assisting different industries and nurture skilled future designers by broadening their intellectual creativity and innovation.

In conclusion, future visual communication designers should have a broader understanding of economic needs and be able to place people at the centre of creation, as well as be able to use various knowledge wisely to give meaning and purpose to a product, brand and service. Importantly, the design process can become more service oriented in advancing economies universally.

Acknowledgements:
We wish to acknowledge the funding support for this project from the Singapore Ministry of Education Academic Research Fund Tier 1 under Nanyang Technological University.

5. References

Archer, B. (1995). The nature of research. *Co-design: Interdisciplinary Journal of Design*, 6–13.

Aspelund, K. (2015). *The design process*. Fairchild Books.

Bennett, A. (2006). Design studies: Theory and research in graphic design. Princeton Architectural Press.

Brown, T. (2009). *Change by Design: How Design Thinking Transforms Organisations and Inspires Innovation*. Harper Business.

Brown, T. (2012). From Blueprint to Genetic Code. *Rotman Magazine,* Spring, 17–21.

Brown, P., Lauder, H., & Ashton, D. (2010). *Education, globalisation and the knowledge economy*. Institute of Education London.

Blevis, E., Koskinen, I. K., Lee, K., Bodker, S., Chen, L. Lim, Y., Wei, H., and Wakkary, R. (2015). Transdisciplinary Interaction Design in Design Education. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 833–838.

Caruso, C. & Frankel, L. (2010). *Everyday People: Enabling User Expertise in Socially Responsible Design*. Paper presented at the Design Research Society: Design and Complexity. Montreal, Quebec.

Chick, A. (2012). Design for social innovation: emerging principles and approaches. *Iridescent: Icograda Journal of Design Research, 2*(1), 52–61.

Chow, R., and Jonas, W. (2008). Beyond Dualisms in Methodology: An Integrative Design Research Medium "MAPS" and some Reflections. Undisciplined! Design Research Society Conference 2008, Sheffield Hallam University, Sheffield, UK, July 16–19 July, 2008.

Davis, M. (2008). Why do we need doctoral study in design? *International Journal of Design, 2*(3), 71-79.

Denicolo, P., Fuller, M., Berry, D., and Raven, C. (2010). *A review of graduate schools in the UK.* UK Council for Graduate Education.

Design Council. (2018). *Designing a future economy. Developing design skills for productivity and innovation*. Design Council.

DesignSingapore Council. (2019). Charting the Future of Design Education. A Report by the Design Education Review Committee. DesignSingapore Council Pte Ltd.

Dziobczenski, P. R. N., & Person, O. (2017). Graphic designer wanted: A document analysis of the described skill set of graphic designers in job advertisements from the United Kingdom. *International Journal of Design, 11*(2), 41-55.

Engel, D. (2010). Define: Big Idea in Advertising. *The Engel Journal.* Retrieved from http://engeljournal.wordpress.com/2010/01/16/define-big-idea-in-advertising/ (Accessed 15 August 2013).

Forlizzi, J. and Lebbon, C. (2006). From formalism to social significance in communication design. In Bennett, A. (Ed.). (2006). *Design studies: Theory and research in graphic design,* pp. 51–63. Princeton Architectural Press.

Frascara, J., and Noël, G. (2012). What's Missing in Design Education Today? *Literature and Language Journals: Visible Language.* 46(1/2).

Friedman, K. (2002). Design Curriculum Challenges for Today's University. *Proceedings of International CLTAD Conference on Enhancing Curricula: Exploring Effective Curricula Practices in Art, and Communication in Higher Education*, pp. 27–63.

Friedman, K. (2003). Design Education in the University: A Philosophical and Socio-Economic Inquiry (Hot Debate). *Design Philosophy Papers*, 1(5), 243–253

FuseLab Creative UI/UX Design agency. (2017). *The role of graphic designers in the healthcare industry.* https://fuselabcreative.com/the-role-of-graphic-designers-in-the-healthcare-industry/ (Accessed 20 May 2019).

Heller, S. (2006) Better skills through better research. In Bennett, A. (Ed.). (2006). *Design studies: Theory and research in graphic design*, 10–13. Princeton Architectural Press.

Kincade, D. H., Turner, W. D., Solis, O. J., & Dull, E. H. (2019). Assessing Millennials in College-Level Fashion Design Studios: A Study of Evidence-Based Practice. The international journal of Art & design education, 38(1), 47–59.

Kolko, J. (2005). New Techniques in Industrial Design Education. *Proceedings of the 6th International Conference of the European Academy of Design*. Pp. 1–10. http://www.jonkolko.com/writingNewTechniques.php

Liedtka, J., King, A., and Bennett, K. (2013). *Solving Problems with Design Thinking: Ten Stories of What Works.* Columbia University Press.

McCoy, K. (1998). Education in an adolescent profession. In Heller, S. (Ed.). (1998). *The Education of a Graphic Designer*, 3–12. Allworth Press.

Meggs, P. B. (2005). *History of Graphic Design* (4th ed.). Revised by Alston W. Purvis. Wiley.

Moore, D. J. (2007). *Design and the creative process*. Thomson Delmar Learning.

Norman, D. A. (2004). Emotional Design: Why We Love (or Hate) Everyday Things. Basic Books.

Norman, D. (2010). Why design education must change. *Core77 design magazine and resource*, 1–6. Retrieved from http://www.core77.com/blog/columns/why_design_education_must_change_17993.asp

Rust, C., Mottram, J., & Till, J. (2007). *AHRC research review practice-led research in art, design and architecture*. Arts and Humanities Research Council.

Sanders, E.B.N. & Chan P.K. (2007). Emerging trends in design research: Changes over time in the landscape of design research. IASDR07 International Association of Societies of Design Research, The Hong Kong Polytechnic University, Hong Kong, November 12–15, 2007.

Sanders, E.B.N. & Stappers, P. J. (2012). Convivial Toolbox: Generative research for the front end of design. BIS Publishers.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. Jossey-Bass Higher Education Series. Jossey-Bass.

Singh, S., Lotz, N., Sanders, E. B. N. (2018). Envisioning Futures of Design Education: An Exploratory Workshop with Design Educator. *Dialectic*, *2*(1), 15–42.

Siu, K. W. M. (2009). Review on the development of design education in Hong Kong: Need of nurturing problem finding capability of design students. *Educational Research Journal.* 23(2), 179–202.

Staley, D. J., and Trinkle, D. A. (2011). The Changing Landscape of Higher Education. *EDUCAUSE Review.* 46(1), 16–33.

Steinert Y. (2017). Faculty Development: From Program Design and Implementation to Scholarship. *GMS journal for medical education*, *34*(4).

Stenlund, F. I. (2018). *What I learned during my internship year at Laerdal Global Health.* https://fuselabcreative.com/the-role-of-graphic-designers-in-the-healthcare-industry/ (Accessed 20 May 2019).

Swanson, G. (1998). Liberal arts and graphic design: Six cautionary questions. In Heller, S. (Ed.). (1998). *The Education of a Graphic Designer*, 3–12. Allworth Press.

The Partnership for 21st Century Skills. (2009). *P21 Framework Definitions*. Retrieved from http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf (Accessed 20 June 2013).

Winn, W. D. (2002a). The place of perceptual and cognitive theory in the understanding and design of graphics. *Proceedings of IPCC, Crossing Frontiers,* pp. 184–189.

Winn, W. (2002b). Current trends in educational technology research: The study of learning environments. *Educational Psychology Review*. 14(3), 331 – 351.

Yeo, J. P., Koh, C., and Chye, S. (2017). Conceptions of design research: discursive phenomenography in undergraduate visual communication design research. *ITERATIONS Design Research and Practice Review*. 5, 14–21.

About the Authors:

Dr. Jesvin Yeo is Associate Professor at Nanyang Technological University Singapore. Her work explores how design affects societies and how these societies also change the design. She is the author of award-winning art books: “Vanishing crafts” and “Architectural decoration”.

Dr. Chua-Tee Teo is a lecturer at the National Institute of Education Singapore. She has presented keynote speeches at several international conferences, including the International Conference of Korea Social Studies 2009 and the First International Symposium on Creative Education 2005.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

The Practice of Design Innovation in the Academic Context: The Project Portfolio by Brunel Design

Giulia COSCO[a], Vanja GARAJ[a]*

[a] Department of Design, Brunel University London, United Kingdom
*Corresponding author e-mail: vanja.garaj@brunel.ac.uk
doi: https://doi.org/10.21606/drs.2020.243

Abstract: Brunel University London (BUL) provides different design innovation support programmes to businesses by involving its students and academics. This paper describes these programmes, the stakeholders involved in the different types of activities, support provided and generated outcomes. The paper highlights the benefits for all stakeholders, stemming from their participation in the programmes and the collaborations taking place in the academic context. The programmes support the companies of different sizes, with different necessities and requirements. The strong internal connections and awareness between the programmes' staff allows for the companies to be pointed towards the programme that fits their particular needs. Besides the direct benefits to the businesses involved (e.g. development of commercial ideas and capabilities in design), the advantages for the academic community are explained, such as the expansion of the research capacity, education and career development.

Keywords: design practice; design innovation; knowledge exchange; academia–industry

1. Introduction

The impact of design on the UK economy is substantial. Design is the fourth driver of innovation in the UK (NESTA, 2009). In 2016, design generated 7% of the total GVA (Gross Value Added), which is equivalent to £85.2bn. This value was generated from both design and non-design sectors (Design Council, 2018). The recognition and use of design in innovation can accelerate economic growth (Innovate UK, 2015). According to the Design Council (2012), for every £1 invested, it is possible to achieve £20 in revenue. Nevertheless, the financial value is just a part of the overall benefit delivered by design. The intangible values – such as human capital and business strategy – are also highlighted by literature (Vijfeyken, Cools and Nauwelaerts, 2015; Design Council, 2008, 2012; Carlgren, Elmquist and Rauth, 2014). The use of design can overcome its role to create the competitive advantage and become embedded in the fabric of firms (von Stamm, 2004), a crucial competence that influences companies' culture and vision (Borja de Mozota, 2003).

Collaborations between university and businesses involving design are worthwhile opportunities to create new knowledge and generate value, bridging the gap between academic research and business practice and identifying the patterns that vehiculate innovation. The academic context offers several advantages to the creation of design value, capabilities and awareness, fulfilling its mission of creating and disseminating knowledge (Newberg and Dunn, 2003) and contributing to economic growth (Blumenthal, 2003).

The Department of Design (Brunel Design) at Brunel University London manages several programmes involving students, academics and businesses in design activities, which deliver different outputs related to capability building and value creation. This paper analyses the dynamics, stakeholders and motivations of these programmes. The different ways in which design activities are performed mirror the multifaceted expressions and contributions of design as an innovation driver. Identifying the effectiveness of these contributions and the benefits and barriers can help understand the university role in design innovation and how the contribution of the role clarifies the design and innovation relationship.

The purpose of this paper is to provide an overview related to the benefits of design innovation in academia-industry collaboration according to the literature and describe how these benefits are achieved by the design innovation support programmes by Brunel Design.

In the following sections, the literature about design innovation and its benefits in academia-industry collaborations is presented. The ways in which Brunel Design supports design innovation through its programmes are described, along with related project descriptions and case studies and an analysis of their benefits supported by the literature.

The case studies have been selected from a number of completed projects based on their overall impact. The three case study images presented below have been licensed for publication via the appropriate consent form signed by the students who authored the projects.

2. Design Innovation

Despite the emerging evidence of design as an innovation driver (NESTA, 2009; Cooper et al., 2017), the role of design in innovation is a matter of study that still lacks a clear and precise definition (Hernández, Cooper, Tether and Murphy, 2018). Even though evidence of the value carried by design in innovation has been highlighted (Nomen and BDC, 2014; Galindo-Rueda and Millot, 2015), the picture is still not fully clear. According to Hernández et al. (2017), design has quickly grown as an independent discipline and in non-design contexts and measuring methods based on firms' success generated confusing interpretations of design role in innovation. Moreover, the design role in innovation suffered from "spurious assumptions like considering design's ability to contribute to innovation as a given" (p. 692). The effects of innovation are more evident than its causes (Fagerberg, 2005) and according to Cruickshank (2010) innovation studies can lack in design domain because design engages with "aspects of innovation that are not easily quantifiable" (p. 23), despite being a valuable source of approaches and methods for economic and businesses growth.

Many scholars support the role of design in innovation process. According to Freeman (1982), design is crucial to innovation, because it is the domain of creativity. According to the OECD (1982), reported in Walsh et al. (1993, p. 80), design is the "very core of innovation" because it involves imagination. Design is a creative activity, the "central factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange" (Maldonado, 1969; Cited in ICSID, 2008) and the design "effort" that can deliver both radical and incremental innovations (Mutlu and Er, 2003).

The connections between design and innovation are described by the Design Council (2011, 2018) and defined by Cox (2005), considering innovation as "the successful exploitation of new ideas" (p. 2) and design as "the link between creativity and innovation" (Ibid.). Design "turns an invention into a successful innovation", to obtain outcomes that fit with our needs, which are usually different interpretations of an existing innovation (Oakley, 1990). Researches that draw attention to how design delivers innovation in the core design and non-design contexts, such as design-driven innovation (Verganti, 2009) and design thinking (Brown, 2008) help to understand the many ways in which design can contribute to innovation. Visual tools, methods and techniques are the common denominator (Hernandez et al., 2018) that encompass academic research (Verganti, 2006; Brown, 2008), business culture (Borja de Mozota, 2003; von Stamm, 2004), professional skills (Walsh et al. 1993, Hobday et al. 2012) and product's innovative value (Verganti, 2009; Rampino, 2011). Therefore, the interpretation of design as the language of innovation (Hernandez et al., 2017) enriches the former definitions and highlights the ways in which design manifests itself.

The increased interest in embedding design as a driver of innovation has determined the development of many national support programmes (e.g. Designing Demand in the UK, Ulysses in Australia and Better by Design in New Zealand). Studies and design programmes highlighted how the development of design capabilities has several positive effects in firms' culture, delivering both the long- and short-term impact, boosting business growth, generating new ideas and improving firms' innovation capabilities in terms of resources, processes and mindset (Carlgren et al. 2014; Design Council, 2008). The development of design capabilities can be crucial for businesses that want to innovate and the demand of these skills is high (Design Council, 2018).

3. Academia-Industry Knowledge Exchange in Design Innovation

Universities are a suitable context to support research and disseminate design skills and mindset, developing theories and training the future professionals. Collaborations involving universities, students and businesses are valuable opportunities to fill the gap between research, education and practice, providing benefits that would be achievable only through their interaction.

Over the years, academia and industry have built different collaboration types, such as classroom and curriculum activities (e.g. courses and projects), workshops, competitions, employment opportunities, research projects, etc. (Roberts, 2007). Furthermore, the opportunities for academia and students to "bring the real world into the classroom or take the classroom into the real world" can increase connections, research approaches and methodologies (p. 11).

Getting access to real world problems in design context (Hakansson and Holmquist, 2010, Wodehouse and Mendibil, 2013, Evans and Waterwoth, 2004) seems to provide benefits to all stakeholders. However, the benefits depend not only on the type of partnership, but also on the industry and university objectives. They are not natural partners (Lambert, 2003) and their different missions push them away from the significant gains that can be achieved by their collaboration.

The Design Innovation Catalyst proposed by Wrigley (2016), for example, is a framework adopted by Queensland University of Technology, with the purpose of letting the students apply design-led innovation principles in business realities, improving experience, corporate culture and design education and research. Similarly, curricular live design projects conducted in Salford University are described by Evans and Spruce (2005) as opportunities for students to improve their curriculum content, maturity and employment opportunities. Project-based learning, for instance, is a strategy enabling students to deal with real activities and tasks, improving team working skills, problem solving, initiative and project management (Wodehouse and Mendibil, 2013) and according to a survey conducted by Hakansson and Helmquist (2010) the students were more satisfied, appreciating working on real life projects. Other academic programmes, such as InnovationRCA (2019) and Startup@Berkeley (2019), offer support for students and alumni that have design-led ideas, providing entrepreneurial coaching and funds to commercialise and manage a business.

Scholars indicate some of the benefits for academia coming from these interactions, such as obtaining relevant information from commercial world, "alternative perspectives", new research insights and career development, creating different job opportunities for staff and professors (Evans and Spruce, 2005, p. 598). The knowledge acquired can contribute to raise funds and to tailor educational contents to industrial practice (Tresseras, MacGregor and Espinach, 2005). Even the university prestige and use of resources can benefit from it, doubling "the student graduation productivity" (Kaufman, 2005, p. 284), increasing the number of enrolments and facilities exploitation. Therefore, a valuable outcome of the collaboration can be the establishment of live project frameworks, nurtured by professional insights, teaching and research material (Evans and Waterworth, 2004).

Beyond the evident advantages for academic community, there are significant motivations for industry to engage with academia. Industry can benefit from the identification of students' skills, directly understanding their potential and needs (Roberts, 2007) and "reveal what they can offer" after graduation (Hakansson and Helmquist, 2010, p. 4). Meeting these human resources is also cost effective (Kaufman, 2005) and the industries involved in live projects can access to Universities' resources, facilitating knowledge transfer (Evans and Spruce, 2005) and technology transfer (Roberts, 2007). Industries then have the opportunity to meet the "refreshing and inspiring" (Watkins and Higginson, 2017, p. 84) approaches to problem-solving provided by students.

> As Helyer (2011) states: "The HE experience should be a holistic one, embracing the widely varying contexts in which knowledge is produced, gained, built upon and used and this stretches beyond academia to encompass work, social and community uses, adding value to the many facets of its students' lives as they become talented and trained individuals." (Helyer, 2011, p. 103).

The collaboration between university and business is the concrete opportunity to increase the level of experience and education of students before graduation, meeting industry demand and creating synergies between research and practice.

4. The Design Innovation Support Programmes at Brunel Design

In the following section, Brunel Design support programmes are described with the purpose of highlighting the different ways in which design innovation activities take place in the collaborations between students, academics and industry. Each programme generates value and builds design capabilities in a specific way, which is outlined. The presented programme descriptions are supported by project case studies to facilitate the comprehension of the related design practice and activity.

As stated in the literature section, the collaborations between universities and businesses can have different dynamics and an important role is played by the type of activities and by the communication between students, academics and firms. Brunel Design manages different industry-facing collaboration programmes with the aim of fostering design innovation. The programmes involve different activities that fit with the needs of different stakeholders. Herewith, the programmes are described in their goals, activities and benefits.

4.1 Brunel Co-Innovate Journeys

Brunel Co-Innovate Journeys is a design innovation support programme that Brunel Design runs since 2016, as a continuation of the previous similar programme called Co-Innovate (2012-2015). Both have been funded by European Regional Development Fund (ERDF), with the match funding provided by Brunel University London. Brunel Co-Innovate Journeys has recently received the funding extension to permit it to continue until March, 2023. As an outcome of Brexit, the funding responsibility may in the future be transferred from ERDF to the Greater London Authority (GLA).

The key aim of Brunel Co-Innovate Journeys is to provide design innovation support to Small and Medium Enterprises (SMEs) in the Greater London area. The programme links the businesses with Brunel Design students and academics, mediated by a team of 8 administration staff.

The SMEs participating in the programme are coordinated by the team's three Innovation Directors, who evaluate the collaboration opportunities, develop the collaboration briefs and then steer the collaborations towards the most appropriate interventions. The programme is aimed at generating value in terms of knowledge transfer and projects development. As such, there are three different kinds of collaboration activities available for the SMEs:

- Workshops, aimed at improving knowledge and skills about design and other relevant topics (e.g. intellectual property law) covering the areas of business and technology;
- Collaborative design projects with students under academic supervision, taking form of both the individual (major) projects and the group (coursework assignment) projects;
- R&D consultancy by academics, covering a range of design, business and technology aspects.

The programme supports SMEs in building their innovation capabilities, through workshops (Innovation Skills Workshops) and mentoring sessions (Knowledge Transfer Mentorships), facilitating access to academic and professional knowledge thanks to the involvement of both internal and external expertise.

From the experience of the Co-Innovate project, very specialised workshops and linked programmes are very successful in providing information and knowledge to the businesses The programme also supports SMEs that want to develop a new product or improve an existing one. Brunel Co-Innovate Journeys Innovation Directors help them to develop a brief and propose it to academics and students, launching a collaborative project. SMEs' briefs introduced to academics and students can become a major project on a single innovation challenge for selected students, a dissertation topic, optional competition or a coursework assignment for several students.

Businesses collaborating with students benefit from academic thinking and new and fresh ideas from students. Students have the support of their supervisors and university's facilities while developing a product or a service related to real-world problems. There is also the opportunity to engage in collaborative projects with academics and researchers, which can be funded by Co-Innovate Vouchers, explained in more detail below.

Students benefit from delivering real-world related dissertation arguments, developing a project together with a firm, which contributes to their learning, and from university facilities, workshops and academic tutors support. Companies can improve their product portfolio and receive valuable business insights and knowledge.

Co-Innovate projects create connections and collaborations between academic staff and SMEs, providing a formal intervention through Innovation Vouchers. Provided via Brunel's Research Support and Development Office (RSDO), the Innovation Vouchers permit the funding of up to £5,000 to the academic staff for the basic costs of a collaborative project.

Case Study: Orange Amplification, A Group Project

The collaborative project proposed by Orange Amplification, was administered as a design competition for MSc Integrated Product Design students. The company needed the development of design solutions for their on-ear/over-ear headphone products, famous for their distinct colouring and warm sound. The final product had to be in line with their heritage brand, with a target retail price of £100. Figure 1, presents the winning design.

Students were motivated by the competition as well as by the opportunity to design a product for an existing company, in line with the study developed by Hakansson and Helmquist (2010). Design processes and methodologies proposed by academics were applied, having the opportunity to test them in a real-world scenario, similar to Wrigley (2016), and the company gathered new fresh ideas in a reasonable amount of time, as in Watkins and Higginson (2017).

Figure 1 Winning Project for Orange Amplification Competition by Alex Roquero Mendiola

4.2 Bridging the Gap

Bridging the Gap (BtG), as Co-Innovate Journeys, has been co-funded by ERDF/GLA and Brunel University London and managed by Innovation Directors. The project started in 2016 and it is available to registered London-based emerging start-ups, Brunel Design students in the final year of their BSc or at the MSc/MA level and SMEs and alumni with less than one year of activity. The participants have to demonstrate an innovative idea, be interested in developing it and, most of all, be motivated to enhance their capabilities in growing the business. The goal of this project is to support these businesses with an appropriate mixture of specialist mentoring, workshops and knowledge, with the aim of decreasing the gap between good ideas and commercial businesses. The businesses involved in the programme are often recruited through networking events and the activities such as Made in Brunel (MiB), an annual design degree show exhibiting projects by undergraduate and postgraduate students.

BtG and Co-Innovate Journeys share the same method of engagement to increase the level of involvement of students and academics. However, unlike Brunel Co-Innovate Journeys, BtG is more focused on building capabilities by offering several activities to help early stage businesses. Online learning platform, skills training, mentoring, pitching and communication opportunities related to their needs are organised and performed. BtG workshops and lectures are delivered by members of Brunel academic and professional staff. They are called Innovation Trainings and focus on Capabilities, Concepts, Context, Commercialisation and Confidence. BtG outputs are tracked considering the development of a new product or service, job positions created, businesses supported and hours dedicated to each client.

Students have the opportunity to build hard and soft skills to improve their innovation capabilities and the training performed by academics has a direct impact on the early stage businesses participating in the programme. As in InnovationRCA (2019) and Startup@ Berkeley (2019), Brunel alumni are supported through individual coaching to bring their design-led ideas to the market.

Case Study: Cosicare

Cosicare, a collaborative project developed by Lauren Bell via BtG is a toy turtle that combines engaging plays with itch management for children suffering Eczema. The toy offers a number of cooling and frictional elements that a child can use to cool the surface of their skin as an alternative to scratching. The wooden shell is covered in metal rotational balls that can be used to rub and massage the skin. There are foam arms to sit on when playing, with the additional two detachable starfish, also covered in cooling balls (Figure 2).

Figure 2 Cosicare by Lauren Bell

In Cosicare, design is a driver of innovation developing a product that meets user needs, solving Rittel's wicked problems (1973). The collaboration with Bridging the Gap trains designers to deal with business challenges and equips them with valuable skill to make their product successful in the market, promoting the business culture mentioned by Borja de Mozota (2003) and von Stamm (2004).

4.3 Design Plus

Design Plus is a design innovation support programme that started in 2004, fully funded by Brunel University London. Unlike Co-Innovate and Bridging the Gap, which work with SMEs, Design Plus links Brunel students and staff with corporations (UK-wide and international), such as British Telecom and Phillips Electronics.

Partnering a final year student with a company for their major project significantly improves the overall outcomes of their work and therefore career prospects. Students work on a variety of real-life design challenges, supported and guided by their supervising tutor. This is an opportunity, not only to access a useful design resource, but also to add considerable value to the educational experience and career prospects and to support the next generation of innovators.

One of the main activities of Design Plus in the group assignment setting is the crowdsourcing of ideas. Students are involved in brainstorming sessions to generate new ideas and provide different insights and solutions to solve a problem in an original way. They also have the opportunity to deal with real-world problems, as described in the literature in Section 3, train their creativity skills and convert the theoretical knowledge into practice. Students are strongly motivated by the collaboration with companies and by the opportunity to add this kind of experience to their curriculum. Businesses get access to new ideas (Watkins and Higginson, 2017) and to human resources (Hakansson and Helmquist, 2010).

4.4 Impacting Business by Design - IBbD

Impacting Business by Design (IBbD) has been funded by Research England, Connecting Capabilities Fund and involves Brunel University London, De Montfort University (Project Lead) and Nottingham Trent University. Having started in 2018, the project offers companies with innovative ideas across England to collaborate and receive support from the team of professional designers hired by the university partners and/or external design studios and freelancers. Usually, the candidates for the collaboration are experts in their field (e.g. physicians, educators) that have identified a business opportunity and need support developing it.

The proposed project ideas are evaluated by the university partners, considering the innovativeness, feasibility and the commercial challenge. The selected ideas are developed at the industrial level, to the point of being ready to be launched to the market. The support to the businesses is covered by a grant, the amount of which depends on the length of work required to develop the project. The projects are managed by the IBbD team, which – together with the client – decides on the activities, times, objectives and funds involved at each project phase. A requirement for the businesses involved in the project is to demonstrate that they don’t have internal design knowledge or capacity. This awareness and the recognition of design value is something that should be transferred through the direct involvement in product development.

Case Study: Airhead

Airhead is a London-based start-up, which had the aim to create a superior pollution protection mask for commuters, cyclists and those breathing polluted air in urban environments. Brunel's IBbD design team helped Airhead to achieve their innovation goals by implementing a design innovation project structured by the four stages of the Double Diamond framework (Design Council, 2005).

A four-person design team using the framework worked with Airehad to systematically research customer and user needs, human factors, enabling technology alternatives and the target market environment into which to launch the new product. The project was underpinned by a clear spirit of collaboration. The Airhead team was involved in the project through all stages, providing critical commercial and strategic context. Brunel's IBbD team provided a pragmatic strategic product focus, creative design direction, prototyping (Figure 3) and technical resources based on the structured design approach of the Double Diamond framework. In doing so, a ready to manufacture product was created, but importantly, Airhead gained significant new insights into how a strategic design innovation process can help accelerate successful product design outcomes. In the Airhead project, design capabilities (Hobday et al. 2012) and professional skills (Walsh et al. 1993) delivered an innovative result and a successful Kickstarter campaign raising over £300,000.

Figure 3 Airhead Pollution Mask Prototype

5. Discussion

From the literature related to the role of design in innovation in Section 2, one can argue that design is able both to generate value and build capabilities. The value generated by design can be considered as financial and non-financial (Vijfeyken, Cools, Nauwelaerts, 2015), involving the generation of new ideas and the development of new products launched on the market. Capability building by design can be regarded as the acquisition of the abilities mentioned by Hobday et al. (2012), related to the acquisition of skills to deal with problems, find solutions and develop a mindset that stimulates creativity and empathy (Hernandez et al. 2018) by the use of processes and visualisation tools.

From the literature related to academia-industry collaboration in design innovation presented in Section 3, it is possible to systematise and highlight the benefits for the stakeholders involved in the Brunel Design support programmes. In the following table, the benefits for students, academia and industry are presented and clustered in the key categories according to the literature – for each of the programmes.

Table 1 Stakeholder Benefits from Brunel Design Support Programmes

Stakeholder	Benefits and References	Brunel Design Programmes			
		Co-Inno.	BtG	Design Plus	IBbD
Students	**Real-World Problems** Obtain access to real-world problems in design context (Hakansson & Holmquist, 2010; Wodehouse & Mendibil, 2013; Evans & Waterwoth, 2004).	Yes	Yes	Yes	N/A
	Skills Development Enhance students' learning and overall experience; Earn money; Test yourself; Understand own strengths and weaknesses; Improve critical thinking, team working, problem solving, project management, communication skills and initiative; Embody the role of both designer and client (Kaufman, 2005; Wodehouse & Mendibil, 2013; Bohemia et al., 2009).	Yes	Yes	Yes	N/A
	Employability Improve employability and job prospects; Link with business realities; Improve CV contents; Work placements; Practice and experience development (Watkins & Higginson, 2017; Evans and Spruce, 2005; Kaufman, 2005; Wodehouse & Mendibil, 2013; Belfield, 2012).	Yes	Yes	Yes	N/A
	Apply University Studies in Real World Merge theoretical knowledge with real-world practice; Apply design principles in business realities; Improve experience, corporate culture, design education and research (Wrigley, 2016; Renganathan et al., 2012).	Yes	Yes	Yes	N/A
	Motivation Improve motivation and satisfaction; Appreciate working on real life projects (Hakansson & Helmquist, 2010).	Yes	Yes	Yes	N/A

Academia	**Bridging Research-Practice Gap** Retrieve relevant information from commercial world; Gain alternative perspectives and new research insights; Get access to real world problems in design context (Evans & Spruce, 2005; Hakansson & Holmquist, 2010; Wodehouse & Mendibil, 2013; Evans & Waterwoth, 2004).	Yes	No	Yes	Yes
	Career Development Career development; Create different job opportunities for staff (Evans & Spruce, 2005).	Yes	No	No	Yes
	Honing Design Theories Application of design principles in business realities; Improve experience, corporate culture and design education and research (Wrigley, 2016).	Yes	Yes	No	Yes
	Education Enhancement Tailor educational contents to industry practice; Live project frameworks establishment, nurtured by professional insights, teaching and research material (Tresseras, MacGregor & Espinach, 2005; Evans & Waterworth, 2004).	Yes	Yes	Yes	Yes
	University Prestige Enhance university prestige; Double students' graduation productivity; Increase the number of enrolments and facilities exploitation (Kaufman, 2005).	Yes	Yes	Yes	Yes
Business	**Human Resources** Identify students' skills, directly understanding potential and needs; Foresee the potential of students after graduation; Develop cost-effective Human Resources connections (Roberts, 2007; Hakansson & Helmquist, 2010; Kaufman, 2005).	Yes	No	Yes	No
	Access to University Resources and Facilities Have access to university resources; Facilitate Knowledge Transfer and Technology Transfer (Evans & Spruce, 2005; Roberts, 2007).	Yes	No	No	Yes
	Ideas Generation Industries have the opportunity to meet the "refreshing and inspiring" approaches to problem-solving provided by students and staff (Watkins & Higginson, 2017).	Yes	No	Yes	Yes

5.1 Benefits to Students

Student benefits are directly related to the development of design capabilities that can make a positive difference in their future job. Collaborative projects are opportunities to improve the quality of the student portfolios with design solutions that are based on real-world problems and developed in partnership with a company.

During the interaction with companies, students also develop problem-solving skills and merge theory acquired in class with design practice. Workplace skills are improved in these collaborations, enabling students to better manage work tasks, deadlines and communication.

Teaching and learning curriculum largely benefits from the collaborations as the students develop their understanding of the business of design, while the connections created with the company, in many cases, improve the employability prospects.

In BtG, the students in their final year or Brunel alumni can benefit from improving their knowledge in business management, commercialisation, growing business and pitching through a focused mentoring support and a facilitated access to start-up accelerator linked to Brunel.

5.2 Benefits to Academics

The collaborations provide Brunel academics with valuable insights into the real world developments, thus filling gaps between research and practice an improving the understanding of business perspectives and personal motivations and goals.

Researchers benefit from external insights – coming from the business world, which improves the motivation to do research and adds to the relevance and novelty of the research focus. The insights include valuable information about users, trends, technologies and processes used by companies and how they deal with design and innovation.

When academics are involved in collaborative projects with companies, they have the opportunity to hone design methods and processes, increase their applicative skills and CV and exploit what they learnt from the experience in their research. They are financially covered in these collaborations and also motivated by the opportunity to differentiate their career and activities.

By supervising the evolution of the project and the implementation of theory into practice by students, they gain a better understanding of the skills demanded by the businesses. In this way, academics can improve the quality of their teaching content and overall student experience by aligning the focus on the job market requirements.

5.3 Benefits to Businesses

The most tangible value generated for businesses is the development of new innovative products and ideas through the collaboration with students and academics. The programmes involving collaborative projects give businesses the opportunity to discover alternative ways to deal with problems, receive different design solutions and increase their portfolio of products. They have access to students motivated by the collaboration with a business and to different design methods and processes applied in academic context. The projects can be delivered at different levels, in the form of challenging crowdsourced fresh ideas and concepts or to a more advanced stage of development. Where the support needed is more technical, they have the opportunity to engage with academic staff, having access to their knowledge and expertise.

Workshops, mentoring and knowledge transfer activities managed by the programmes provide businesses with a clear opportunity to improve their capabilities in different fields. Moreover, businesses have a priority access to the student talent and thus a temporal advantage in terms of recruitment. During the project work, students acquire the knowledge and experience from the collaboration and become aware of the company's culture, business focus and background, which reduces the need for training in case of hiring.

5.4 Brunel Support Programmes Ecosystem

Generating value and building capabilities in design innovation are the main objectives of design innovation support programmes by Brunel Design. The availability of the programmes that share the same academic context, but support different goals for different stakeholders provides an opportunity to address the most suitable support to the specific needs of a business through a valuable mediation of Brunel Design staff. The programmes are interrelated and activities are fully integrated into Brunel fabric, without redundant overlaps.

In this collaborative context, academia has the role to intercede between parties, acting as a mediator (e.g. Innovation Directors for student-academic-business projects, mentoring and workshops or academic staff for student supervision) to help students in major projects and coursework assignments. The process of knowledge transfer happens reciprocally: students give fresh ideas and design solutions, while businesses and academics provide their knowledge, insights and experience. These goals are reached through strong connections between stakeholders, encouraged by a positive attitude towards innovation through design. A crucial role is played by the programmes staff, which carry collaborations by guiding businesses and students through the support process and managing communication between stakeholders in all stages. The results of these interactions are the increased awareness by the stakeholders of the importance of design innovation and how their knowledge and experience can be enhanced by collaboration.

6. Conclusions and Future Research

This paper presents Brunel Design support programmes that involve students, academics and industry under the domain of design innovation. The literature is still not fully clear in defining the role of design in innovation and this discourse needs further considerations. The literature related to academia-industry collaboration in design is also not completely systemised, but it is possible to identify relevant scholars' experiences, insights and dynamics for collaboration activities.

Brunel Design support programmes attempt to foster the activities that can instigate the generation of value and capability building, supported by synergic connections that are advantageous for all stakeholders involved, thus directly fulfilling the role of design as a driver of innovation within the UK economy. To integrate the benefits just highlighted, future studies should be carried out to identify the barriers to collaboration and how to tackle them and devise evidence-based practice related to collaborations among such variety of stakeholders.

Qualitative and quantitative studies related to the impact of such collaborations under the design innovation domain in the short- and long-term should be conducted to help improve the quality of future support programmes. The correlations between the activity participation and stakeholders' performance should also be identified, since they can be monitored within the same academic context. Beyond the short-term impact generated by the collaborations – NPD, acquisition of knowledge, projects and dissertations – the additional impacts should be analysed in the long run in term of business growth, post-graduate employability and research relevance.

7. References

Belfield, H. (2012). *Making Industry–University Partnerships Work: Lessons from Successful Collaborations*. Brussels, Belgium: Science/Business Innovation Board AISBL. https://tinyurl.com/qr98lut

Blumenthal, D. (2003). Academic–industrial relationships in the life sciences. *New England Journal of Medicine*, 349, 2452-2459. doi:10.1056/NEJMhpr035460

Bohemia, E., Smith, N., Harman, K., Duncan, T., Turnock, C. & Hwang, S.G. (2009). Distributed collaboration between industry and university partners in HE. *Proceedings of Rigour and Relevance in Design: The International Association of Societies of Design Research 2009 Conference*, 18-22 October 2009, Seoul, Korea, 235-244.

Borja de Mozota, B. (2002). Design and competitive edge: A model for design management excellence in European SMEs. Academic Review. *Design Management Journal*, 2(1), 88-103. doi:10.1111/j.1948-7177.2002.tb00014.x

Brown, T. (2008). Design thinking. *Harvard Business Review*, 86(6), 84-92.

Carlgren, L., Elmquist, M. & Rauth, I. (2014). Design thinking: Exploring values and effects from an innovation capability perspective. *The Design Journal*, 17(3), 403-423. doi:10.2752/175630614X13982745783000

Cooper, R., Hernandez, R., Murphy, E. & Tether, B. (2017). *Design Value: The Role of Design in Innovation*, Final report. Lancaster University: Lancaster, UK. doi: 10.13140/RG.2.2.28595.43046

Cruickshank, L. (2010). The innovation dimension: Designing in a broader context. *Design Issues*, 26(2), 17-26. doi: 10.1162/DESI_a_00002

Design Council (2005). *Eleven Lessons: Managing Design in Eleven Global Brands: A Study of the Design Process*. https://tinyurl.com/rj59wo2

Design Council (2008). *The Designing Demand Review*. https://tinyurl.com/us3roqc.

Design Council (2011). *Design for Innovation*. https://tinyurl.com/t4yh8xr

Design Council (2012). *Design Delivers for Business*. https://tinyurl.com/sayn7nq

Design Council (2018). *The Design Economy 2018*. https://tinyurl.com/ybnep4f5

Evans, M. & Spruce, J. (2005). Knowledge networks: Collaboration between industry and academic in design. *Proceedings of the 3rd Engineering & Product Design Education International Conference, Crossing Design Boundaries*, 15-16 September 2005, Napier University, Edinburgh, Scotland. https://tinyurl.com/ub4zfpf

Evans, M. & Waterworth, S. (2004). Industrial collaboration and its importance to ensuring currency in design education. *Proceedings of E&PDE 2004 (DS 33): The 7th International Conference on Engineering and Product Design Education, The Changing Face of Design Education*, 02-03 September 2004, Delft University of Technology, Delft, The Netherlands. https://tinyurl.com/y7cyp3nk

Fagerberg, J. (2004). Innovation: A guide to the literature. In J. Fagerberg and D. C. Mowery (eds.), *The Oxford Handbook of Innovation*. Oxford, UK: Oxford University Press, 1-26.

Freeman, C. (1982). *The Economics of Industrial Innovation* (2nd ed.). London, UK: Frances Pinter.

Galindo-Rueda, F. & Millot, V. (2015). *Measuring Design and Its Role in Innovation*. OECD Science, Technology and Industry Working Papers, No. 2015/01. Paris, France: OECD Publishing. doi:10.1787/5js7p6lj6zq6-en

Håkansson, A. & Holmqvist, B. (2010). University–industry cooperation and student driven projects: A model for educating design engineers. *Proceedings of E&PDE 2010 (DS 62): The 12th International Conference on Engineering and Product Design Education, When Design Education and Design Research Meet...*, 02-03 September 2009, Trondheim, Norway. https://tinyurl.com/wq5qphj

Hernandez, R.J., Cooper, R., Tether, B. & Murphy, E. (2017). The value of design in innovation: Results from a survey within the UK industry. *The Design Journal*, 20(sup1), S691-S704. doi: 10.1080/14606925.2017.1353015.

Hernández, R.J., Cooper, R., Tether, B. & Murphy, E. (2018). Design, the language of innovation: A review of the design studies literature. *She Ji: The Journal of Design*, Economics and Innovation, 4(3), 249-274. doi: 10.1016/j.sheji.2018.06.001.

Helyer, R. (2011). Aligning higher education with the world of work. *Higher Education, Skills and Work-based Learning*, 1(2), 95-105. doi:10.1108/20423891111128872

Hobday M., Boddington, A. & Grantham A. (2012). An innovation perspective on design: Part 2. *Design Issues*, 28(1), 18-29. doi:10.1162/DESI_a_00137

International Council of Societies of Industrial Design (ICSID) (2008). *Official Definition of Design*. https://tinyurl.com/yx4y875s

Innovate UK (2015). *Design in Innovation Strategy 2015-2019*. https://tinyurl.com/yxy7oeta

InnovationRCA (2020). *Our Programmes*. https://tinyurl.com/y8orq9v3

Kaufman, J. (2005). Professional internships and cooperative product design education. *Proceedings of the 3rd Engineering & Product Design Education International Conference, Crossing Design Boundaries*, 15-16 September 2005, Napier University, Edinburgh, Scotland.

Lambert, R. (2003). *Lambert Review of Business–University Collaboration*, Final Report. https://tinyurl.com/vd79hkl

Maldonado, T. (1969). *Industrial Design Definition History*. ICSID/WDO. https://tinyurl.com/szdmfz4

Mutlu, B. & Er, A. (2003). Design innovation: Historical and theoretical perspectives on product innovation by design. *Proceedings of the 5th European Academy of Design Conference*, 28-30 April 2003, Barcelona, Spain. https://tinyurl.com/vnanza3

National Endowment for Science, Technology and the Arts (NESTA) (2009). *The Innovation Index: Measuring the UK's Investment in Innovation and Its Effects*. London, UK: NESTA. https://tinyurl.com/wetsmdc

Newberg, J.A. & Dunn, R.L. (2001). Keeping secrets in the campus lab: Law, values and rules of engagement for industry–university R&D partnerships. *American Business Law Journal*, 39(1), 187. doi:10.1111/j.1744-1714.2002.tb00298.x

Nomen, E. & Barcelona Design Centre (2014). *€Design: Measuring Design Value*. https://tinyurl.com/ruxs2o7

Norman, E.W.L. (2012). *Curriculum Convergence and Divergence in "Industrial Design" and "Technology" Programmes in Higher Education*. Orange Series: Design Curriculum Matters 3. Loughborough: Loughborough University. https://tinyurl.com/sd3bwzd

Oakley, M. (1990). *Design Management: A Handbook of Issues and Methods*. Oxford, UK: Blackwell.

Rampino, L. (2011). The innovation pyramid: A categorization of the innovation phenomenon in the Product–Design Field. *International Journal of Design*, 5(1), 3-16. https://tinyurl.com/stegy5p

Renganathan, S., Karim, Z.A.B.A. & Li, C.S. (2012). Students' perception of industrial internship programme. *Education+Training*, 54(2-3), 180-191. doi:10.1108/00400911211210288

Rittel, H.W. & Webber, M.M. (1973). Dilemmas in general theory of planning. *Policy Sciences*, 4(2), 155-169. doi: /10.1007/BF01405730.

Roberts, J. (2007). The future of academic–industry collaboration. *Proceedings of IASDR07: International Association of Societies of Design Research*, 12-15 November 2007, Hong Kong Polytechnic University, Hong Kong, China. https://tinyurl.com/tpmbjtf

Skelly, M. & Bruce, F. (2017). Designing collaborations at the intersection of academia and industry. *Proceedings of E&PDE 2017 (DS 88): The 19th International Conference on Engineering and Product Design Education, Building Community: Design Education for a Sustainable Future*, 07-08 September 2017, Oslo, Norway. https://tinyurl.com/rlounk5

Startup@Berkeley (2019). *Learn. Build. Fund. We Connect Student Entrepreneurs with UC Berkeley's Startup Ecosystem*. https://startup.berkeley.edu/

Tresserras, J., MacGregor, S. & Espinach, X. (2005). SME collaboration as a driver of design research and education development. *Proceedings of the 3rd Engineering & Product Design Education International Conference, Crossing Design Boundaries*, 15-16 September 2005, Napier University, Edinburgh, Scotland.

Verganti, R. (2009). *Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean*. Brighton, MA, USA: Harvard Business Review Press.

Verganti. R. (2006). Innovating through design. *Harvard Business Review*, 84, 114-122. https://tinyurl.com/vhg6ub7

Vijfeyken, E., Cools, M. & Nauwelaerts, Y. (2015). Measuring the value created by design: A qualitative study generating a comprehensive overview. *Journal of Creativity and Business Innovation*, 1, 129-159. https://tinyurl.com/su8m8nv

von Stamm, B. (2004). Innovation–What's design got to do with It?. *Design Management Review*, 15(1), 10-19. doi:10.1111/j.1948-7169.2004.tb00145.x

Walsh, V., Roy, R., Bruce, M. & Potter, S. (1993). Perspectives on design and innovation. *Creativity and Innovation Management*, 2(2), 78-86. doi:10.1111/j.1467-8691.1993.tb00076.x

Wilson, T., (2012). Business-university collaboration: The Wilson review. Independent Review. https://tinyurl.com/vo32y3m

Wodehouse, A.J. & Mendibil, K. (2013). Collaboration mechanisms for university–industry projects. Proceedings *of E&PDE 2013 (DS 76): The 15th International Conference on Engineering and Product Design Education, Design Education – Growing Our Future*, 05-06 September 2013, Dublin, Ireland. https://tinyurl.com/rjy6ule

Wrigley, C. (2016). Design innovation catalysts: Education and impact. *She Ji: The Journal of Design*, Economics and Innovation, 2(2), 148-165. doi:10.1016/j.sheji.2016.10.001

About the Authors:

Giulia Cosco is Research Fellow on the Impacting Business by Design project, funded by Research England. Her current research interests include Design Innovation and Design Methodologies. Previously, she worked as a researcher in the area of Biomechanical Design and Additive Manufacturing.

Vanja Garaj is Head of Brunel Design and Principal Investigator for Impacting Business by Design at Brunel. His research is aimed at design, development and evaluation of innovative systems, products and services—with the focus on digital and digital‐physical domains and the application of the latest technology.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Towards Design-Driven Transdisciplinary Education: Navigating the Challenges and Envisioning the Role of Design as a Facilitator

JiaYing CHEW[a]*, Jung-Joo LEE[a]*, Miikka J. LEHTONEN[b]*

[a] National University of Singapore
[b] Dubai Institute of Design and Innovation
*Corresponding author e-mail: jiaying.chew@nus.edu.sg
doi: https://doi.org/10.21606/drs.2020.344

Abstract: The contemporary society deals with challenges that are complex, dynamic and networked, which requires different knowledge domains to work together beyond their knowledge silos. Transdisciplinarity is one of the responses to this mandate, and universities are increasingly trying to implement transdisciplinary education. Transdisciplinarity, however, is seen disruptive to existing university structures, and there is a need to examine the challenges to inform future directions. This paper presents an exploratory study into the existing challenges towards implementing transdisciplinary education through action research in one graduate degree program. Through a series of interviews, observations and co-design workshops accompanied with frameworks and tools developed, we identify the existing challenges of the curriculum development and delivery. We also explore how design could play a facilitator role in unveiling assumptions and aligning different perspectives among multiple parties in the curriculum development.

Keywords: transdisciplinary education; curriculum development; design; transdisciplinarity

1. Introduction

The contemporary era sees unprecedented interconnected systems, unpredicted disruption and ever-changing currents and trends as forces moving towards solving problems on human and environmental scale (Buchanan, 1992; Hyysalo et al., 2019). As such, the contemporary knowledge landscape witnesses an increasing yield from industry and society for a holistic and cross-disciplinary understanding, rather than focusing solely on the depth of individual disciplinary knowledge (Ramadier, 2004). An acknowledgement to these complex issues is the concept of “transdisciplinarity” that considers not only a relevant mix of disciplinary knowledge, but also external factors like localized domain knowledge, strategic foresight, culture and phenomenology in creating a collective understanding of an issue (Brown et al., 2010; Nicolescu, 2005; Hyun, 2011; Jahn, Bergmann and Keil, 2012).

This outlook challenges the perceptions of the role of the university in contemporary society. The disciplinary barriers in current university structures that were consequentially created in the advancement of individual majors and specializations, have since proved limiting towards innovation (Russell, Wickson and Carew, 2008).

As an answer to this need, many universities are trying to develop and experiment with inter-, cross- or trans-disciplinary programs on a small (e.g. modules and projects) and large scale (e.g. degree programs). What is observed in those attempts is that design is seen as a tool in bridging different disciplines, especially when it comes to dealing with wicked problems (Rittel and Webber, 1973) and organizational change (e.g. Boland and Collopy, 2004; Brown, 2009; Martin 2009; Kimbell 2011). As described by Bremner and Rodgers (2013, p.8), "the terrain of design continues to shift and extend well beyond the boundaries of the (single) discipline. Design now encompasses multiple disciplinary perspectives and entails cross-disciplinary pursuits."

Most of these programs, however, hover in the domain of multidisciplinarity as they remain paradoxically homogenous in their setups as well as curriculum design (e.g. Ertas, Maxwell, Rainey and Tanik, 2003; Tully, 2013; Self and Baek, 2017; Self, Evans, Jun and Southee, 2018). The aspect of transdisciplinarity appears to be challenging for implementation due to various systemic issues present, for example, the persisting focus on individual majors and specializations in universities (Russell et al., 2008) and a lack of integrative platform for knowledge exchange (Jahn et al., 2012).

This paper presents an exploratory study to unveil challenges of developing transdisciplinary higher education and discuss potential roles of design in overcoming the challenges. Design has been increasingly used to facilitate multidisciplinary collaboration, by supporting the creation of collaborative platforms, providing a shared language through visualization, and guiding solution-envisioning activities (Lee et al., 2018; Hyvärinen, Lee and Mattelmäki, 2015). We tap on such qualities of design and explore its role as a facilitator in a transdisciplinary education context.

We illustrate this through the case from one design school in the Nordic region. The intent is not to raise epistemic questions about transdisciplinary pedagogy (Klein, 2008; Hyun, 2011; Gibbs, 2017), but to analyse the challenges in the current institutional setup that may be causing impediment to transdisciplinarity being implemented in higher education.

2. Transdisciplinarity and Design

2.1 Transdisciplinary Higher Education

As described by Land (2012a, p.38), university curriculum have typically been developed in "their own conceptual worlds" to deal with issues that have a clear demonstration of causality— often coupled with solutions that have been tried and tested. However, since society's most significant challenges are complex, ever-changing and cannot be definitively described (Buchanan, 1992; Rittel and Webber, 1973; Dorst, 2015), the concept of crossing disciplinary boundaries is increasingly welcomed in attempts to break free from knowledge silos, and to provide more holistic and comprehensive solutions to global challenges.

Yet, the concept of transdisciplinarity is loosely understood and rarely adopted in higher education as observed by Gasper (2010). By synthesizing the earlier definitions that have been the most consistently established on the cross-disciplinary spectrum (Nicolescu, 1999; 2005; Ramadier, 2004; Gasper, 2010; CERI, 1972), we interpret the different notions around mixing disciplines as follows:

- *Multidisciplinarity* refers to the juxtaposition of more than one discipline. In a project setting, this suggests separate input from each discipline, typically presented independently with no interaction.
- *Interdisciplinarity* thrives at the crossroads of multiple disciplines and sets of practical demands. In a project, this describes interaction between disciplines and can range from simple communication of ideas, to the mutual exchange of understandings and organization of research.
- *Transdisciplinarity* concerns not just interaction across multiple disciplines, but also looks at diversity in background, experience and prior knowledge. It is an approach which is at once between the disciplines, across the disciplines and beyond all disciplines. The goal is to work within and beyond the constraints rather than creating a mega-silo, thus emphasizing understanding and embracing disciplinary differences.

The challenge surrounding interdisciplinarity stems from the difficulty to transcend or break out of the existing setups that have already been deeply in place, since there are little academic incentives to share resources or engage in discourses for mutual deconstruction of frameworks (Gasper, 2010; Land, 2012b). This results in resistance and renders it even more challenging to develop and deliver transdisciplinary curriculum, as it not only requires instructors exchanging viewpoints, but going back and forth disciplinary and transdisciplinary standpoints (Nicolescu, 2005; 2006). Furthermore, it also means that the level of understanding and the depth of knowledge of individual actors— instructors and students, will be different (Nicolescu, 2010).

2.2 Design in a Transdisciplinary Setting

Within transdisciplinarity, design's role is two-fold: design as a problem-solving logic and design as a method. For the former notion, design can provide a shared logic to approach complex problems for multiple actors in a transdisciplinary setting. This acts as a platform that reduces resistance to interaction and exchanges. According to Bremner and Rodgers (2013, p. 8), design can be "characterized by fluid, evolving patterns of practice that regularly traverse, transcend, and transfigure disciplinary and conceptual boundaries". As design is employed in a wide range of making and planning disciplines, extant literature around transdisciplinary discussion and applications in education often surface with the term design or design thinking as a problem-solving logic, bonding different tools and thinking processes of different disciplines (Jahn et al., 2012; Hyun, 2011; Ertas et al., 2003; Garbuio et al., 2018).

Recently the role of design has been addressed in a co-creation settings with heterogeneous knowledge groups (e.g. see Lee et al., 2018). Extant research (Lee et al., 2018; Hyvärinen, Lee and Mattelmäki, 2015; Bason, 2010; Junginger and Sangiorgi, 2009) has focused on design's innate qualities that are human-centered, collaborative, and future-oriented. Through analysis of 13 co-creation projects, Lee et al. (2018) explained how design can facilitate co-creation by multiple actors with heterogeneous knowledge, power and interests: visual and narrative components of design help actors construct and articulate their knowledge and expectations; creative collaboration tools help them negotiate their different views and form a shared goal; future-oriented components of design allow them to imagine future scenarios.

Tapping on these qualities, design has been recognized as a method to organizational transformation (e.g. see Junginger, 2009; Sangiorgi, 2011; Bason, 2010). Junginger and Sangiorgi (2009) suggested that design enquiry can be used as a conversational tool within an organization to unveil organization's deeper assumptions and show how such assumptions frame its current situation and actions. Similarly, Hyvärinen et al. (2015) illustrated the roles of design approaches in helping organizations externalise their different views and expectations in a cross-sector collaboration. Bason (2010) advocated the role of design in achieving the public sector transformation from expert-oriented, siloed ways of working to more collaborative one.

The emerging roles of design in multidisciplinary collaboration and organizational transformation hint us at its potential to be used in transdisciplinary curriculum development where multiple actors with different knowledge backgrounds gather. As the above-mentioned studies indicate, design can facilitate creative collaboration among different disciplines and challenge the existing structure of universities. Design tools could help identify different views and knowledge gaps among educators from different disciplinary backgrounds, as well as between educators and students, during the curriculum development process. Upon the mutual understanding achieved, design could facilitate to co-create shared goals and action plans for transdisciplinary education.

In the following sections, we first present the challenges observed from one graduate program whose aim is to embed transdisciplinarity in their education, and then map the challenges with possible opportunities from design.

3. Case: IDBM Curriculum Redesign for Transdisciplinarity

3.1 Introduction to the Case and Research Process

We illustrate the challenges surrounding networked actors - program management, faculty member and students - within a potential transdisciplinary setup, through the case of Aalto University's International Design Business Management (IDBM) graduate program. Established as a multidisciplinary minor program in 1995, and conferred as an interdisciplinary two-year major program in 2010; the IDBM program hosts an equal-part setup across the Design, Business and Technology schools. Through equal disciplinary-representation, cultural backgrounds and work/ industry experience, the program's heterogeneous conditions (Lawrence and Després, 2004; Ramadier, 2004; Klein, 2004) across the student body and faculty put it in an ideal position to be developed towards transdisciplinarity. The program's unique structure allows for a dynamic exchange across disciplines beyond the typical siloed structure of traditional institutes of higher learning.

The program curriculum is structured such that during the first year, students take a series of mandatory courses aimed at equipping each cohort with a foundational understanding in Design, Business and Technology disciplines, respectively. Thereafter, finishing the first year of their studies with a six-month long industry-based project designated by an industry collaborator: for the project, students are assigned to multidisciplinary teams where they get to apply their cumulative knowledge.

This structure remains core to the program, thus resembling a "threshold concept (Land, 2012b, p. 176)" to transdisciplinarity that "lead to a transformed way of understanding, or interpreting, or viewing something without which the learner finds it difficult to progress". In the case program, this is facilitated through mandatory exposure to different disciplinary perspectives, in hopes that students embrace the differences when collectively navigating the uncertainty and ambiguity within diverse teams.

Yet, despite the program's long-standing history of experimenting with mixing disciplines in curriculum setups, it was observed that it has been consistently difficult for students to articulate their learnings or break out of their comfort zones beyond their disciplinary experiences when working on team projects. Guided by an action research approach, this research leverages on insights from observations, in-depth interviews and co-creation workshops based upon the process of the program's curriculum development (Figure 1). Overall, the action research was conducted over the span of six months (October 2018 - March 2019).

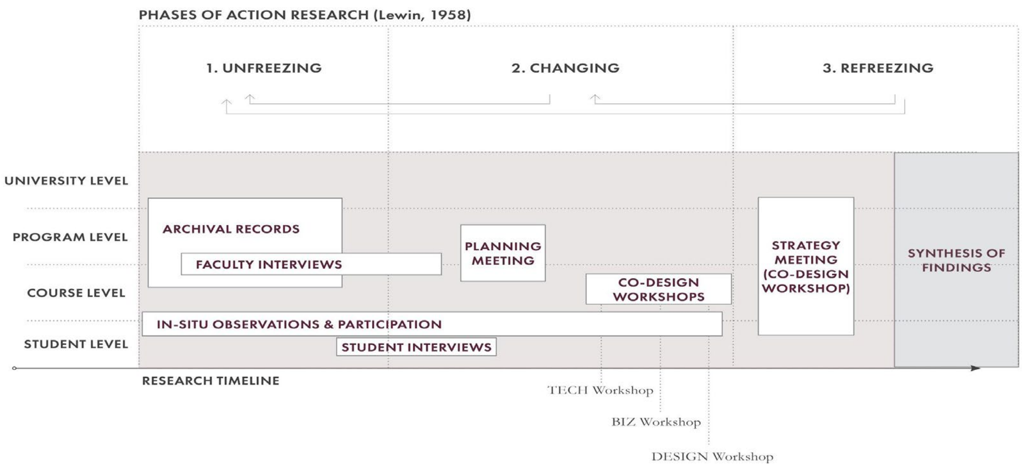


Figure 1 Research process and methods adopted based on phases of action research

We adopted Lewin's (1958) changing in three steps model: 'unfreezing' in action research aims to uncover and bring attention to the underlying issues that the group is facing; the 'changing' phase entails an understanding of the issues and introducing an intervention to be tested; and finally 'refreezing' looks at the application and evaluation of the intervention introduced.

The first author played a "stewarding role" following the research and intervention process, to which we describe as the person appointed to supervise or direct the process. In the 'unfreezing' phase archival records served as a foundational understanding of how the program's design and legacy transpired, while faculty and student interviews surfaced challenges and issues with existing practices. Synthesis of the interview findings led to the development of a framework that navigates the influences for transdisciplinary course design and development. The framework was later developed into a tool, 'curriculum alignment canvas', as an intervention to test out the framework and delve into deeper knowledge and challenges around.

Introduction of the tool in a planning meeting with all faculty members marked the 'changing' phase, as it allowed for intervention at program level but also on an individual course level through a series of four co-design workshops. Thereafter, the 'refreezing' phase looked at implementation of interventions in a collective setting, by integrating the various modules into a holistic transdisciplinary curriculum. Finally, an analysis of the implementation challenges and future considerations were mapped in relation to the qualities of design.

3.2 Stewarding the Curriculum Design Process through Action Research

As opposed to the "consultative" review that qualitative research adopts in providing analysis and commentary from outside-in (Muratovski, 2015), the emic-etic (Pike, 1967) outlook of action research enabled a situated response and reflection in and around the context. Waterman, Tillen, Dickson and De Koning (2001, p. iii) described action research as “a group activity with an explicit value basis and is founded on a partnership between action researchers and participants, all of whom are involved in the change process”. The focus of action research is in the improvement of an existing practice that is based around a problem, dilemma, or ambiguity from the situation in which practitioners find themselves in (Muratovski, 2015). As such, it makes a dual commitment to study a system and concurrently, collaborate with members of the system in changing it together, to what is regarded as a desirable direction (Huntjens et al., 2014).

We initiated the data collection by the first author conducting 13 in-depth interviews with the key actors of the program: two members of management (program directors who also taught courses); five faculty members (two program administration and the three instructors who taught the design, business and technology courses) and selected first-year students across the various disciplines (two Design, two Business, two Technology). Each interview lasted 45- 60 minutes, focusing on key themes presented in Table 1. All interviews were recorded and transcribed verbatim.

Table 1 Key themes of interviews

To the Faculty Members	To the Students
• Their understanding of transdisciplinarity and its implications for the program • Program’s goals, aims and directions • Experiences in course and program planning, design and delivery • Student expectations towards the program • Their understanding of how individual courses fit into the larger picture of the program • Challenges and opportunities for the program from a faculty perspective	• Rationale for choosing a cross-disciplinary graduate program • Their understanding of transdisciplinarity • Program experience thus far vs expectations when they applied for the program • Experiences with individual courses and learning outcomes • Mapping their transdisciplinary understanding of the program based on the courses • Challenges and opportunities for the program from a student perspective

In these interviews, participants were first asked to reflect on their individual experiences of the program. They were also asked to provide suggestions for future improvements and were encouraged to talk about their past educational experiences, backgrounds and expertise so as to allow the interviewer to better understand their frame of mind and possible disciplinary approaches and cultural influences.

One of the key findings from the interviews was that the curriculum intent and learning outcomes were loosely interpreted and sometimes mismatched. As it turns out, the instructors had independently designed their course curriculum and learning outcomes in response to societal and industry needs and trends, yet the students found difficulty in navigating their expectations and applying learning experiences. The interview findings indicated that the students had attempted to make sense of the courses as part of a collective program experience, rather than individual instructional settings. Due to the independent design of the curriculum, both students and faculty members shared their confusion and struggle to map out their understanding of the program and its core components. It was evident that interrelations between the courses were critically missing. Identifying these aspects of dissonance enabled a clearer overview of the influences and processes that shape curriculum development.

3.3 Framework for Transdisciplinary Curriculum Development and Application

Based on our data, we crafted a framework that navigates the various influences, phases and key stakeholders of transdisciplinary curriculum (Figure 2). This framework illustrates the factors that influence course design and development on multiple levels, as well as the actors involved in each level.

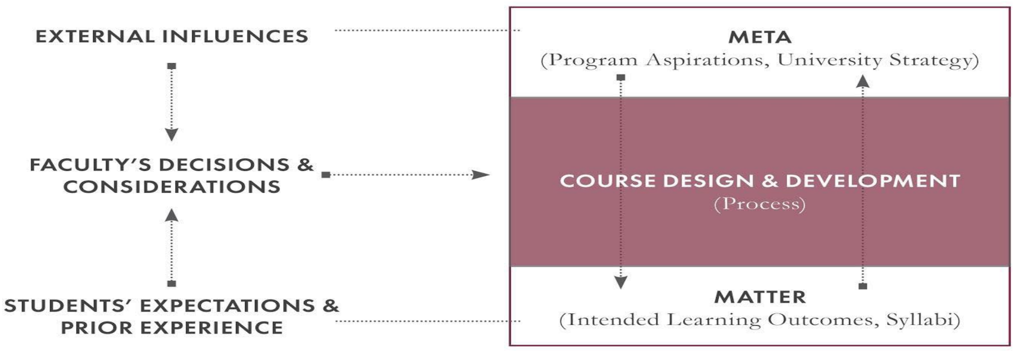


Figure 2 Influences for Transdisciplinary course design and development

At a "meta" level, universities aim to equip students with the necessary skills and knowledge for employment upon graduation. Industry and societal needs thus become the external influences that greatly impact faculty's decisions and considerations, which in turn frame and provide inputs to the syllabus and course design.

On the receiving end, students' expectations and learning experiences are key indicators that demonstrate whether or not the intended learning outcomes have been met, and whether the curriculum design is successful. Since students learn through the circumstantial environment and tangible material, the course curriculum and delivery then become the "matter", a product of course design and development. The mismatch between meta and matter could be bridged by redesigning the process of course design and development.

The framework was broken down into more actionable items to facilitate transdisciplinary curriculum design, which in turn were developed into a tool, "curriculum alignment canvas". Built upon Biggs' (1996) constructive alignment model as the common denominator across the various disciplines, the tool (Figure 3) was designed to encompass the following six elements:

- **Syllabus**: Breaking down the context of which the course operates in, as well as the trends and external influences that drive this.
- **Levels of 'Difficulty'**: Acknowledging that there are varied levels of knowledge within the diverse student body is critical. 'Difficulty' here refers to the considerations for evaluation in correlation to the individual's relative prior experience and knowledge. In a way, this means that students are evaluated on their individual growth and learning rather than on a yardstick.
- **Intended Learning Outcomes (ILOs)**: Identifying the skills and knowledge that the course is intended to equip the students with.
- **Theoretical Learning Artefacts**: Grounded in theory and literature, students will use these materials in relation to the activities to achieve the ILOs.
- **Practical Learning Activities**: The format in which learning, and teaching will take place. These activities provide the environment to which the artefacts will make sense for achieving the ILOs.
- **Evaluation and Assessment**: The teaching methods used and the assessment tasks, have to be aligned with the learning activities assumed in the intended outcomes. As a result, the learner is in a sense "trapped", and finds it difficult to escape without learning what he or she is intended to learn (Biggs, 1996).
- These elements were crystallised through the analysis and review of past and existing syllabus archives. Most of these elements were present in individual course designs, however, the approach and attention to each component varied depending on instructor. The format of each syllabus was also presented differently, depending on the instructor's preference and focus. As such, the tool was designed to provide the instructors with a shared vocabulary in the process of program development and their individual course redesign.

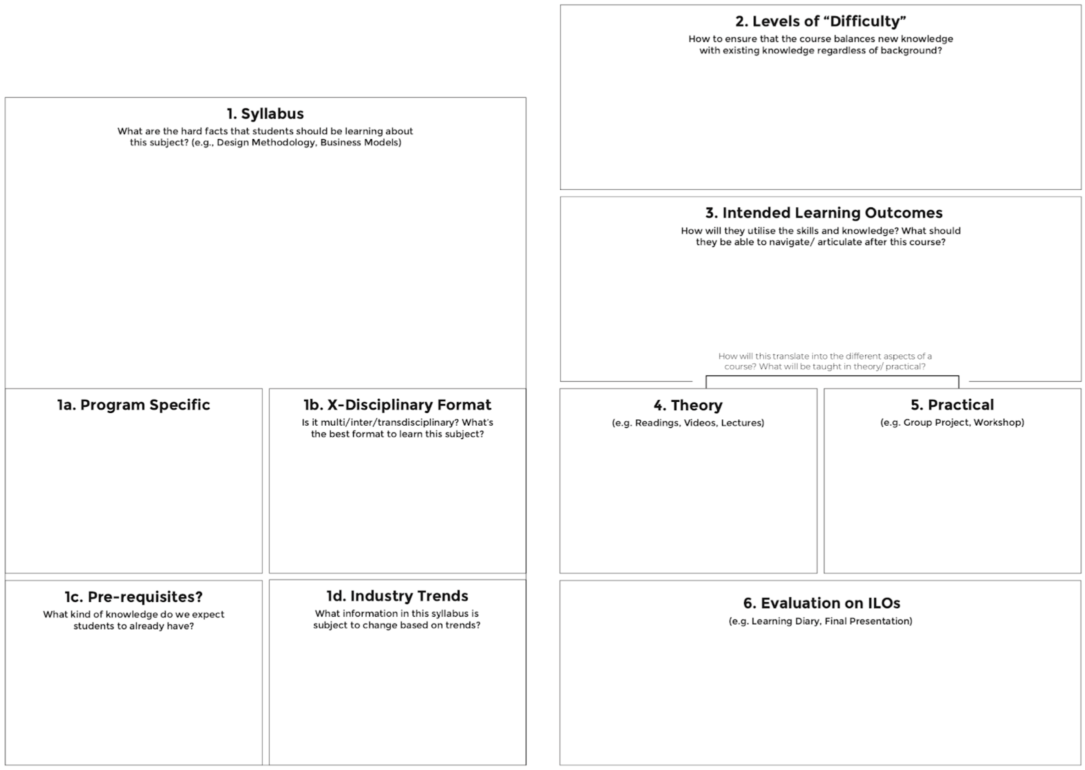


Figure 3 Curriculum Alignment Canvas

Taking shape in the format of a canvas to be used in collaborative settings with faculty members for the redesign of the program's foundational courses, the tool played a central role in navigating an understanding of the key concerns and periphery considerations for each of the courses (Comi and Whyte, 2018).

First used in co-design workshops with individual faculty members, the three instructors teaching the foundational Design, Business and Technology courses were tasked to fill out the canvas by reflecting on their own curriculum plans and existing practices. The filled-out canvases were then used as a focal point for discussions in a co-design workshop with the rest of the faculty, framed as a strategy meeting.

In the individual setting, key issues of resonance were ironed out for each course by going over the format of the current curriculum. The goal here was to allow the instructors to articulate their rationales around their course design and discuss curriculum delivery challenges. Thereafter, the instructors engaged in ideation to suggest improvements to their existing curriculum. In these sessions, the instructors had not made significant changes to what they were intending to teach, but verbalizing their thoughts allowed them to sound out what the main priorities were, as well as the pitfalls for the existing curriculum. The one-to-one sessions also allowed the *steward* to seed a shared vocabulary through the canvas as a platform for discussion.

Thereafter, in the co-design workshop where all ten key faculty members were present, the agenda was broadly listed as curriculum planning for the following academic year. This provided a frame of mind for participants as they anticipated discourses around roles, rescheduling and improvements to the existing curriculum. In this setting, the filled-out canvases were put up on the walls to facilitate sharing around the existing syllabus and curriculum format of individual courses (see Figure 4).

*Figure 4 **C**anvases in use during Strategy Meeting Workshop*

A blank timeline of the academic year was also provided, as it allowed for visualization of individual course components. This setup as a tangible artefact for instructors to express the intent and pedagogy within and around their courses, as well as identify synergistic opportunities that were present in the larger context of the transdisciplinary program.

Although the same canvas was introduced to the individual instructors, they had filled them out differently, as each instructor had a different concern for their courses. This was especially evident when the canvases were put up adjacent to one another. Moreover, having familiarised themselves with the canvas' six elements in the earlier individual co-design sessions, the three instructors reflexively partook as co-facilitators in leading the collective co-design workshop. This allowed them to articulate their individual concerns and rationales, while creating a common understanding for the rest of the faculty. The workshop also provided an exemplified understanding of the nuances and underlying tensions that persist within existing siloed structures.

As such, the canvases acted as a starting point for discussions to be built upon. It was also the medium that enabled transparency and the acknowledgement of challenges between the various layers, actors, and elements of curriculum design as it provided a common platform for discussion and comparison.

4. Challenges in Transdisciplinary Curriculum Development and Future Opportunities

Our data reveals multiple challenges in transdisciplinary curriculum development. Through thematic analysis (Braun and Clarke, 2006) we observed that challenges that were pertinent across various levels of the program's operations can be categorized as follows:

- The need for initiation and stewardship
- Lack of collective understanding towards transdisciplinarity
- Syllabi Incompatibility

In the following, we discuss our findings under each theme, explaining why and how these challenges persist.

4.1 The need for collaborative initiatives and stewardship

Having the instructors fill out the canvas and verbalize their thought processes behind the course development revealed that the course development is often done solitarily and disciplinarily, based on existing norms and practices within a discipline. However, this results in courses designed to be standalone, much like courses offered in various disciplinary-based programs. It is due to discipline-dominated administrative structures and reductionism within institutions (Ertas et al., 2003; Klein, 2008), where bottlenecks often occur in transcending disciplinary silos (Mieyeville et al., 2015; Ramadier, 2004). Customarily, curating the design and development of any education program is perceived as the role of the program's steering committee that decides the teaching directive. However, design and development in a transdisciplinary program demands the contribution of various expertise, and thus requires community efforts.

In transdisciplinary programs where diversity and representation are vital to its success, facilitation of such settings requires a "*steward*". Comparable to "innovation champions" (Kotter, 2007; Cooper, Junginger and Lockwood, 2013), who are seen as key agents who extend beyond their formal role to engage in innovation (Bankins et al., 2016) and implement the use of design in an organization to bring creative ideas to life; the steward's primary role is to guide collective curriculum development (cutting across the different disciplines) by putting the intended learning outcomes at the forefront. This process is referred to as "designing backwards", by first establishing what the level of outcomes and standards were required and then deciding on the logistical details (Angelo, 2012).

Alongside the program director whose role is to make strategic decisions, the steward facilitates transdisciplinary discussions by identifying and harnessing the synergistic opportunities between stakeholders while navigating tensions. This role can be akin to an "insider-consultant", best portrayed by a non-partisan personality unbound by disciplinary limits and hierarchy. This role requires a certain level of familiarity with the program structure, but also agility and flexibility within the organisation (i.e., non-teaching staff, program manager, coordinator or researcher). The appointed person often has to rally support and interests from within the institution and play the mediator role.

4.2 Lack of collective understanding towards transdisciplinarity

Through the co-design workshops, all participants agreed that the concept of transdisciplinarity is best communicated through the program structure. As discussed in the case section, the goal is to provide students with an opportunity to build a repertoire of understanding through exposure to individual disciplinary perspectives within course contexts.

However, because the topic of transdisciplinarity is so loosely understood, it is critical to set up the threshold concept (Land, 2012b) through curriculum design. In this setting, the threshold concept refers to crafting the liminal boundaries within each course– depth of individual subjectivity and scope of perspectives to consider (e.g., what are the distinct or overlapping boundaries between design and business?). These parameters allow students to navigate what may be counterintuitive for them, as they encounter unfamiliar discourses in the process of acquiring new knowledge and relinquishing old knowledge (Land, 2012a).

This is critical not just for the students, but also for the faculty members, as the alignment amongst instructors creates the basis for students' understanding and in turn affects the collective crafting of learning objectives of the program. Fundamentally, the concept of transdisciplinarity looks at tackling complex challenges by having a well-rounded understanding of the present world, of which one of the imperatives is the unity of knowledge (Nicolescu, 1999). Thus, identifying a shared ground or "boundary objects (Star and Griesemer, 1989)" becomes a mandate. As such, the program curriculum could provide a platform whereby viewpoints are explored through different disciplinary lenses; and encompasses the recognition of diverse views, experiences, and cultural backgrounds.

4.3 Syllabi Incompatibility

Unlike disciplinary-based programs that typically use similar metrics for evaluation and intended learning objectives, it is critical to recognize that different disciplines have different approaches in teaching and learning (Land, 2012a). One of the main struggles we identified in the co-design workshops, was the lack of shared practices for reviewing and crafting the program's syllabi collectively as each school and individual has their own *modus operandi*: this poses a considerable obstacle in developing a transdisciplinary program curriculum as there are diverse viewpoints.

In a transdisciplinary curriculum, it is critical to leverage on synergistic opportunities across disciplines to create a collective understanding of the topic/ challenge. As such, the syllabus of each individual course is no longer standalone, instead it provides one facet to a multi-dimensional understanding.

Due to the lack of shared platforms or standardisation in the way the syllabi and curriculum are structured for individual disciplinary courses, the dissimilarity and incompatibility made it extremely difficult to cross-reference and make comparisons across the course descriptions (assessment modes, session formats, content and study material). Not only were the syllabi varied in format, presentation and choice of platforms for dissemination; there was use of jargons and discipline-specific terminologies and frameworks that made it difficult for communication, much less an avenue to design and develop the curriculum together. As such, it is essential to distil commonalities or leverage on existing pedagogical frameworks (i.e., Biggs' (1996) Constructive Alignment as we have used here), in order to create shared platforms or standard practices for the development of syllabus and curriculum.

4.4 Opportunities for Design

Breaking down the layers of tensions and challenges that are causing impediment to implementation, we recognized that the issues listed here are interlaced and occur on several levels of transdisciplinary program's operations. While navigating the existing practices of curriculum development through action research, we identified the challenges around the need for collaborative initiatives and stewardship and lack of shared grounds for exploring varying viewpoints and syllabi development. At the same time, we also find opportunities for design in tackling these challenges (Table 2), especially because the existing siloed structures often call upon design's strengths in navigating organizational challenges and creativity in difficult situations (Junginger and Sangiorgi, 2009).

Table 2 Challenges in implementation of Transdisciplinary (TD) Curriculum and Opportunities for Design

Type of Challenge	**Challenges in implementation of TD Curriculum**	**Qualities of TD Curriculum**	**Opportunities for Design**
The need for collaborative initiatives and stewardship	Inertia from faculty to navigate current hierarchical and siloed institutional structures	Equal representation across participating disciplines (Faculty and Student body)	Playing the stewardship role in engaging stakeholders at the start of the co-creation process to elicit a sense of ownership amongst (potential) participating members

	Differences in curriculum design and needs across disciplines. Lack of understanding and platform to enable tangible contribution across disciplines	Real life challenge-based curriculum that allows for integration of various disciplinary perspectives	Identifying and sharing the needs of the involved parties (educators, students and management) through a co-design process Framing and re-framing the challenge brief to facilitate learning activities (Dorst, 2015)
	Lack of institutional support and autonomy/ flexibility	Need for institutional and management support in experimentation of curriculum design	Engaging the management level through a co-design process and presenting the needs and challenges of the students and educators Simulate future benefits through scenarios to actors and stakeholders
Lack of collective understanding towards transdisciplinarity	Challenge/ Project brief needs to be well-framed to allow students to operate within "threshold concept"	Intended level of ambiguity that facilitates the students' understanding of transdisciplinarity within set parameters	Identifying and sharing the needs of involved parties (educators, students and management) through a co-design process Framing and re-framing the challenge brief to facilitate learning activities
	Curriculum needs to be designed backwards and together	Creating Transparency, Structure and Clarity in Curriculum Design and Assessment through identification of collective intended learning outcomes	Visualizing/ navigating parallel goals and mapping a common understanding through visualization and co-design (e.g., Blueprinting)

	Assumptions due to lack of understanding, use of discipline-specific jargon. Lack of commitment and shared values	Shared platform/ understanding of transdisciplinarity and vocabulary, goal alignment and learning objectives	Revealing tensions and prejudices between actors through visualizations and co-design workshops Setting common/ compatible goals and experimenting collaborative platforms through a co-design process
Syllabi Incompatibility	Leveraging on different teaching and learning styles, varying levels of understanding and domain knowledge/ expertise	Distilling commonalities or leveraging on existing pedagogical frameworks to develop a shared platform for curriculum development	Visualizing instructors' thought processes for syllabi development and identifying common denominators through visualizations and co-design workshops
	Goals alignment and foundational understanding amongst all faculty members as a crucial starting point for developing strategy and processes that are complementary	Strategy is a key guiding factor for TD programs due to the heterogeneity of participants. A guiding document serves as a framework for the team Coherence, relevance and resonance are by-products of structural and processual clarity	Visualizing/ navigating parallel goals and mapping a common understanding through co-design (e.g. Blueprinting)

Moreover, the sticky nature of transdisciplinarity gives rise to circumstances where there is a constant need to engage stakeholders, resolve underlying tensions for framing, and creating a collective understanding. As such, we translate the challenges identified from the case study into qualities that transdisciplinary curriculum should consider and embrace, thereby suggesting a list of opportunities for design to play the facilitation role in transdisciplinarity.

5. Conclusion and Future Work

This paper presents our exploration into the existing challenges of the development of transdisciplinary education, and how design could play a role as a facilitator in aligning different expectations and knowledge among the involved parties. As the transdisciplinary nature of problems has gained currency, universities also ought to follow suit in equipping their students with relevant skills to solve such problems and challenges. We see transdisciplinary higher education as the medium, and thus have mapped the opportunities from design for facilitating a shared understanding and developing transdisciplinary curriculum.

In terms of limitations, our study took place only within a time period of six months, and as such we followed a temporal snapshot of an ongoing process towards transdisciplinarity. Moreover, the program we studied did not face as much inertia as other, more uni-disciplinary programs and therefore our analysis might be skewed with less resistance and administrative challenges experienced. Therefore, future research should include longitudinal cases in different institutional contexts. Finally, on a more practical level, our propositions on the opportunities for design should be developed into design interventions and tested in future inquiries.

6. References

Angelo, T. (2012). Designing Subjects for learning: Practical research-based principles and guidelines. In Hunt, L., and Chalmers, D. (Eds.), *University Teaching in Focus: A learning-centered approach* (pp. 93-111). London: Routledge.

Bankins, S., Denness, B., Kriz, A. and Molloy, C., 2017. Innovation agents in the public sector: Applying champion and promotor theory to explore innovation in the Australian Public Service. *Australian Journal of Public Administration*, *76*(1), (pp.122-137).

Bason, C. (2010). Leading public sector innovation: Co-creating for a better society. Bristol, UK: Policy Press

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education*, 32(3), 347-364.

Boland, R. J., and Collopy, F. (2004). *Design matters for management* (pp. 3-18). na.

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Bremner, C., and Rodgers, P. (2013). Design without discipline. *Design Issues, 29(3)*, 4-13.

Brown, T. (2009). Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. New York: Harper Colins

Brown, V. A., Deane, P. M., Harris, J. A., and Russell, J. Y. (2010). Towards a Just and Sustainable Future. In Tackling Wicked Problems: Through the Transdisciplinary Imagination(pp. 3-15). New York, NY: Earthscan.

Buchanan, R. (1992). Wicked problems in design thinking. Design Issues, 8(2), 5–21. http://doi.org/10.2307/1511637

CERI (Centre for Educational Research and Innovation), 1972. *Interdisciplinarity: Problems of Teaching and Research in Universities*. Paris: OECD.

Comi, A., and Whyte, J. (2018). Future Making and Visual Artefacts: An Ethnographic Study of a Design Project. *Organization Studies*, 39(8), 1055-1083. https://doi.org/10.1177%2F0170840617717094

Cooper, R., Junginger, S., & Lockwood, T. (Eds.). (2013). *The handbook of design management*. A&C Black.

Dorst, K. (2015). Frame innovation: Create new thinking by design. Cambridge, MA: MIT Press.

Ertas, A., Maxwell, T., Rainey, V. P., and Tanik, M. M. (2003). Transformation of higher education: the transdisciplinary approach in engineering. *IEEE Transactions on Education, 46(2)*, 289-295.

Garbuio, M., Dong, A., Lin, N., Tschang, T., and Lovallo, D. (2016). Demystifying the genius of entrepreneurship: How design cognition can help create the next generation of entrepreneurs. *Academy of Management Learning and Education, 17(1)*, 41-61. https://doi.org/10.5465/amle.2016.0040

Gasper, D. (2010) Interdisciplinarity and Transdisciplinarity. Diverse purposes of research: Theory-oriented, situation-oriented, policy-oriented. In P. Thomson and M. Walker (Eds) *The Routledge Doctoral Student's Companion*. London and New York: Routledge.

Gibbs, P. (Ed.). (2017). Transdisciplinary higher education: A theoretical basis revealed in practice. Springer.

Hadorn, G. H., Bradley, D., Pohl, C., Rist, S., and Wiesmann, U. (2006). Implications of transdisciplinarity for sustainability research. *Ecological economics, 60(1)*, 119-128.

Huntjens, P., Eshuis, J., Termeer, C. J. A. M., van Buuren, M. W., and van Vliet, M.(2014). *Forms and foundations of action research*. Routledge, London.

Hyun, E., 2011. Transdisciplinary higher education curriculum: a complicated cultural artifact. *Research in Higher Education Journal,* 11, p.1.

Hyvärinen, J., Lee, J.-J., and Mattelmäki, T. (2015). Fragile liaisons: Challenges in cross-organizational service networks and the role of design. *The Design Journal, 18(2),* 249–268.

Hyysalo, S., Marttila, T., Perikangas, S., and Auvinen, K. (2019). Codesign for transitions governance: A mid-range pathway creation toolset for accelerating sociotechnical change. *Design Studies, 63,* 181-203. https://doi.org/10.1016/j.destud.2019.05.002

Jahn, T., Bergmann, M., and Keil, F. (2012). Transdisciplinarity: Between mainstreaming and marginalization. *Ecological Economics,79,* 1-10. doi:10.1016/j.ecolecon.2012.04.017

Junginger, S. (2009) 'Designing from the Outside In: The Key to Organizational Change' in Proceedings of the 8th Conference of the European Academy of Design, Aberdeen.

Junginger, S. and Sangiorgi, D. (2009) 'Service design and organizational change: Bridging the gap between rigour and relevance'. In *3rd IASDR Conference on Design Research,* Seoul, Korea.

Kimbell, L. 2011. "Rethinking Design Thinking." *Design and Culture*, 3(3): 285–306.

Klein, J.T. (2004). Prospects for transdisciplinarity. *Futures, 36,* 515–526. https://doi.org/10.1016/j.futures.2003.10.007

Klein, J.T. (2008) Education. In: Hadorn G.H. et al. (eds) Handbook of Transdisciplinary Research. Springer, Dordrecht

Land, R. (2012a). Discipline-based Teaching. In Hunt, L., and Chalmers, D. (Eds.), *University Teaching in Focus: A learning-centered approach* (pp.38-55). London: Routledge.

Land, R. (2012b). In Trowler, P., Saunders, M., and Bamber, V. (Eds.), Tribes and territories in the 21st-century: rethinking the significance of disciplines in higher education (pp. 175-185). New York: Routledge.

Lawrence, R. J., and Després, C. (2004). Futures of transdisciplinarity. *Futures, 4(36)*, 397-405.

Lewin, K. (1958). *Group decision and social change*. New York Holt, Rinehart and Winston.

Lee, J-J., Jaatinen, M., Salmi, A., Mattelmäki, T., Smeds, R., and Holopainen, M. (2018). Design choices framework for co-creation projects. *International Journal of Design, 12(2)*, 15-31.Mieyeville, F., Gaultier, R., Péché, J. P., and Silberzahn, P. (2015, April). A design-based approach research on innovation: from multidisciplinarity to transdisciplinarity. In EAD11: 11th Conf of the European Academy of Design: The value of design research (pp. 1-13).

Kotter, J., 2007. Leading change: Why transformation efforts fail. *Harvard Business Review*, *86*, (pp.97-103).

Martin, R. 2009. The Design of Business: Why Design Thinking Is the Next Competitive Advantage. Cambridge, MA: Harvard Business Press.

Muratovski, G. (2015). Research for designers: A guide to methods and practice. Sage.

Nicolescu, B. (1999). The transdisciplinary evolution of learning. In Symposium on Overcoming the Underdevelopment of Learning at the Annual Meeting of the American Educational Research Association, Montreal, Canada.

Nicolescu, B. (2005). Towards transdisciplinary education. *TD: The Journal for Transdisciplinary Research in Southern Africa*, 1(1), 5-15.

Nicolescu, B. (2006). Transdisciplinarity: past, present and future. Moving Worldviews: Reshaping sciences, policies and practices for endogenous sustainable development. *ETC/COMPAS, Leusden*, 142-166.

Nicolescu, B. (2010). Methodology of Transdisciplinarity–Levels of Reality, Logic of the Included Middle and Complexity. *The ATLAS Transdisciplinary-Transnational-Transcultural Bi-Annual Meeting.*

Pike, K. L. (1967). Etic and emic standpoints for the description of behavior.

Ramadier, T. (2004). Transdisciplinarity and its challenges: the case of urban studies. Futures, 36(4), 423-439.

Rittel, H., and Webber. M. (1973). Dilemmas in a General Theory of Planning, *Policy Sciences*, Vol. 4, pp. 155–169.Sangiorgi, D. (2011) 'Transformative services and transformation design', *International Journal of Design*, 5(2), pp. 29-40.

Russell, A. W., Wickson, F., and Carew, A. L. (2008). Transdisciplinarity: Context, contradictions and capacity. *Futures, 40(5)*, 460-472. doi:10.1016/j.futures.2007.10.005

Self, J. A., and Baek, J. S. (2017). Interdisciplinarity in design education: Understanding the undergraduate student experience. *International Journal of Technology and Design Education, 27(3)*, 459-480.

Self, J. A., Evans, M., Jun, T., and Southee, D. (2018). Interdisciplinary: challenges and opportunities for design education. *International Journal of Technology and Design Education*, 1-34.

Star, S. L., and Griesemer, J. R. (1989). Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science*, 19(3), 387-420.

Tully, R. (2013). Design education; at the crossroads of different disciplines. Paper presented at the Proceedings of the 15th International Conference on Engineering and Product Design Education: Design Education - Growing our Future, EPDE 2013, 830-835.

Waterman, H., Tillen, D., Dickson, R., and De Koning, K. (2001). Action research: a systematic review and guidance for assessment. *Health technology assessment (Winchester, England), 5(23),* iii.

About the Authors:

JiaYing Chew is an Education Design Strategist at the Division of Industrial Design, National University of Singapore. Her current research interests focus on design-driven transdisciplinary higher education, social innovation and the role of design in systems-level transitions.

Jung-Joo Lee is an Assistant Professor and Deputy Head of Research in the Division of Industrial Design, National University of Singapore. Since 2014 she heads Service Design Lab Singapore and her research focuses on service design for organisation transformation.

Miikka J. Lehtonen is an Assistant Professor at Dubai Institute of Design and Innovation and one of the co-founders of the Nordic Rebels movement. He earned his PhD from Aalto University School of Business in 2014. Miikka's current research interests focus on visual methodologies, design management, and the game industry.

Design Pedagogy SIG

Overview of papers in the Design Pedagogy SIG highlights

Editorial: Design Pedagogy

Derek JONES[a*], Liv Meret NIELSON[b], Ingvild Digranes[c], Nicole LOTZ[a], Lesley-Ann NOEL[d], Naz A G Z BÖREKÇI[e]
Co-conveners of the DRS Design Pedagogy Special Interest Group (PedSIG)

[a] The Open University, UK
[b] Oslomet, Norway
[c] Western Norway University of Applied Science, Norway
[d] Tulane University, US
[e] METU, Turkey
*derek.jones@open.ac.uk
doi: https://doi.org/10.21606/drs.2020.123

The number of DRS 2020 paper submissions relating to design education reflects the ongoing and active engagement of the design education research community. 2020 will, of course, be remembered for the Covid-19 pandemic and its impact on design education programs and colleagues around the world. The rapid shift to new and unfamiliar modes of delivery has been a challenge for teaching colleagues and design students and looks likely to have further longer-term impacts over the next years.

The pandemic has highlighted a number of issues in design education. Colleagues have had to be far more explicit and articulate about design education and confront a number of assumptions taken for granted in proximate and synchronous teaching settings. For many, this has been a particular challenge: our (design) knowledge is often experiential making it exceptionally difficult to communicate. But this is part of the ongoing maturation of design education research as its own area of inquiry, reflected in many of the papers submitted this year.

A particularly strong theme in papers this year is the continuing debate around the purpose of design education. In particular, whether its value should be the induction of students towards a profession or the development of individual learners' general design competencies and abilities (papers 120, 193, 386). Another theme is that of the relationship between student and teacher and its importance in design learning. The complexity of what is a complex and nuanced relationship like this is explored in terms of how this can be reconsidered and reshaped (papers 157, 194, 315).

And, of course, there are many papers describing case studies of design instruction, studios, curricula, and courses. These give a sense of the contemporary landscape of design education and highlight the importance of sharing knowledge in the community of design educators.

Some institutions have seen the pandemic as an opportunity to rethink approaches: to explore critical pedagogy and ideas. For others, the necessity of physical learning in proximity to experts has been more challenging to replicate. And, for yet others, the uncertainties of unpredictable learning contexts and unreliable technologies are simply an everyday reality. The exposure of these challenges has highlighted the importance of having an inclusive design education research community that recognises and values all design education colleagues.

The DRS Pedagogy SIG Convening Team.

About the Authors:

Naz A.G.Z. Börekçi received her BID from METU Department of Industrial Design (1995); MFA from Bilkent University IAED (1997); PhD from University of Kent at Canterbury / KIAD (2003). She is currently Associate Professor at METU Department of Industrial Design.

Lesley-Ann Noel is Associate Director of Design Thinking at the Phyllis M. Taylor Center for Social Innovation and Design Thinking at Tulane University. She received her PhD from NCSU, MBA from the UWI and BID from UFPR.

Derek Jones is a Senior Lecturer in Design at The Open University (UK), part of the OU Design Group, and the Convenor of the DRS Pedagogy SIG. His research interests are: the pedagogy of design, embodied cognition in physical and virtual environments, and theories of design knowledge.

Liv Merete Nielsen has her PhD from Oslo School of Arcitecture, Norway (2000) and teacher training from Konstfack University of Arts, Crafts and Design, Sweden (1978). Professor at Faculty of Technology, art and design, OsloMet, Norway since 2003.

Nicole Lotz is a Senior Lecturer in Design at The Open University, UK. Nicole is interested in design processes across cultures and levels of expertise and she has studied co-located as well as distance designing across Europe, USA, Africa and South East Asia.

Ingvild Digranes is a Professor in Art and Design Education at Western Norway University of Applied Science. Ingvild was a lead organiser for the first Learn X Design conference in Oslo, 2013.

For more information on the Design Pedagogy SIG, please visit the SIG's webpage at http://drs.silkstart.com/cpages/design-pedagogy-sig. To find out whether the SIG is organising a satellite event to the DRS2020 conference, or just to get in touch with members and see news on the SIG, please visit the SIG webpage.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Educating for design character in higher education: Challenges in studio pedagogy

Elizabeth BOLING[a], Colin M. GRAY[b]*, Kennon M. SMITH[a]

[a] Indiana University, United States of America
[b] Purdue University, United States of America
*Corresponding author e-mail: gray42@purdue.edu
doi: https://doi.org/10.21606/drs.2020.120

Abstract: Some particular challenges in studio pedagogy arise from teaching for design character versus focusing solely on skills, knowledge or the cognitive processes of our students. In this paper, three authors with extensive combined experience in studio learning, teaching, and scholarship address these challenges via reflection on our own experiences of research and teaching and in-depth discussion with each other. We adopt a co/autoethnographic approach (Coia & Taylor, 2009), identifying a range of challenges we have faced ourselves across three established and emergent design disciplines. These challenges are grouped in relationship to students, to curriculum, to our colleagues, and to ourselves. In our experience these challenges affect instructors differently than—and in addition to—those presented by traditional studio, and we present opportunities to build on these articulated challenges to further studio pedagogy.

Keywords: design pedagogy; design character; studio pedagogy

1. Introduction

Within three studio settings in higher education, we address the pedagogical challenges of teaching from a philosophical perspective placing the students' character, rather than their cognition, at the center of design learning. Each of us has conducted studies embedded in studio teaching, at both the graduate and undergraduate level, over a combined 20+ years during which we were also mutually involved in reflection and discussion of studio teaching. We reviewed all these studies independently and jointly reflected on our own experiences via extended discussion through the lens of pedagogical challenge.

2. Education for design character

The cognitive perspective on teaching and practicing design emphasizes mental processes and the actions (design moves) to which they give rise (Cross, 2011; Lawson 2006; Lawson

& Dorst, 2009; Schön, 1983). In comparison—although not in full opposition to—the cognitive perspective, Nelson and Stolterman (2012) build a philosophical perspective which positions the full character of the designer, not just the designer's thinking, at the center of the activity of designing. They explain that designers' beliefs, experiences and faculties of judgment, in addition to cognitive knowledge and processes, are critical to designing and that "becoming a designer … means maturing as a whole person within larger webs of life—natural, social, and cultural … listening to the inner guidance of the seed of character pushing for full expression in a well-lived life" (p. 215). This perspective is by no means ubiquitous, or even widespread, in design education, where even discussions of future trends are notably focused on cognition and skills (Baynes, 2010; Davis; 2017; Ockman & Williamson, 2012; Salama & Wilkinson, 2007), although it does appear (McClean & Hourigan, 2015; McDonald &. Michela, 2019). As educators who have taught from this perspective in increasingly deliberate ways, our emergent realization is that the future of design practice depends on such a shift in design pedagogy (Boling, 2016; Boling & Smith, 2018).

Logically and experientially, this perspective carries implications for design teaching. When we set out to address the whole student, we have to begin with their "capacities, interests, and habits" (Dewey, 1925), not assuming they are simply non-designers (Siegel & Stolterman, 2008), but considering and valuing what they bring to the studio (Boling & Gray, 2015b; Boling, Gray, & Smith, 2017; Gray, 2013). From this starting point, we have to recognize the complex academic lives in which our students participate during their studies as well (Gray, 2014; Boling, 2016). Our concern for their individual development requires that we appreciate differences in the designers they will become, rather than assuming each will—or should—learn now, or later practice, in the same way as all the others (Nelson & Stolterman, 2012; Boling & Smith, 2014; Smith, 2015). Adopting a perspective that calls for educating the whole student—intentionally and systematically developing their design character—has been for each of us an individual matter linked to and informing our scholarship (Gray, 2014; Boling, 2016; Smith, 2016).

3. Method of this study: Co/autoethnography

We conducted this study as co/autoethnography (Coia & Taylor, 2009), a collaborative method elaborated as a means to "examine our teaching selves" (p.3). The method comprises a process of iterative writing, reflection, talking and feedback, interspersed with practice and followed by collaborative writing and editing of the research paper. This method suggested itself as appropriate for our exploration of the challenges we have encountered, and continue to encounter, as studio instructors who pursue education of the whole designer versus education as transmission of knowledge and skill. We recognized that the first elements of the method had been pursued between us over a period of a decade as we taught in higher education and discussed our teaching with each other, and as we conducted individual and co-authored studies within our individual classrooms, discussing those studies with each other repeatedly over time. At one point each of us has taught either single sessions or entire terms of the same studio class in the first author's program, in which cases our discussions of teaching have focused on fully shared experiences and collaborative goals.

To carry out the final stages of this method, the authors reviewed our own previously published studies relevant to design pedagogy, some co-authored between us and some individually authored. We attended to explicit, and implicit, statements we had made in those studies regarding the challenges inherent in educating for design character. We brought these statements to multiple hours of culminating, in-depth discussion during which we shared our thoughts on the lens of the pedagogical challenges arising from emergent studio practice focused on development of design character and on the particulars of those challenges. Our discussion ranged beyond the formal studies any of us has conducted to include additional studio teaching experiences on which we had reflected together previously and were reflecting in the moment.

The flow of that discussion included points at which our streams of thought converged on certain challenges, and points at which they diverged, based primarily on differences in the fields where we teach. We questioned each other and ourselves regarding our perceptions and experiences, confirming some ideas and rendering others more complex. As long-time collaborators, we felt comfortable to challenge ourselves and one another during this discussion so that it was as rigorous as we could make it. The discussion yielded a dozen top level issues addressing the challenges of educating for design character, and over 50 related issues. Later, the extended list of topics we generated through our discussion was examined to discover repeated items, connected items, and items that were extensions of others, or explanations of others. We did not write the draft of our study together in real time, but shared it between ourselves for mutual review and revision.

4. Authors' backgrounds and contexts of teaching

The authors of this chapter hold degrees earned in studio-based programs including fine arts printmaking (Elizabeth), graphic design (Colin) and architectural studies (Kennon). These experiences enculturated us into what might be called traditional studio—classes held in big rooms with large windows, outfitted with specialized equipment and materials; long days and nights spent on individual projects; regular desk and wall critiques carried out with strong emphasis on competitive performance; with full aesthetic and technical authority vested in the instructors (Brandt et al., 2013).

As university faculty members, each of us has also taught in studio settings, some more and some less traditional. Elizabeth introduced, and is still teaching, a summer elective (Instructional Graphics Design) in the masters level curriculum in instructional design at Indiana University in 2009. Kennon also taught this course one summer, and Colin took the course several years ago. At the time of this writing Elizabeth is teaching and coordinating that same masters program, now in a studio-based format, revised together with colleagues two semesters previously.

Colin teaches user experience (UX) design and leads the UX Pedagogy and Practice Lab (UXP^2) at Purdue University in the Purdue Polytechnic Institute. He has co-developed one of the first undergraduate studio-based programs in UX design in the United States (Vorvoreanu, Gray, Parsons, & Rasche, 2017), building on his professional experiences as a graphic and instructional designer and academic experiences in graphic design, instructional design, and human-computer interaction. This program relies on an integrated model of studio education, bridging multiple disciplinary perspectives on which UX design relies, including psychology, anthropology, visual design, and development.

Kennon currently teaches in the Eskenazi School of Art, Architecture, and Design at Indiana University. Courses in the school include a mix of lecture- and studio-based formats, both of which she has taught. Specifically, she has taught a range lecture-based courses addressing topics such as construction methods, design materials, and design history, as well as approximately ten undergraduate design studios for interior design majors.

Each of us brings experience from practice to our studio teaching. Elizabeth spent five years illustrating and designing educational software, and five more managing graphics and animation design for digital in-box documentation at a Fortune 100 technology company before joining the faculty of Indiana University. Colin worked as an art director, contract designer, and trainer in South Carolina prior to beginning his doctoral study. Before joining the design faculty at IU, Kennon worked professionally at design firms in Utah and Arizona, and worked as an instructional systems designer in the Midwest United States, creating instructional and procedural materials associated with critical processes for one of the world's largest pharmaceutical companies.

5. Challenges

We addressed the challenges faced by instructors in the studio rather than any other stakeholders because instructors shape and drive the nature of each studio as a learning environment (Davis, 2017). We grouped these challenges according to the contexts in which instructors encounter and grapple with them.

5.1 Challenges in the context of students

Managing complex relationships influenced by power dynamics. The (incomplete) transformation of architectural studios, and those modeled after them, from overwhelmingly male, rigidly hierarchical and mercilessly competitive, to an increasingly open, collaborative and transparent format has been underway for well over half a century (Ockman & Williamson, 2012). In our experience, this means that relationships in general have gotten more complicated, while power relationships remain as a factor. Within the university structure we assess our students' progress and their performance, while within the modern studio structure we act as their guides, supporters and even collaborators (Boling, Siegel, Smith, & Parrish, 2013). Arguably this is more confusing for our students, and for us, than was true in the days of closed juries and competition-based progress through educational programs. To complicate these relationships further, vertical integration of curricula and formal mentorship programs call upon students to attend to power dynamics in multiple ways, both towards instructors and their colleagues (Gray & Howard, 2015). When we are concerned with design character, we cannot view these dynamics simply as complications in teaching, but as forces to be negotiated for active, positive purposes.

Attending to dimensions of learning beyond knowledge and skill. Declarative and performative learning are clearly part of learning design (Cross, 2011; Davis, 2017; Brown, 2019), and they offer their own challenges. Lawson and Dorst (2009), speaking from a cognitive perspective and from observations of instructors (tutors) holding discussions in the studio, acknowledge that they "require enormous skill to manage" (p. 256), while Fleming's (1998) investigation of design talk between students and instructors observes that the instructor "... has to satisfy conflicting goals: responding to students' work without actually designing for them" (p. 62). Davis (2017), who also frames design education in terms of skills and knowledge, does observe that students learn the values of their design profession through critiques offered by faculty, whether these are explicitly stated or not. This process, as described, is more received than collaborative.

However, teaching from the perspective that design entails the whole person requires that we know the whole person, begging the question—how much do we need to know, and how much should we know? This is a challenge. While Nelson and Stolterman (2012) discuss core judgments of designers as being fundamental to their character, so basic that the designers themselves may not have access to them, do we, as the instructors of student designers, have to dig so deep? Should we? On a day to day basis in the studio, when we are not just modeling or explicating values, but engaging students in discussing and developing their professional character collaboratively, these decisions have to be made. We have to decide for ourselves when a personal revelation or confidence is rightly available to be used in learning, and when such use would be more exploitative than is warranted for potential gain. Even when we are well-intentioned, and when we may know, for example, that a students' private concerns are shaping their views and actions in design, do we have the right to probe those concerns—especially if we are leveraging our power positions to do so? And when, and how, do we communicate boundaries to our students when we do have those boundaries figured out? It can be difficult to present as a helpful partner in the hard, personal work of developing design character in one moment, and an education professional at arms' length the next.

A similar concern involves the inevitable and productive pain of learning (Adler, 1941; Mintz, 2008). Rather than distancing ourselves from our students' pain, addressing them as whole persons while they learn requires recognizing their pain, acknowledging that we have set up the circumstances for creating it, and constantly assessing how much of it is productive versus that which we could and should work to eliminate. This requires almost constant examination of what we are doing, what we expect to accomplish, and what assumptions we are making about the studio. Elkins' (2001) examination of critique practice in the arts offers a detailed—and excruciating—deconstruction of the fine arts studio critique, illustrating multiple points at which pain is inflicted through the unexamined enactment of interchanges with which we are familiar from our own experiences, and to which we may even subscribe as necessary for learning. It can take some time to let go of practices, even with attention (Boling & Gray, 2015a; Boling & Smith, 2010).

Our perspective on teaching is supported by Austerlitz and Aravot's (2007) conclusion that "design students, not unlike others, learn with the whole range of their human capacities and not as intellectual beings only … [and therefore] it seems imperative to look into the role at emotions in their learning" (p. 235). Engaging the emotional energy of students in order to know them individually, support their development and help them navigate pain in learning, requires constant responsiveness to them. This, in turn, requires terrific energy on our part. Attoe & Mugerauer (1991) document vitality, energy and excitement as several of the hallmarks of excellent studio teaching; our observation is that these overlay the energy requirement involved in teaching for the development of design character. The load may not be doubled, but it is substantial. We do not ignore the influx of energy that comes to us from the students, but realize that sometimes it does not fully offset the outlay from us.

Seeing the individual within the patterns of students' learning. A commitment to educate the whole student designer entails an appreciation of the individual, and where the individual is at any given time, even though experience makes it clear that there are patterns—at least, cognitive patterns—in their learning (Crismond &. Adams, 2012; Dorst &. Reymen, 2004; Siegel & Stolterman, 2008). Close study of design students shows, however, that while they may operate within larger patterns of learning (Atman, Chimka, Bursic, & Nachtmann, 1999; Ozkan & Dogan, 2013), students can legitimately, not erroneously, differ in the clusters of activities they use to approach and complete their designs (Boling & Smith, 2010). In the developmental view, these differences foreshadow the designers of differing strengths and sensibilities that they will come to be (Nelson & Stolterman, 2012), and in our study of students, these patterns of individual becoming seems to be related to the knowledge and the qualities they bring with them to the studio (Boling & Gray, 2015; Boling et al., 2017; Gray, 2013) as well as their social ties in the studio (Boling, 2016; Gray & Howard, 2015). Knowing all this and remembering it are two different propositions, however. The longer we teach, the more evident certain patterns become and it can be a challenge not to anticipate, or assume, where—or who—any given student may be in the moment.

5.2 Challenges in the context of colleagues.

In different ways for each of us, challenges involving colleagues arise in the context of studio teaching for development of design character. Where everyone shares an educational background that includes studio, we have found that differing experiences of studio and resulting pedagogical beliefs and philosophies can exist. Where no one else shares a background that includes studio, differences are inevitable. And where studio instructors come from multiple disciplinary backgrounds, negotiation of differences is equally inevitable. For example, the traditional view of studio "assumes the mastery of the studio instructor" (Salama & Wilkinson, 2007, p. 73), an assumption that fundamentally affects the roles and relationships of instructors and students—certainly making it difficult, or impossible, for an instructor to assume, say, a "mentor-companion" (Boling et al., 2013, p. 184), or a "squire riding alongside each [student]" (p. 186-7) role. When one instructor teaching part of a studio series holds a traditional view of studio and another holds a view oriented toward developing design character, a good deal of flexibility may be required on the part of those colleagues to adjust their roles to accommodate each other. Further, the colleague holding the less traditional view may have to explain more, offer more student support, and generally "make up the difference" between herself and colleagues. Similarly, an instructor enacting roles and practices from the perspective of both studio and teaching the whole designer in the design student (Boling et al., 2017) is likely to spend extra time with colleagues explaining both the perspective and the expectations to which it gives rise, and/or negotiating these with colleagues from other disciplines. Further, a negotiation with one or more colleagues from another discipline, or even those with colleagues in one's own, can be complicated by how variable the understandings of studio and its epistemological foundations are (Atman et al., 1999; Gray, 2016).

5.3 Challenges in the context of curriculum.

In a long-established field like architecture, where "a highly regulated regulatory scheme for ... state registration [of practitioners]" has its roots in the late 1800s (Ockman & Williamson, 2012), and interior design, where debates regarding legal regulation of the profession have been on-going for decades, there is "a real tension within the program's overall curriculum because there seems to be an ever-increasing body of content … which is necessary to meet accreditation standards … this eats into studio time where a "long" desk consultation between instructor and student may be 10-15 minutes, and these are difficult to accomplish for every student during a three-hour class session (Smith, 2016). Under these circumstances, finding the sheer time to know any individual student beyond the immediate concern of that student's work—as central to professional character as that work clearly is—can be difficult. However, developing such relationships may be equally critical to the educational endeavor as students report that their relationships with instructors, including a student's impression that the instructor does or does not have confidence in their abilities, may have significant impact on their developing design expertise (Boling, 2016) and on their perceptions of the validity of project assessments(Smith, 2013).

The challenge of a curriculum loaded with regulatory requirements is less problematic for instructional design where standards have existed for some time, but licensure (as in interior design where national criteria must be met by practitioners) does not (Koszalka, Russ-Eft, & Reiser, 2013). It is also less for user experience design where multiple entities promote standards but, again, there is no licensure and there have, in fact, only been specialized degree programs (e.g., Human Computer Interface (HCI), or UX (User Experience)) for less than a decade (Vorvoreanu et al., 2017; Kou & Gray, 2018). Another challenge arises, however, because in an open curriculum it can be difficult to define what is "enough" learning—and particularly so when attending to individual students' development is a central goal over and above ticking off the skills they have gained. This open-endedness is also a challenge in emerging trans-disciplines, where skills and knowledge are expected of students, both in a discrete disciplinary sense, and also through the traversal between disciplinary spaces where knowledge boundaries are contested and chaotic (Gray & Fernandez, 2018).

Finding and keeping the resources necessary for studio teaching is a challenge usually discussed in terms of affording workspace sufficient for student projects and dedicated to studio work for an adequate number of hours a day. This includes, as well, tools and resources specific to each area in which design is taught (Boling, 2016; Boling & Smith, 2009). While the resources necessary for studio in traditional disciplines have, in some ways, been quite stable, new disciplinary areas require new methodological, physical, and practical supports which deserve further investigation. For instance, while fabrication and making are central to disciplines such as architecture, what might resources entail when addressing third and fourth order design disciplines where the outputs are more ephemeral, such as services and systems? Therefore, this challenge is grouped with curriculum.

5.4 Challenges in the context of ourselves.

Once we move to expand our responsibilities in studio teaching to encompass design character, our own character is called into play. Davis (2017) discusses pedagogical styles in the studio (art-direction, Socratic and coaching) with examples of interchanges between instructor and student in each style, with the last sounding much like a frame experiment as presented by Schön (1983). Other options are available. An earlier study by Webster (2004) found that students perceived three roles in their tutors (studio instructors): "'the entertainer', 'the hegemonic overlord' and 'the liminal servant,'" with only the last perceived to support them (p. 101).

In our discussions and some of our writing (Boling et al., 2013; Exter, Gray, & Fernandez, 2019), we explore the need to recognize and inhabit roles in studio teaching—these are flexible ways of interacting with students on a holistic basis, covering all communications, including talking about design. Part of the challenge of inhabiting a role can be recognizing what fits you versus what may have been appropriate for a past, perhaps greatly admired, studio instructor of your own, and to inhabit that role fully and comfortably.

The roles we inhabit are ideally consistent with our values in teaching the whole design student of course, but the challenge does not stop with identifying, forging or building a role and then maintaining it. In the face of many complexities, holding onto and enacting a role tied to our values can be difficult. Even the most natural role requires reflexivity, because multiple questions arise as we teach: "am I operating within my role as I understand it?";, "does this role support this student appropriately at this moment ?"; and, as suggested by McDonald and Michela's 2019 study of critique in studio pedagogy, "is my understanding of the good I am trying to accomplish accurate?" and "how do I reconcile competing goods?"

As colleagues we agree that maintaining transparency with our students and keeping multiple options for studio interactions top of mind while we teach are essential when we are responding to the development of students, not just the improvement of their design cognition or moves. Both these responsibilities require a kind of fluid vigilance that traditional studio teaching, demanding enough in its own right, does not.

6. Conclusion

In this chapter we have built on years of shared and individual experiences, and on shared as well as individual scholarship in studio teaching, explored through joint discussion and analysis, to surface and examine the challenges that arise when studio instructors commit to developing design character in their students. We have recognized that the design learning experiences we had when we were students form a framework for the way we teach now, but that we have each been driven to reconsider those experiences in light of our changed and changing understanding of design teaching and learning.

Clearly, we have discussed challenges and raised questions here without presuming, or attempting, to offer resolution or answers. Each of us wrestles with these challenges more or less successfully—sometimes more, and sometimes much less, effectively. Knowlton (2016) has posited that, in the field of instructional design and technology, we need a "specific and meaningful prescription for pedagogy within [our] studios" (p. 352), which he points out is scant in the broader design literature as well. Possibly such prescriptions would make facing our challenges easier. As with prescriptive principles for design itself, however, it is doubtful that prescriptions can address the specific forms that challenges take in the "ultimate particular" of context without significant application of judgment on the part of instructors (Nelson & Stolterman, 2012)—particularly when those instructors are not simply teaching skills and knowledge while grappling with the bothersome social and emotional needs of students, but developing the professional character of those students as a primary goal of studio. As colleagues who have taught, learned, and conducted research together, we understand that the perspective we bring to studio teaching mandates that each of us finds our response to these challenges within our own professional character. It is fair to say that each of us has changed our own perspectives on studio and studio teaching as we have focused more explicitly on design character, and that we have therefore recognized our challenges differently than we did either early in our careers or when we were studio students ourselves. This has happened over time and "in the moment" as have any highly contextual efforts we have made to address them. We invite other studio instructors committed to a similar perspective to reflect continuously on their teaching practices (explicit and implicit), as a primary means of improving studio education—in their own studios and in their disciplines.

7. References

Adler, M. J. (1941). Invitation to the Pain of Learning. *The Journal of Educational Sociology, 14*(6), 358–363. https://doi.org/10.2307/2262535

Atman, C. J., Chimka, J. R., Bursic, K. M., & Nachtmann, H. L. (1999). A comparison of freshman and senior engineering design processes. *Design Studies*, *20*(2), 131–152. https://doi.org/10.1016/S0142-694X(98)00031-3

Attoe, W., & Mugerauer, R. (1991). Excellent studio teaching in architecture. *Studies in Higher Education, 16*(1), 41–50. https://doi.org/10.1080/03075079112331383081

Austerlitz, N., & Aravot, I. (2007). Emotions of architectural students: A new perspective for the design studio. *Design Studio Pedagogy: Horizons for the Future* (pp. 233–246).

Baynes, K. (2010). Models of Change: The future of design education. International Journal of *Technology and Design Education, 15*(3). Retrieved from https://jil.lboro.ac.uk/ojs/index.php/DATE/article/view/1532

Boling, E. (2016). How I learned, unlearned, and learned studio again. In E. Boling, R. A. Schwier, C. M. Gray, K. M. Smith, & K. Campbell (Eds.), *Studio Teaching in Higher Education: Selected Design Cases* (pp. 100–112). New York, NY: Routledge.

Boling, E., & Gray, C. M. (2015a). Designerly Tools, Sketching, and Instructional Designers and the Guarantors of Design. In B. Hokanson, G. Clinton, & M. W. Tracey (Eds.), *The Design of Learning Experience: Creating the Future of Educational Technology* (pp. 109–126). Springer. https://doi.org/10.1007/978-3-319-16504-2_8

Boling, E., & Gray, C. M. (2015b, April). *Who are these novices? Challenging the deficit view of design students.* Presented at the American Educational Research Association (AERA) Annual Meeting, Chicago, IL, USA.

Boling, E., Gray, C. M., & Smith, K. M. (2017). *The designer in the design student: The evolution of feedback in an instructional graphics studio*. Presented at the American Educational Research Association (AERA) Annual Meeting, San Antonio, TX, USA.

Boling, E., Siegel, M. A., Smith, K. M., & Parrish, P. (2013). Student goes on a journey; stranger rides into the classroom: Narratives and the instructor in the design studio. Art, Design & Communication in Higher Education, 12(2), 179–194. https://doi.org/10.1386/adch.12.2.179_1

Boling, E., & Smith, K. M. (2009). *Design tensions: Adapting a signature pedagogy into instructional design education*. Presented at the American Educational Research Association (AERA) Annual Meeting, San Diego, CA, USA.

Boling, E., & Smith, K. M. (2010). *Intensive studio experience in a non-studio masters program: Student activities and thinking across levels of design*. Design Research Society International Conference.

Boling, E., & Smith, K. M. (2014). Critical Issues in Studio Pedagogy: Beyond the Mystique and Down to Business. In B. Hokanson & A. Gibbons (Eds.), *Design in Educational Technology: Design Thinking, Design Process, and the Design Studio* (pp. 37–56). https://doi.org/10.1007/978-3-319-00927-8_3

Boling, E., & Smith, K. M. (2018). Changing conceptions of design. In R. A. Reiser & J. Dempsey (Eds.) *Trends and Issues in Instructional Design and Technology* (pp. 323–330). Pearson.

Brandt, C. B., Cennamo, K., Douglas, S., Vernon, M., McGrath, M., & Reimer, Y. (2013). A theoretical framework for the studio as a learning environment. *International Journal of Technology and Design Education, 23*(2), 329–348. https://doi.org/10.1007/s10798-011-9181-5

Brown, T. (2019). *Change by Design, Revised and Updated: How Design Thinking Transforms Organizations and Inspires Innovation*. New York, NY: Harper Collins.

Coia, L., & Taylor, M. (2009). Co/autoethnography: Exploring Our Teaching Selves Collaboratively. In L. Fitzgerald, M. Heston, & D. Tidwell (Eds.), *Research Methods for the Self-study of Practice* (pp. 3–16). https://doi.org/10.1007/978-1-4020-9514-6_1

Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education, 101(*4), 738–797. https://doi.org/10.1002/j.2168-9830.2012.tb01127.x

Cross, N. (2011). *Design Thinking: Understanding How Designers Think and Work*. London, UK: Bloomsbury.

Davis, M. (2017). *Teaching Design: A Guide to Curriculum and Pedagogy for College Design Faculty and Teachers Who Use Design in Their Classrooms*. New York, NY: Allworth Press.

Dewey, J. (1925). My Pedagogic Creed. *Journal of Education, 101*(18), 490–490. https://doi.org/10.1177/002205742510101803

Dorst, K., & Reymen, I. (2004). Levels of expertise in design education. *DS 33: Proceedings of E&PDE 2004, the 7th International Conference on Engineering and Product Design Education*, Delft, the Netherlands, 02.-03.09 2004.

Elkins, J. (2001). *Why Art Cannot Be Taught: A Handbook for Art Students.* Chicago, IL: University of Illinois Press.

Exter, M. E., Gray, C. M., & Fernandez, T. M. (2019). Conceptions of design by transdisciplinary educators: disciplinary background and pedagogical engagement. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09520-w

Fleming, D. (1998). Design Talk: Constructing the Object in Studio Conversations. *Design Issues, 14*(2), 41–62. https://doi.org/10.2307/1511850

Gray, C. M. (2013). Informal peer critique and the negotiation of habitus in a design studio. *Art, Design & Communication in Higher Education, 12*(2), 195–209. https://doi.org/10.1386/adch.12.2.195_1

Gray, C. M. (2014). Living in two worlds: A critical ethnography of academic and proto-professional interactions in a human-computer interaction design studio. (Unpublished doctoral thesis). Indiana University, Bloomington, IN. Retrieved from http://hdl.handle.net/2022/18772

Gray, C. M. (2016). Emergent Views of Studio. In E. Boling, R. A. Schwier, C. M. Gray, K. M. Smith, & K. Campbell (Eds.), *Studio Teaching in Higher Education: Selected Design Cases* (pp. 271–281). New York, NY: Routledge.

Gray, C. M., & Fernandez, T. M. (2018). When World(view)s Collide: Contested Epistemologies and Ontologies in Transdisciplinary Education. *International Journal of Engineering Education, 34*(2), 574–589.

Gray, C. M., & Howard, C. D. (2015). "Why are they not responding to critique?": A student-centered construction of the crit. *LearnxDesign: The 3rd International Conference for Design Education Researchers and PreK-16 Design Educators* (pp. 1680–1700). Chicago, IL: School of the Art Institute of Chicago.

Knowlton, D. S. (2016). Design Studios in Instructional Design and Technology: What Are the Possibilities? *TechTrends*, *60*(4), 350–358. https://doi.org/10.1007/s11528-016-0073-0

Koszalka, T. A., Russ-Eft, D. F., & Reiser, R. (2013). *Instructional Designer Competencies: The Standards* (4th Edition). Information Age Publishing.

Kou, Y., & Gray, C. M. (2018). Towards Professionalization in an Online Community of Emerging Occupation: Discourses among UX Practitioners. *Proceedings of the 2018 ACM Conference on Supporting Groupwork* (pp. 322–334). New York, NY: ACM Press. https://doi.org/10.1145/3148330.3148352

Lawson, B. (2006). *How designers think*. Oxford, UK: Architectural Press.

Lawson, B., & Dorst, K. (2009). *Design Expertise*. New York, NY, USA: Routledge.

McClean, D., & Hourigan, N. (2013). Critical Dialogue in Architecture Studio: Peer Interaction and Feedback. *Journal for Education in the Built Environment, 8*(1), 35–57. https://doi.org/10.11120/jebe.2013.00004

McDonald, J. K., & Michela, E. (2019). The design critique and the moral goods of studio pedagogy. *Design Studies, 62*, 1–35. https://doi.org/10.1016/j.destud.2019.02.001

Mintz, A. (2008). *The labor of learning: A study of the role of pain in education*. (Unpublished doctoral thesis). Columbia University, New York, NY. Retrieved from http://search.proquest.com/openview/b34626626cbde7da1208fba719f20526/1?pq-origsite=gscholar&cbl=18750&diss=y

Nelson, H. G., & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world* (2nd ed.). Cambridge, MA: MIT Press.

Ockman, J., & Williamson, R. (2012). *Architecture school: three centuries of educating architects in North America*. Cambridge, MA: MIT Press.

Ozkan, O., & Dogan, F. (2013). Cognitive strategies of analogical reasoning in design: Differences between expert and novice designers. *Design Studies*, *34*(2), 161–192. https://doi.org/10.1016/j.destud.2012.11.006

Salama, A. M. A., & Wilkinson, N. (2007). *Design Studio Pedagogy: Horizons for the Future*. Urban International Press.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York, NY: Basic Books.

Siegel, M. A., & Stolterman, E. (2008). Metamorphosis: Transforming Non-designers into Designers. *Undisciplined! Design Research Society Conference 2008*, 378:1–13. Sheffield, UK: Sheffield Hallam University.

Smith, K. M. (2013). Assessment as a Barrier in Developing Design Expertise: Interior Design Student Perceptions of Meanings and Sources of Grades. *International Journal of Art & Design Education, 32*(2), 203–214. https://doi.org/10.1111/j.1476-8070.2013.01746.x

Smith, K. M. (2015). Conditions influencing the development of design expertise: As identified in interior design student accounts. *Design Studies, 36*, 77–98. https://doi.org/10.1016/j.destud.2014.09.001

Smith, K. M. (2016). Emergent tensions in teaching an interior design studio: Reflections and opportunistic redesign. In E. Boling, R. A. Schwier, C. M. Gray, K. M. Smith, & K. Campbell (Eds.), *Studio Teaching in Higher Education: Selected Design Cases* (pp. 72–84). New York, NY: Routledge.

Vorvoreanu, M., Gray, C. M., Parsons, P., & Rasche, N. (2017). Advancing UX Education: A Model for Integrated Studio Pedagogy. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 1441–1446. New York, NY: ACM Press. https://doi.org/10.1145/3025453.3025726

Webster, H. (2004). Facilitating critically reflective learning: excavating the role of the design tutor in architectural education. *Art, Design & Communication in Higher Education*, *2*(3), 101–111. https://doi.org/10.1386/adch.2.3.101/0

About the Authors:

Elizabeth Boling is professor of instructional systems technology in the School of Education at Indiana University. Prior experience includes 10 years in design practice, five with Apple Computer, Inc. Her research interests include visual design for information and instruction, and design theory, pedagogy and practice. She is past editor-in-chief of TechTrends, founding editor and current editor-in-chief of *International Journal of Designs for Learning*, lead editor of the forthcoming Routledge title *Historic Design Cases in Educational Technology* and a co-editor of the *Handbook of Research in Educational Communications and Technology*, 5th Edition.

Colin M. Gray is an Assistant Professor at Purdue University and program lead for an undergraduate major and graduate concentration in UX Design. His research focuses on the interplay between design theory and practice, and particularly the development of design expertise and ethical design character.

Kennon M. Smith is an Associate Professor of Design in the Eskenazi School of Art, Architecture + Design at Indiana University Bloomington. Her research interests include design pedagogy, design history, and comparative design.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Design Education for the Knowledge Society: An Action Research Study of Implementing a Liberal Arts Approach to Industrial Design Education

Luke FEAST[a]*

[a] Auckland University of Technology, New Zealand
*Corresponding author e-mail: lukefeast@gmail.com
doi: https://doi.org/10.21606/drs.2020.193

Abstract: Educationists have argued that professional design education has come to function as an alternative form of general liberal arts education. However, professional design education has not fully embraced the liberal arts model of education for democratic citizenship. More often design education teaches skills for maximizing economic growth. I investigated the implications of the liberal arts approach to design education by conducting action research in an industrial design program at a public university. The insights reveal that shifting from skills-based vocational training to knowledge-based liberal education is not only a matter of implementing different pedagogical methods, there may also be changes in teacher identity. I conclude that the abilities crucial for the liberal arts model of education for democracy align with the aspects of design education for post-industrial economies and the knowledge society.

Keywords: liberal arts; design education; teacher identity; peer learning

1. Education for Economic Growth or Human Development?

Trends in higher education have led educationists and academics to argue that design education has come to function as an alternative form of general liberal arts education (Buchanan, 1992, p. 5). Now students might choose to study design as they might choose to study the humanities and arts, that is, without the intention to pursue design as a career (Donald A. Schön, 1985, p. 2). Consequently, design education is caught within the 'The Conflict of the Faculties' between design as form of professional education and design as an alternative form of liberal arts education (Friedman, 2003, p. 245). Consequently, a core challenge for university-level design education is meeting the plural needs of educating students for a demanding job in a professional field and preparing citizens for life in the global knowledge economy (Friedman, 2002, pp. 27-33).

Liberal arts education, according to Martha Nussbaum (2012), is about "challenging the mind to become active, competent, and thoughtfully critical in a complex world" (p. 18) to "stimulate students to think and argue for themselves, rather than defer to tradition and authority" (p. 48). The ability to think critically and empathically about another with an understanding of the sociohistorical contexts of many cultures and nations enable democracies deal with the divisions within societies and work through the complex problems we face as members of an interdependent world (Nussbaum, 2012, p. 10). Consequently, Nussbaum (2012, p. 24) argues for a human development model of education for democracy, rather than a for-profit model of education aimed at maximizing economic growth. Education for democracy (Nussbaum, 2012, pp. 25-26) includes the ability to:

- think and deliberate about political issues without deferring to tradition or authority;
- recognise fellow citizens as people with equal rights who are worthy of respect;
- have concern for others and with a grasp of what different policies mean for others' opportunities for a good life;
- imagine complex issues that affect human lives;
- judge political leaders critically and realistically;
- think about the good of the nation as a whole, not only local issues;
- see one's nation as part of a world order where deliberation is needed to resolve transnational issues.

Professional design education has not fully embraced the human development model of education for democracy. Most often, design education is oriented towards skills training for economic growth. However, recently some researchers and academics have argued that design should support the kind of capability approach that Nussbaum advances (see, for example: Dong, 2008; Oosterlaken, 2012, 2013). Education in the abilities for democratic citizenship and communicative action of the kind that Nussbaum claims, produces the *synergy* associated with dealing with divisions in society to bring together people to meet the challenges of the present and future in an interconnected world. Consequently, this paper contributes to the DRS2020 conference theme by investigating the question: how might we incorporate the abilities for democratic citizenship and communicative action into design education?

2. Research Methodology

This project investigated incorporating communicative action into design education through conducting action research into teaching practise. This approach supplied opportunities for students to learn to communicate and think with clarity and vigour, and created conditions that enabled students to develop their own understanding of communicative action and design through implementing a constructionist rather than transmission model of education. For example:

- Students were provided with early access to the required learning materials and written questions so that students had enough time to do structured prereading.

- The class was periodically divided into groups to change pace and keep discussion going. For example, by asking students to form into small groups to answer specific questions about a text.
- The level of criticism was maintained by having students play defined conversation roles such as the story teller who presents a standpoint, or the detective who finds hidden assumptions, or the umpire who monitors conversation.
- Questioning, listening, and responding was used to keep discussion going. And student-to-student interaction was extended by responding using silence, inviting contrasting standpoints, or by restating comments.

In their book *Discussion as a Way of Teaching: Tools and Techniques for Democratic Classrooms*, Brookfield and Preskill (2005) describe how the properties of discussion groups support students to learn to do communicative action. These properties were implemented into the teaching activities in a series of action research cycles. Prior to this project, the teacher mostly utilised lectures to teach design theory and one-on-one desk reviews to teach design studio. Through completing the project, the teacher's practise changed to make use of peer-to-peer learning and their teacher identity changed from studio master to learning guide. Consequently, they aligned their actual teaching practise with their preferred theory of design pedagogy, and aligned their actual teacher identity in practice with their preferred teacher persona.

2.1 Utilising Action Research in Design Education

The primary investigator used action research as a framework to systematically self-reflect during their teaching practise. Action research is an approach that aligns well with Jurgen Habermas's (1984, 1987) theory of communicative action (Kemmis & McTaggart, 2005, p. 578). The history of action research goes back to the 1950s and draws on several related traditions such as participatory research, critical action research, action learning, action science, and soft systems approaches (Kemmis & McTaggart, 2005, pp. 560-562). Action research investigates actual practices in a specific concrete way that makes them available for discussion and reflection (Brookfield, 1995). The action research process that the primary investigator employed utilised the following sequence of cycles of implementation and reflection:

1. Planning activity
2. Acting and observing process and activity
3. Reflecting on process and consequences
4. Re-planning
5. Acting and observing again
6. Reflecting again

After each action, the primary investigator wrote entries in a journal in response to the following set of questions:

1. What outcomes did I obtain?

2. How well did they accord with the outcomes I desired?
3. In what ways was I mistaken about the desirability of the outcomes?
4. What have I learned about myself, my skills, and my attitudes?
5. What actions will I try next time?

The research was conducted on campus at a public university between August 2019 and November 2019. The primary investigator transformed the pedagogical properties of discussion groups into a set of practical techniques and approaches for design education. They conducted four cycles of planning, action, and reflection on the teaching and learning activities in an undergraduate Industrial Design Studio course and a corequisite Industrial Design Theory course.

The primary investigator's design approach was influenced by Roberto Verganti's (2016) model of design as *innovation of meaning* through the *art of criticism*. The project brief was to apply knowledge of collaborative industrial design to design a concept that supports sustainable intergenerational wellbeing.

Table 1 Syllabus Outline

Week	Design Studio	Design Theory	Core Readings
1	Observation	Design ethnography, HCD	Button (2000); Norman (2013)
2	Co-design workshop	Co-design, user innovation	Hyysalo, Jensen, and Oudshoorn (2016)
3	Self-documentation	Empathic design, user experience	Koskinen, Battarbee, and Mattelmäki (2003)
4	Story	Interaction design, usability	Lowgren and Stolterman (2004)
5	Chart	Service design, systemic design	Meroni and Sangiorgi (2011); Sevaldson (2018)
6	Image	Concept design	Dorst (2015); Keinonen and Takala (2006)
7	Evaluation	Accessibility, justice	Coleman (2007); Oosterlaken (2012)
8	Sparring partners	Design Criticism	Verganti (2016)
9	Radical circle	Reflective practice	Donald A. Schön (1995)
10	Interpreters	Design Knowledge	Cross (2006); Friedman (2000)
11	Detail design	-	-
12	Final design	-	-

The primary sources of data were field notes and memos recorded in a journal. In addition, the primary investigator collected various documents and artefacts that were utilised in the teaching and learning activities. The data was analysed using constant comparative method to identify patterns and insights (Hallberg, 2006, p. 143). The constant comparative method is a data analysis technique whereby all codes, categories, and concepts are constantly compared with all other parts of the dataset to explore variations, similarities, and differences. This approach grounds the researcher's final theorizing in the respondents' experiences so that the reader can make the connections between analytical findings and the data from which they were derived.

Table 2 Data Collection

Date	Activity	Topic	Documents	Observations	Student Reports	Journal Entries
27/08/2019	Discussion 1	Justice	Quotes	Photographs	-	1 entry
17/09/2019	Discussion 2	Criticism	Quotes	-	-	1 entry
19/09/2019	Studio 1	Sparring partners	Handout	-	7 entries	1 entry
26/09/2019	Studio 2	Radical circle	Handout	Obs. booklet	4 entries	1 entry
01/10/2019	Discussion 3	Knowledge	Quotes	-	-	1 entry
03/10/2019	Studio 3	Interpreters	Handout	Obs. booklet	5 entries	1 entry

The primary investigator conducted two closely-related cycles of action research in parallel. The first sequence focused on discussion seminars in the design theory class and the second project focused on design reviews in the design studio class.

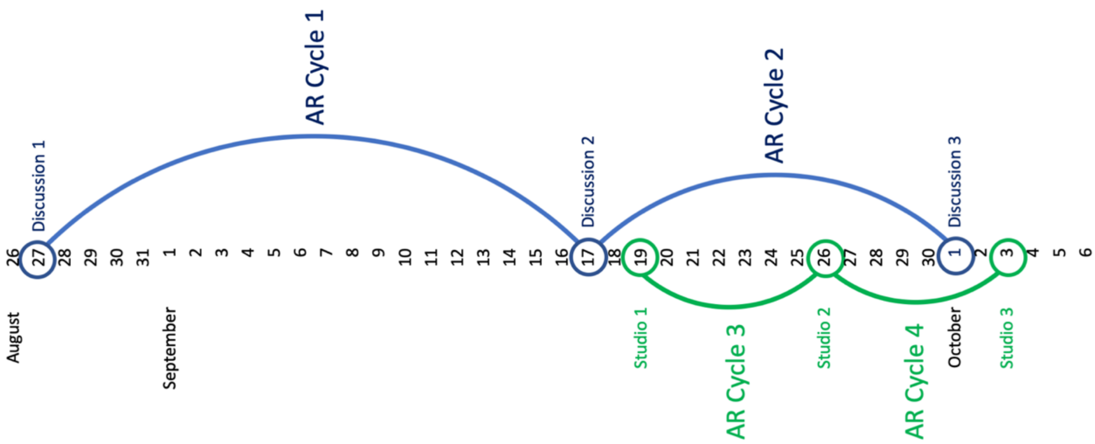


Figure 1 Timeline of Action Research Cycles

The first action research sequence addressed the teaching and learning practices in the design theory class. The primary investigator's initial intention was to change from lecturing to discussion, so, in Discussion 1, they supplied the students with printed handouts containing selected quotations and utilized the small group discussion format. After reflecting on the outcomes of Discussion 1, the primary investigator decided to increase the criticality of the students' argumentation. So, in Discussion 2, they supplied the students with a set of critical questions to accompany the selected quotations. After reflecting on the outcomes of Discussion 2, the primary investigator decided to obtain greater integration of concepts. So, in Discussion 3, they supplied a printed handout with quotes and critical questions for the whole text rather than just for selected sections.

The second action research sequence addressed the primary investigators teaching and learning practices in the design studio class. Their intention for Studio 1 was to change from teacher-student design reviews to student-student design reviews. So, they organized the students in pairs to give feedback to each other. After reflecting on the outcomes of Studio 1, the primary investigator decided they wanted to keep the student-student review format in Studio 2 but obtain group discussion. So, they supplied the students with a set of conversation roles and organized them in small groups to give feedback to each other. After reflecting on the outcomes of Studio 2, the primary investigator decided they wanted to obtain in-depth evaluative feedback in Studio 3, so they reorganized the student-group interactions in a more adversarial format.

The overall result of the action research cycles was to reorganise the social structure of the studio to decentralise authoritative knowledge across the student body. In addition, the primary investigator's sense of teacher identity changed from being the studio master to guiding the students' educational experiences.

3. Insights into Implementing a Liberal Arts Approach to Industrial Design Education

The following insights were produced through synthesis of the data collected across both sequences of action research cycles.

3.1 Pedagogy Change from One-on-One to Peer-to-Peer Teaching and Learning

The first outcome was that the studio's social structure changed from an organisation where authoritative knowledge was centralised in the teacher to an organisation where knowledge was decentralised across many students (Boud, Cohen, & Sampson, 2001). This outcome was achieved by implementing two changes in teaching and learning practise.

First, the teacher changed their primary studio teaching practise from instructing students' design activity in one-on-one desk reviews to organising peer-to-peer student feedback activities. Traditionally, a one-on-one desk reviews is an activity in which the teacher and student participate in a discussion about the student's work in progress. In a design review the student arranges their drawings, models, and project materials on their desk and the teacher offers questions and comments to prompt the student to reflect on their decisions and to try out alternative courses of action. The dialogue does not merely describe the work the student has already completed, it also uses discussion to frame the design problem in new ways and uses drawing to test new solutions on-the-spot. In a design review, drawing and talking are done together in a form of reflective practice that Donald Schön (1985; 1992) calls a reflective conversation with the materials of the situation. The design review is a social activity of learning by doing and discussion, rather than learning by accumulating facts.

Changing the studio social structure from one-on-one instruction to peer-to-peer feedback produced students as new sources of instructions and also increased the number of different sources of feedback. By using other students as sources of feedback the students did not have to wait to receive instruction from only one authoritative source—the teacher—instead students could quickly obtain feedback from one another.

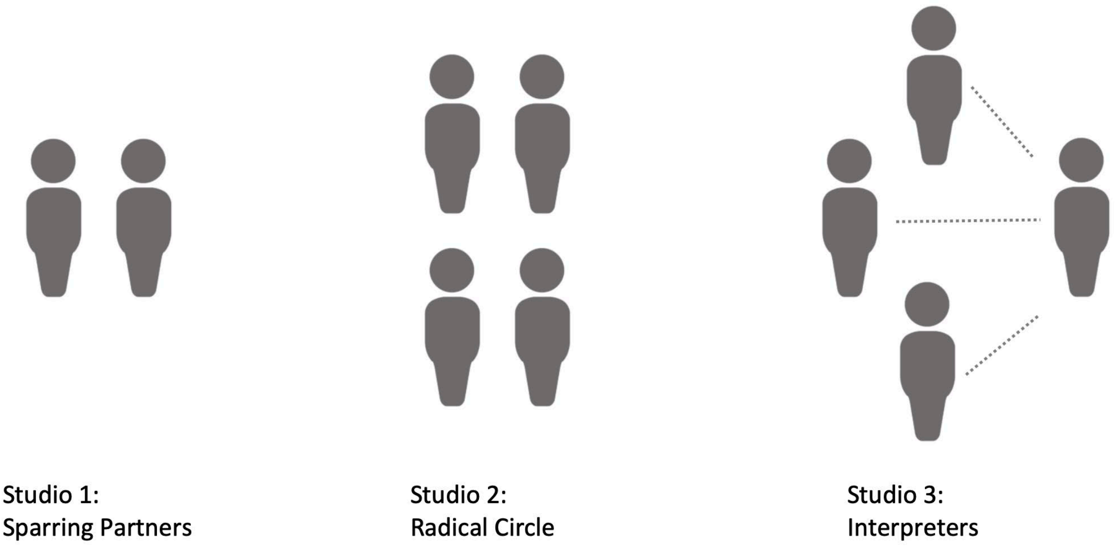


Figure 2 Changing the studio social structure from one-on-one instruction to peer-to-peer feedback (see: Verganti, 2016, Part III)

The peer-to-peer feedback structure meant that the students shifted from mostly waiting to receive instructions from the teacher to groups of students continuously interacting and receiving feedback together. Which strengthened the students' argumentation skills and supported their self-reflection skills. The following quotes from the student's reports illustrate the impact of the new social structure on the teaching and learning activities.

> "The sparring partner activity was very interesting and helped reaffirm some of my ideas. I enjoyed the interplay between two designers. Having to justify myself and realising I was making a design assumption or understanding I had thought critically about the design, making intelligent creative decisions." (Student Report 1)

> "This particular method of feedback [Radical Circle] was interesting given that each member in the circle plays a persona card with a key focus to maintain during each person's presentation. With these personas centred around the six thinking hats, this gave the feedback and questions I received very valid and ranged in terms of the components of my system. It was also very interesting and fascinating to see other people's projects and the goals they aim to achieve. A refreshing change of view and minds." (Student Report 2)

> "For the interpreters feedback activity, we were split into two groups of five. Then one person at a time goes up to the other group and sits down with their back against the group to receive feedback. I found this activity very interesting because by receiving feedback without facing the group, we were able to get more direct and honest responses." (Student Report 3).

Second, the teacher changed their primary theory teaching method from delivering information to students through lectures to guiding students' discussions of texts. The discussions of the texts made information time independent, meaning that students did not have to wait for the teacher to deliver a lecture in real time, rather they could use the printed handout before and during the discussion. Using the hand out meant that the students could follow the discussion and make connections between the parts.

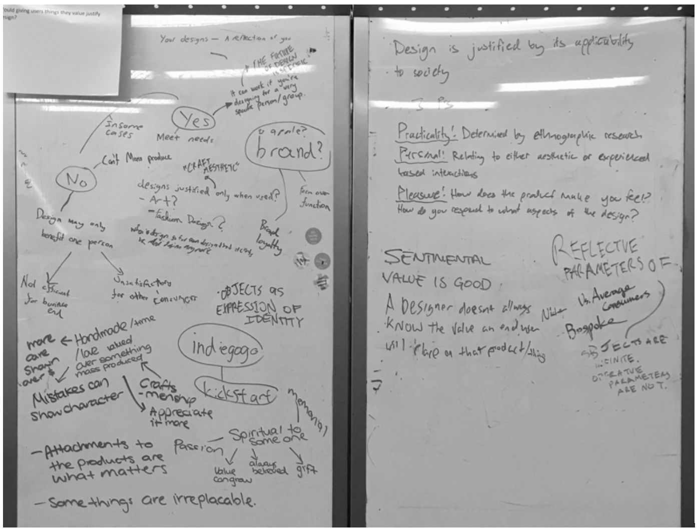


Figure 3 *Using printed handouts with quotes and questions to support group discussion (left) and whiteboards to capture group discussion (right).*

3.2 Identity Change from Studio Master to Learning Guide

The second outcome was that the teacher's primary identity changed from master to guide. This identity change is correlated with the changes to their teaching practise. Since this section address my own teacher identity it mostly draws on my journal entries and self-reflection.

First, my identity changed from master to guide when I changed my teaching practise from primarily delivering instruction in one-on-one desk reviews to organising peer-to-peer feedback activities. The students presented their design projects and gave critical feedback to each other. The students demonstrated their designs using models and drawings, they justified their decisions in response to other students' doubts, and they debated alternative courses of action. I guided the students' interactions by using grouping, conversation roles, and discussion processes. In contrast to the one-on-one approach, this peer-to-peer practise meant that students learned by interacting with each other rather than by imitating my demonstrations. Consequently, my role changed from demonstrating designing to supervising learning. Which meant that my teacher identity changed from studio master to guiding learning.

> "An unanticipated consequence [of the Sparring Partner activity] was that later on when I gave my own feedback to the students, there were instances where my authority was

> challenged the students said for example "my sparring partner recommended I add an augmented reality aspect to the design", this was a direction that I wouldn't have suggested myself since I wanted the student to focus on a simple product. I was forced to think about whether my advice was correct and whether I should overrule the student's sparring partner – I decided not to since I wanted to make sure that the sparring partner's advice was validated." (Reflective Journal Entry 1)

Second, my identity changed from master to guide when I changed my teaching practise from lectures to discussions. The discussions featured students interacting with each other through asking questions, giving answers, and listening to what was said. I guided the students' interactions by providing comments as needed to keep the conversation moving and to surface assumptions. In contrast to a didactic lecture, this practise meant that I was not the only possible source of information. Consequently, my role changed from delivering authoritative knowledge to guiding a discussion of different points of view.

Shifting from lectures to discussions was probably a worthwhile. However, discussion in itself does not necessarily supply epistemic value. Of course, it is possible for a discussion to remain superficial. For example, my journal entry below illustrates this issue, since in Discussion 2 the students analysed particular sections of a text in depth, but they did not integrate their analysis within the whole text.

> "I handed out the quotes and gave the students 15 minutes to read and discuss in pairs and record answers to the questions. When we started the discussion in the round, the students immediately read out their answers to handout questions. Although answers were adequate, I expected there to be a more critical discussion and there was little flow between the pairs answering the questions." (Reflective Journal Entry 2)

Consequently, I modified my approach in Discussion 3. Rather than dividing the text into sections for pairs of students to analyse, I provided a handout that included quotes and questions for the whole text. This way the all students could follow along with the discussion.

> "The illustrative quotes with targeted questions were a useful method to obtain student participation. And although all students participated in the discussion, to some extent I didn't get synthesis of the concepts, rather I got a connected sequence (i.e. coverage rather than integration). We went through all the sections of the text one after the other, but did not develop a deep synthesis or interpretation of the whole." (Reflective Journal Entry 3)

Journal Entry 3 shows that even though I modified the handout structure to link each section to the next section, I did not obtain the depth of conceptual integration I desired. Rather I obtained a sequence of analyses.

Although I did not obtain all the outcomes I desired, I did change my role from delivering authoritative knowledge and demonstrating designing to guiding a discussion and supervising learning. Consequently, by changing from instructing to guiding, I aligned my actual teacher identity in practice with my preferred teacher persona.

4. Discussion

Industrial design grew out of the first industrial revolution, when capitalism emerged in the beginning of 19th century England and Europe (Forty, 1986; Heskett, 1980). The early industrial designers were not managers of the new product development process, their responsibility was to shape the form of a product's enclosure (Spark, 1986). In the 20th century, post-industrial economies emerged (Friedman, 2012). These new types of economies were not based on exploiting natural resources to create desirable goods, rather they created value by exploiting knowledge to invent innovative kinds of goods, services, interfaces and systems (Gilbert, 2005). In the post-industrial era the primary job of industrial designers is not limited to styling products, rather industrial designers need to work at the beginning of the new product development process and to produce innovation through cooperating in multi-disciplinary teams (Coyne & Snodgrass, 1993; Jones, 1980; Rittel, 1984).

Since post-industrial economies create value by exploiting knowledge, industrial design education should equip students with the capabilities is work with knowledge and build knowledge (Friedman, 2000). Scardamalia and Bereiter (2014) identify five aspects of knowledge building in education:

- Knowledge building is viewed in terms of authentic knowledge creative work within classroom communities.
- Knowledge building should open up new possibilities for improving ideas rather than aiming to reach final truths.
- Knowledge building discourse should integrate critical and collaborative dialogue.
- Information of all kinds is valuable insofar as it contributes to knowledge building.
- Knowledge building should produce explanatorily coherent practical knowledge for innovation and socially responsible change. A kind of principled practical knowledge.

The changes I implemented into my teaching and learning activity in this project align with Scardamalia and Bereiter's (2014) five aspects of knowledge building in education. First, students were supported to *build knowledge together* when I changed the social structure from one-on-one instruction to peer-to-peer learning. Second, by implementing a series of peer-to-peer feedback activities, I supplied the students with opportunities to *feed criticism forward to develop and improve their design projects* for the next feedback session. Third, by shifting from lectures to discussion groups I implemented an approach that supported *collaborative dialogue between students*. Fourth, by decentralizing authoritative knowledge within the student cohort, I *valued information from all participants*. Fifth, by aligning the curriculum content for the theory paper with the design brief for the studio paper, I supported the students to *shift their knowledge between explanatory concepts and practical applications*. Consequently, I produced educative experiences in industrial design that are appropriate for post-industrial economies and the knowledge society.

Arguably, Scardamalia and Bereiter's (2014) five aspects of knowledge building align with the abilities Nussbaum (2012, pp. 25-26) lists as crucial for the human development model of education for democracy. Consequently, we are not faced with a choice between education for profit or education for democracy. Rather, in a post-industrial economy and knowledge society, the human development education provides a base that supports the potential for economic growth.

For example, the syllabus described in this paper (Table 1) supplied experiences that supported students to obtain abilities in education for democratic citizenship. First, the students had to *think and deliberate about political issues* by engaging with the topic of sustainable intergenerational wellbeing. Second, the students learned to *recognise and respect fellow citizens as people with equal rights* through conducting ethnographic research in context. Third, students needed to *have concern for what different policies mean for others' opportunities for a good life* by implementing empathic design approaches in co-design workshops. Fourth, the concept design process entails *imagining complex issues that affect human lives*. Fifth, the student compared and contrasted their own design concepts with existing policies which provided them with the opportunity *to judge political leaders critically and realistically*. Sixth, by utilising systemic design approaches, the students were supported to think about how their concepts affected *good of the nation as a whole, not only local issues*. Seventh, by critically reflecting on their concepts in relation to theories of justice and epistemology, the students were able to *see their projects with a world order with transnational issues*. Consequently, the teacher produced educative experiences in industrial design that are appropriate for the human development model of education for democracy.

However, modifying the teacher's teaching and learning practises for design education for democracy in a post-industrial knowledge society had the correlated effect of changing their teacher identity from master to guide. Teacher identity is an ongoing process of personal and contextual interpretation of who one considers oneself to be and who one would like to become (Beijaard, Meijer, & Verloop, 2004; Trautwein, 2018; van Lankveld, Schoonenboom, Volman, Croiset, & Beishuizen, 2017). From reflection on the literature and through discussion with my colleagues, four aspects of teacher identity stand out:

- That forming teacher identity separates identity from personal self;
- That teacher identity is also separated from professional identity and researcher identity;
- That as teacher identity becomes institutionalized it excludes emotional aspects of teaching;
- That, despite these forces of separation and exclusion, teachers may view the value of education in terms of social justice and transformation.

After completing this action research project, I believe that I empathize with some of these aspects of teacher identity and not others. First, I agree that conceptualizing my teacher identity as a guide who organizes educative experiences rather than a professional designer, separates my teacher identity from my personal identity, my professional identity, and my researcher identity. Second, my experience of developing an institutionalized teacher identity has not excluded emotional aspects of teaching; I still feel that there is an emotional component in teaching as a guide-on-the-side. Third, I agree that despite developing a separate teacher identity, I still view the value of education in terms of social justice and transformation.

Further research is needed to understand the implications of the shift in design education from skills-based vocational training to knowledge-based higher education. This research project indicates that the change to knowledge-based higher education is not only a matter of implementing different pedagogical methods. My experience suggests that there also correlated changes in teacher identity. Future research that investigates teacher identity change in design education, for example through interviews with expert design educationists, would provide insight into the lived experience of design education for democracy in a post-industrial knowledge society.

5. Conclusion

This article began by claiming that design education may be framed as both as a form of professional education and as an alternative form of liberal arts education. The primary focus of liberal arts education is human development for democratic citizenship, as opposed to a model of education aimed at maximizing economic growth. But, arguably professional design education has not fully embraced the human development model of education for democracy. The primary investigator conducted action research to investigate the implications of the liberal arts approach to design education through implementing peer-to-peer learning and communicative action activities in their teaching practise.

This paper has made the argument that the abilities crucial for the human development model of education for democracy align with the aspects of education for post-industrial economies and the knowledge society. The value of this perspective is that it critiques the false choice between “education for profit” or “education for democracy” (Nussbaum, 2012). In particular, the argument suggests that the human development model of education provides a base that supports the potential for economic growth in a post-industrial economy and knowledge society. Indeed, Nussbaum (2012), makes a similar argument:

> “a mixed liberal arts education recognizes that higher education prepares students in two distinct ways: for a career, but also for citizenship and life. The liberal arts system does not force any student to make a bitter choice between studying all humanities and studying no humanities, and it does not force parents to subsidize what looks like a dead-end major. You can get your valuable engineering degree while still reading Plato and Tolstoy. And this allows parents to relax: their child can pursue the humanities while still doing something useful that prepares them for career success.” (p. 149)

The issues discussed in this paper give us better insight into the implications of aligning design education with liberal arts education. The discussion highlighted that shifting from skills-based vocational training to knowledge-based liberal education is not only a matter of implementing different pedagogical methods, there may also be changes in teacher identity. The teacher found that changing from delivering authoritative knowledge and demonstrating design skills to guiding discussions and supervising learning changed their teacher identity from sage-on-a-stage to guide-on-the-side. In doing so the insights contribute to our understanding of the lived experience of educationists working in public universities. The contribution of this paper has been to highlight that managing pedagogical changes should also take into account how those changes will affect teacher identity.

Caveats worth mentioning include that since the insights are the product of systematic self-reflection and interpretation of qualitative data, they represent an in-depth account of the primary investigator's experience rather than objectively generalizable results. We do, however, hope that by making these arguments, that we have made clearer some of the issues involved in educating designers for democratic citizenship in post-industrial knowledge societies.

6. References

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and Teacher Education, 20*(2), 107-128. doi:https://doi.org/10.1016/j.tate.2003.07.001

Boud, D., Cohen, R., & Sampson, J. (Eds.). (2001). *Peer learning in higher education: Learning from and with each other*. London: Routledge.

Brookfield, S. D. (1995). *Becoming a critically reflective teacher*. San Francisco: Jossey-Bass.

Brookfield, S. D., & Preskill, S. (2005). *Discussion as a way of teaching: Tools and techniques for democratic classrooms* (Second edition. ed.). San Francisco: Jossey-Bass.

Buchanan, R. (1992). Wicked problems in design thinking. *Design issues, 8*(2), 5-21.

Button, G. (2000). The ethnographic tradition and design. *Design Studies, 21*(4), 13-13.

Coleman, R. (2007). *Design for inclusivity : A practical guide to accessible, innovative and user-centred design*. Aldershot: Gower.

Coyne, R., & Snodgrass, A. (1993). Cooperation and individualism in design. *Environment and Planning B: Planning and Design, 20*(2), 163-174. doi:10.1068/b200163

Cross, N. (2006). *Designerly ways of knowing*. London Springer-Verlag

Dong, A. (2008). The policy of design: A capabilities approach. *Design issues, 24*(4), 76-87.

Dorst, K. (2015). *Frame innovation: create new thinking by design*. Cambridge: MIT Press.

Forty, A. (1986). *Objects of desire: Design and society since 1750*: Thames and Hudson.

Friedman, K. (2000). *Creating design knowledge: From research into practice*. Paper presented at the IDATER 2000 Conference, Loughborough.

Friedman, K. (2002). Design curriculum challenges for today's university. In A. Davies (Ed.), *Enhancing the curricula: Exploring effective curricula practices in art, design and communication in higher education* (pp. 27-63). London, United Kingdom.

Friedman, K. (2003). Design education in the university: A philosophical and socio-economic inquiry (hot debate). *Design Philosophy Papers, 1*(5), 243-253. doi:10.2752/144871303X13965299302596

Friedman, K. (2012). Models of design. *Visible Language, 46*(1-2), 132-153.

Gilbert, J. (2005). *Catching the knowledge wave? : The knowledge society and the future of education*. New Zealand: NZCER Press.

Habermas, J. (1984). *The theory of communicative action: Vol. 1, reason and the rationalization of society* (T. A. McCarthy, Trans.). Boston, Mass.: Beacon Press.

Habermas, J. (1987). *Theory of communicative action: Vol. 1, lifeworld and system: A critique of functionalist reason* (T. A. McCarthy, Trans.). Boston, Mass.: Beacon Press.

Hallberg, L. R. M. (2006). The 'core category' of grounded theory: Making constant comparisons. *International Journal of Qualitative Studies on Health and Well-being, 1*(3), 141-148. doi:10.1080/17482620600858399

Heskett, J. (1980). *Industrial design (world of art series)*: W.W. Norton and Co Inc.

Hyysalo, S., Jensen, T. E., & Oudshoorn, N. (Eds.). (2016). *The new production of users: Changing innovation collectives and involvement strategies*. New York and London: Routledge.

Jones, J. C. (1980). *Design methods: Seeds of human futures*. London: Wiley.

Keinonen, T., & Takala, R. (Eds.). (2006). *Product concept design: A review of the conceptual design of products in industry*. Germany: Springer.

Kemmis, S., & McTaggart, R. (2005). Participatory action research: Communicative action and the public sphere. In *The sage handbook of qualitative research, 3rd ed.* (pp. 559-603). Thousand Oaks, CA: Sage Publications Ltd.

Koskinen, I., Battarbee, K., & Mattelmäki, T. (2003). *Empathic design*. Helsinki: IT-press.

Lowgren, J., & Stolterman, E. (2004). *Thoughtful interaction design : A design perspective on information technology*: MIT Press.

Meroni, A., & Sangiorgi, D. (2011). *Design for services*: Gower.

Norman, D. A. (2013). *The design of everyday things* (Revised and expanded ed.): Basic Books.

Nussbaum, M. (2012). *Not for profit: Why democracy needs the humanities* Princeton and Oxford: Princeton University Press.

Oosterlaken, I. (2012). The capability approach, technology and design: Taking stock and looking ahead. In I. Oosterlaken & J. van den Hoven (Eds.), *The capability approach, technology and design* (pp. 3-26). Dordrecht: Springer Netherlands.

Oosterlaken, I. (2013). *Taking a capability approach to technology and its design: A philosophical exploration*. Delft: 3TU.Centre for Ethics and Technology.

Rittel, H. (1984). Second-generation design methods. In N. Cross (Ed.), *Developments in design methodology* (pp. 317-327). Chichester: Wiley.

Scardamalia, M., & Bereiter, C. (2014). Knowledge building and knowledge creation. In R. K. Sawyer (Ed.), *The cambridge handbook of the learning sciences* (2 ed., pp. 397-417). Cambridge: Cambridge University Press.

Schön, D. A. (1985). *The design studio: An exploration of its traditions and potentials*. London: RIBA Publications for RIBA Building Industry Trust.

Schön, D. A. (1992). Designing as reflective conversation with the materials of a design situation. *Knowledge-Based Systems, 5*(1), 3-14.

Schön, D. A. (1995). *Reflective practitioner: How professionals think in action* (New ed.). Aldershot, England: Arena.

Sevaldson, B. (2018). Visualizing complex design: The evolution of gigamaps. In P. Jones & K. Kijima (Eds.), *Systemic design: Theory, methods, and practice* (pp. 243-269). Tokyo: Springer Japan.

Spark, P. (1986). *An introduction to design and culture: 1900 to the present*: Allen and Unwin

Trautwein, C. (2018). Academics' identity development as teachers. *Teaching in Higher Education, 23*(8), 995-1010. doi:10.1080/13562517.2018.1449739

van Lankveld, T., Schoonenboom, J., Volman, M., Croiset, G., & Beishuizen, J. (2017). Developing a teacher identity in the university context: A systematic review of the literature. *Higher Education Research & Development, 36*(2), 325-342. doi:10.1080/07294360.2016.1208154

Verganti, R. (2016). Overcrowded : Designing meaningful products in a world awash with ideas. In: MIT Press.

About the Authors:

Luke Feast is a Senior Lecturer in Industrial Design at AUT, his research focuses on practices of design-led innovation in interdisciplinary contexts. Areas of specialisation include: design education, design for sustainability, design anthropology, collaborative design, and public and social innovation.

Why am I Studying Design?

Ehsan BAHA[a]*, Maartje KOCH[b], Nick STURKENBOOM[b], Rebecca PRICE[b], Dirk SNELDERS[b]

[a] Delft University of Technology, Delft, the Netherlands; Meaningwise, Eindhoven, the Netherlands
[b] Delft University of Technology, Delft, the Netherlands
*Corresponding author e-mail: s.e.baha@tudelft.nl
doi: https://doi.org/10.21606/drs.2020.386

Abstract: Identity development of design students is a dynamic entanglement between personal and professional identities. Yet, literature primarily focuses on professional identity, based on institutionalized definitions of design to which students must conform. In contrast, we explore personal motivations for wanting to become a designer. An instrumental case study explores how an undergraduate design student develops personal principles for good design, and a personal vision for designing. Results show these principles and underlying vision are applied in the student's design work, leading to development of a holistic identity (personal and professional). Finally, we note this exercise necessitated a plural and dynamic understanding of design (education). We therefore encourage design students and educators to co-design educational spaces and processes to stimulate enriched potentiality of design culture.

Keywords: design education; designer identity; principles for good design; research through design

1. Introduction

> "When I was a first year undergrad student in industrial design, I received a copy of 'Understanding Design' by Kees Dorst (2003), one of the professors in my school. The book contained 175 reflections on being a designer and posed the question: 'What does it mean to be a designer, and what does it take to be a good designer?' Kees Dorst told us this is a book he wished he had when he started studying industrial design himself. His aim was to stimulate designers to think about what they do, how they do it, and why they aim for a certain effect. The mini-essays in the book gave insight into the design process and encouraged reflection. Later that year, I attended a lecture by Kees at another school, in which he argued that design finds itself in an era in which ideologies have come to an end, referring to the styling movement in the history of design. While listening to the lecture, I was thinking how I had just entered the faculty council and education committee as a student member. In these groups we had been reflecting on the undergraduate curriculum, which followed a competency-based education model, with the first year focusing on a transition from 'blank' to 'awareness' of 'designing interactive systems'" (1st author reflection, 2017).

What does it mean to be a designer? Am I a designer? What kind of designer do I want to be(come)? Why do I want to be(come) that kind of designer? These are difficult questions to answer, yet necessary to confront as design students transform towards design professionals (Buchanan, 2001). The possibility of guidance in answering these questions can stimulate design students' to find their element1 (Robinson & Aronica, 2009, 2014). When in their element, design students' realize their potential in the world. These questions not only relate to a designer's professional identity, they relate to the designer's personal identity too. Educational philosopher and theorist Dall'Alba (2009) states:

> "Learning to become a professional involves not only what we know and can do, but also who we are (becoming). It involves integration of knowing, acting, and being in the form of professional ways of being that unfold over time. When a professional education program focuses on the acquisition and application of knowledge and skills, it falls short of facilitating their integration into professional ways of being. In addition, through such a focus on epistemology (or theory of knowing), ontology (or theory of being) is overlooked." (p. 34).

For design education, the above implies that an understanding of design is a fundamental aspect of becoming a design professional (Adams et al., 2011; Hara, 2003). Design education and understanding are interrelated and yet distinct. Two points of distinction are particularly important in the context of this paper. First, design education is constructed by design educators through their framing of (good) design; which forms the basis of curricula, courses, pedagogy, and educational models. Although there are many different understandings of design (Daly et al., 2012; Exter et al., 2019; Micklethwaite, 2002), design schools usually develop and overtly or subliminally promulgate a dominant view of design according to their own preference (Glasser, 2000; Fry, 2003b; Porter & Kilbridge, as cited in Mewburn, 2010). This preference can be based on geopolitical strategies and influenced by leaders in the design community revolving around it.2 A network of educators and leaders co-construct an identity for the school (Ghajargar & Bartzell, 2019), and profile one or more design professionals that the school aims to deliver to society.

The second distinction between knowledge and education is that design students use their understanding of design as a basis for learning design and becoming a design professional (Daly et al., 2012; Ghassan, 2011; Ghassan & Bohemia, 2011). Prior to selecting and starting a design education program, design students have a limited understanding of design and the particular design philosophy they are subscribing to, set by their choice of school. Their understanding of a school's identity will be based on a set of manifestations – i.e. school's website, samples work of graduate projects, celebrated alumni and staff, the school's building and environment itself. For some other students, they may simply choose the design school that is most nearby.

---

1 The term 'element' concerns, "doing something that feels so completely natural to you, that resonates so strongly with you, that you feel that this is who you really are" (Robinson and Aronica, 2014, p. ix).

2 For example, in The Netherlands in the 1970s, the influential designer Wim Crouwel set the stage for the nation's design industry around a somewhat authoritarian notion of design integration he called 'Total Design'. From the 1970s onward he then promoted this notion in the educational curriculum of the Faculty of Industrial Design Engineering at Delft University of Technology (Mertz, 2019; van Winkel, 2005).

A designer's identity development starts as soon as the student enrolls into an undergraduate design program. This act often forecloses their professional identity, with students gradually developing an authorized understanding of design, and learning to meet prescribed standards (Smith, 2015). However, a designer's identity development does not only proceed with acquired knowledge, skills, and ethos. It is also affected by the student's hopes, dreams, and the related understanding of themselves in becoming a professional. Moreover, students get to know themselves as designers based on their proficiencies, what topics or approaches resonate with them, or simply by the spectrum of possibilities they are able to see.

In design schools, some students may end up happily subscribed to the foreclosed design identity of the school. They become professionals, and as alumni stay loyal to the identity of their alma mater. Others, however, may fall into an identity crisis3 at some stage of their education. These students sense a feeling of malaise that potentially can result in insecurities and suboptimal achievements in education and later work. However, from our own education experience we can contend that there may be students who do not subscribe to a foreclosed design identity of their design school, but do not care enough to become unhappy about this lack of commitment. For it is convenient to adopt the schools approach to design – i.e. getting good grades and causing no trouble. Confirmation is in the work of Fry (2003a), who proposes that a majority of students fall into the latter category, and that design schools silently accommodate these students. If this is the case, then a majority of students risk losing care and initiative, and may seek confirmation and comfort rather than realizing their potential. We have thus far, examined the practice of design schools professing and upholding standards of good design. However, even without setting such standards, should design educators then be satisfied with comfortable yet unimpassioned students? Or should design educators offer authentic support to stimulate students to identify and realize their hopes and dreams?

Research on design education stresses the importance of meeting standards, focusing primarily on knowledge and skills development (Dorst & Reymen, 2004; Eckert, 2020; Fleischmann, 2014; Giard, 1990; Meyer & Norman, 2020). Literature also acknowledges the existence of personal aspects that make up a professional identity (i.a. Adams et al., 2011; Gray, 2014; Kosonen, 2018; McDonnell, 2016; Tracey & Hutchinson, 2018). Among these authors, we find particular inspiration in the work of McDonnell (2016), who states; "novice designers find their own voice as designers whilst simultaneously learning what is expected from them as professional practitioners in a particular design field" (p. 1). In our paper, we acknowledge the need to balance a relationship between personal hopes and dreams, and professional standards in design education. This need presents in many design schools (Winters, 2011), where students lack support in developing a good understanding of

---

3 The term 'identity crisis' was coined by the German developmental psychologist Erikson (Levesque, 2018, p. 94), who also developed the leading theory in this area. 'Identity crisis' is, "a time of intensive analysis and exploration of different ways of looking at oneself". In psychology, an identity crisis is seen as a positive phenomenon for one's identity development.

themselves and their personal view on design (Escobar, 2017; Margolin, 2003). As indicated by Julier and Kimbell (2019), design students often do not know why they are studying design, who they are as a designer, and how they may speak up and contribute to design culture (and society) through the realization of their potential, i.e. what Manzini (2015) describes as their 'life project', and Escobar (2018) builds by describing the, 'planes de vida'.

In what follows, we explore designer identity from one student's perspective. We report an instrumental case study in which an undergraduate design student overcomes her identity crisis through design.

2. Research Design and Methodology

2.1 Method

A two-year instrumental case study is applied with Research through Design (RtD) as the underlying paradigm (Isley & Rider, 2018).

Instrumental case study

Creswell (2012, p. 465) defines a case study as, "an in-depth exploration of a bounded system (e.g., activity, event, process, or individuals) based on extensive data collection. Bounded means the case is separated out for research in terms of time, place, or some physical boundaries". An 'instrumental case study' is most appropriate for this research as this type of case study, "serves the purpose of illuminating a particular issue" (Creswell, 2012, p. 465). The particular issue at hand concerns the notion of designer identity.

Research through design

Designer identity is studied through (visual) narratives that are produced through post-hoc reflection (i.a. Gray, 2014; Kosonen, 2018; Sonneveld & Hekkert, 2008; Tracey & Hutchinson, 2013). While this approach has been fruitful for understanding designer identity, it lacks embeddedness into the everyday work of design students as they confront an identity crisis. We are not only interested in describing the development of a designer identity, but also in the performance of design students as they 'come into being'. As Lawson and Dorst (2009) explain:

> "The quotes of the most experienced designers in this book suggest they are their practices. (...) most designers seem to feel easier describing themselves through the projects that, taken together, make up their practice. (...) designing is not just something you do, or that you take lightly when you practice it, but rather it helps form your identity" (p. 270).

We therefore deploy a RtD approach. RtD offers an ontology that brings design activity and materiality together with research (Fryling, 1993). For example, in reflective practice where RtD is rooted, Schön (1983) emphasizes the importance of reflection in relation to actions and creation. He demonstrates how designers may use reflection in and on action, and how they may see their creations through different lenses. In this way, design activity and materiality become the means through which practitioners advance a personal style, within particular contexts, or 'situations at hand' (Schön & Wiggins, 1992). Similar ideas are echoed by Jonas (2007, p. 191), who views RtD as, "a research and design process intrinsic to design" where, "designers / researchers are directly involved in establishing connections and shaping their research object". Similarly, Dow et al. (2013) argue for the 'projection of vision' to be one of the main characteristics of RtD.

Although designing and reflecting would be the preferred approach to sense a designer identity, this approach does not work well for students in an identity crisis. Our experience tells that students in an identity crisis have difficulty producing unique work because of their insecurities and alienation from their element. However, selecting and reflecting upon the work of other designers is a task that is more feasible. Therefore, we consider annotated portfolios as an inclusive approach, open to all students for sensing their designer identity – be it indirectly, through the design work of others (Gaver & Bowers, 2012). By putting together multiple design outcomes and reflecting upon them, annotating portfolios allows for a meta-reflection that can facilitate finding what underlying principles resonate with a person while becoming a design professional. We have found this approach successful in empowering design students. For example, in earlier work we showed how a designer's principles for good design influence the planning, decision making (design process), and the outcome of a design project in industry (Baha et al., 2018).

2.2 Sample

Context and participants

The study includes two main participants; (1) An undergraduate student in Industrial Design Engineering (second author, henceforth 'the student') at Delft University of Technology,4 and; (2) A design practitioner, educator, and researcher (first author, henceforth 'the researcher') at the same school performing research on designer identity. The case reported in this paper is selected from a series of fourteen performed cases, as the best case to illuminate an individual student's experience of an identity crisis.

The student and researcher met within a first-year undergrad course. Staying in touch, they would occasionally meet and have conversations about the student's journey within her design education. Listening to the experiences of the student, the researcher was reminded of his own (designer) identity crisis when he was still a student. When the student was in the second year of the undergrad program, the intrinsic motivation of both participants to improve good design education resulted in the production of this research.

2.3 Procedure

Data generation, collection, and analysis

The procedure for data generation, collection, and analysis was twofold. First, a sequence

4 Delft is a relatively plural design school in which design is understood as a human faculty. The school has a high focus on technology and design theory and methodology. For more, see Voûte et al. (2020).

of eight steps as indicated in Table 1 (below), were followed for and during the designer's identity work (DIW) session5. Second, a serendipitous6 informal co-reflection concerning the two-year activity based on the sagacity7 of the student occurred. An overview of all methods and rationale for their usage is provided in Table 2 (see next page).

Table 1 Overview of the data generation, collection, and analysis procedure.

	Step	**Description**
1.	DIW session assignment	The student was assigned by the researcher to create a good design board – a portfolio of good design examples in order to express the student's vision for designing.
2.	Good design board	The student collected and selected personal examples of good design with which she created a good design board.
3.	Annotated good design board	During the DIW session, the student's good design board was annotated through a critical dialogue between the student and researcher similar to Scagnetti (2017), based on the annotated portfolios method of Gaver & Bower (2012) (see Figure 1).
4.	Post-DIW session reflections	The annotations were used to continue with the critical dialogue after the DIW session, using an online co-reflective journal (Parker & Goodwin, 1987). The co-reflection was based on the post-intentional phenomenology approach of Vagle (2010).
5.	Intermediate principles for good design	The annotations and the post-DIW session critical dialogue were used by both participants to derive two sets of principles for good design as an intermediate result. The intermediate result regarded data analysis from two perspectives (student and researcher).
6.	Clustering principles for good design	The principles were then iteratively clustered by both participants, based on Kawakita's (1991) affinity diagram method.
7.	Final principles for good design set	The clusters were then merged into a final set of principles for good design.
8.	Designer's vision for good design	Eventually, the relation between the student's principles for good design was further analyzed and discussed to express her vision for good design through a diagram (see Figure 2).

5 A 1:1 engagement between the student and the researcher emphasizing dynamic aspects and on-going struggles around creating a sense of self as a designer. A DIW session provides students with a starting point for resolving questions such as: 'who am I as a designer' and, 'what do I stand for as a designer'.

6 Serendipitous here means an unexpected valuable finding from ambiguous objects open to interpretation within RtD (Halvorsen, 2016). For more on serendipity in design see Amacker (2019).

7 Sagacity is an individual's ability to make use of serendipity in some sort of intellectual leap (Halvorsen, 2016).

Table 2 Overview of the mixed methods and specific foci.

Method	Materials	Participants	Time	Foci	Authorities
Annotated Portfolios	16 pages (Apple Keynote slide deck)	Designer and researcher	1,5 hours (during the DIW session)	Meta reflection based on multiple design work	Gaver & Bowers, 2012
(Co-)Reflective Journal	43 pages (Google Docs, A4)	Designer and researcher	6 weeks planned online reflection with unplanned informal aftermath for another 2 years	Illumination of personal designers' identity and its agency	Parker & Goodwin, 1987
Post-Intentional Phenomenology	43 pages (Google Docs, A4)	Designer and researcher	6 weeks planned online reflection	Nurture the perspectives of both student and researcher without influencing each other	Vagle, 2010
Critical Dialogue	43 pages (Google Docs, A4)	Designer and researcher	6 weeks planned online reflection with unplanned informal aftermath for another 2 years	Constructive feedback to support designers' identity development	Scagnetti, 2017
Principles for Good Design	5 principles (Adobe Illustrator diagram)	Designer and researcher	1 day of joint data analysis and visualization	Capture and express designers' identity	Klemp, 2017
Affinity Mapping	5 clusters (Post-it notes)	Designer and researcher	1,5 hours (during the DIW session)	Organizing recurrent and variant expressions of designers' identity as principles for good design	Kawakita, 1991

Research ethics and other considerations

Designer identity is a complex and sensitive research topic to be approached with utmost care. Table 3 (below) provides an overview of the ethical considerations in our research. Further research on this topic must acknowledge these ethical considerations.

Table 3 Overview of research ethics.

Ethical consideration	Description
Status	The student was informed that the design identity work session was an experimental method as part of research in progress. She was allowed to walk away from the exercise at any time.
Safe space	The design identity work session was not part of the school curriculum or subject to media attention, hence there was no formal or informal assessment of the student's participation in the research prior to the manuscript of this paper.
A student-led approach	Priority was given to the reasons of the student for doing designer identity work – not the reasons of the researcher.
Minimizing bias	The researcher sensed his design identity prior to the student's design identity work to avoid the projection of his own design identity onto the student.
Transparency	The idea to write this paper came after the DIW session, planned co-reflective journal, and developing principles for good design. Therefore, publication considerations did not affect the context of the student's participation in these events. The proposal of the researcher was to write this paper together, in collaboration with a larger project team.
Control	The student opted for egalitarian co-production of this research article, which allowed her to safeguard disclosure of personal experiences.

3. The student's personal designer identity

Analysis of data resulted into a personal designer's identity based on five principles for good design. These principles are structured in Figure 2. Principles 5 – 'good design brings out the best in people' – is an overarching principle in relation to principles 1 to 4, and can be seen as the core of the student's vision. In the remainder of this section we explain each principle, as voiced by the student after a critical dialogue with the researcher.

3.1 Principle 1: good design flows from integrity

In designing, integrity (both personal and product-related) is achieved when designer(s) and other producers are authentic in their actions. Since authenticity is inherently inclusive, by extension it will elicit the best out of people who eventually use the design. This results in design that is neither pretentious nor dominant. Consider the example provided for this principle: The 1,5 liter green recycled glass pitcher by the Dutch franchise Dille & Kamille. The integrity of the product, i.e. the artisanal production and the product material is preserved in the design. Each pitcher varies in both shape and color. There are some bubbles in the glass that are unintended and irregular, but are a result of the production process. The green color of the pitchers results from the recycling process and is not uniform throughout the object. In sum, every pitcher has its own authentic appearance.

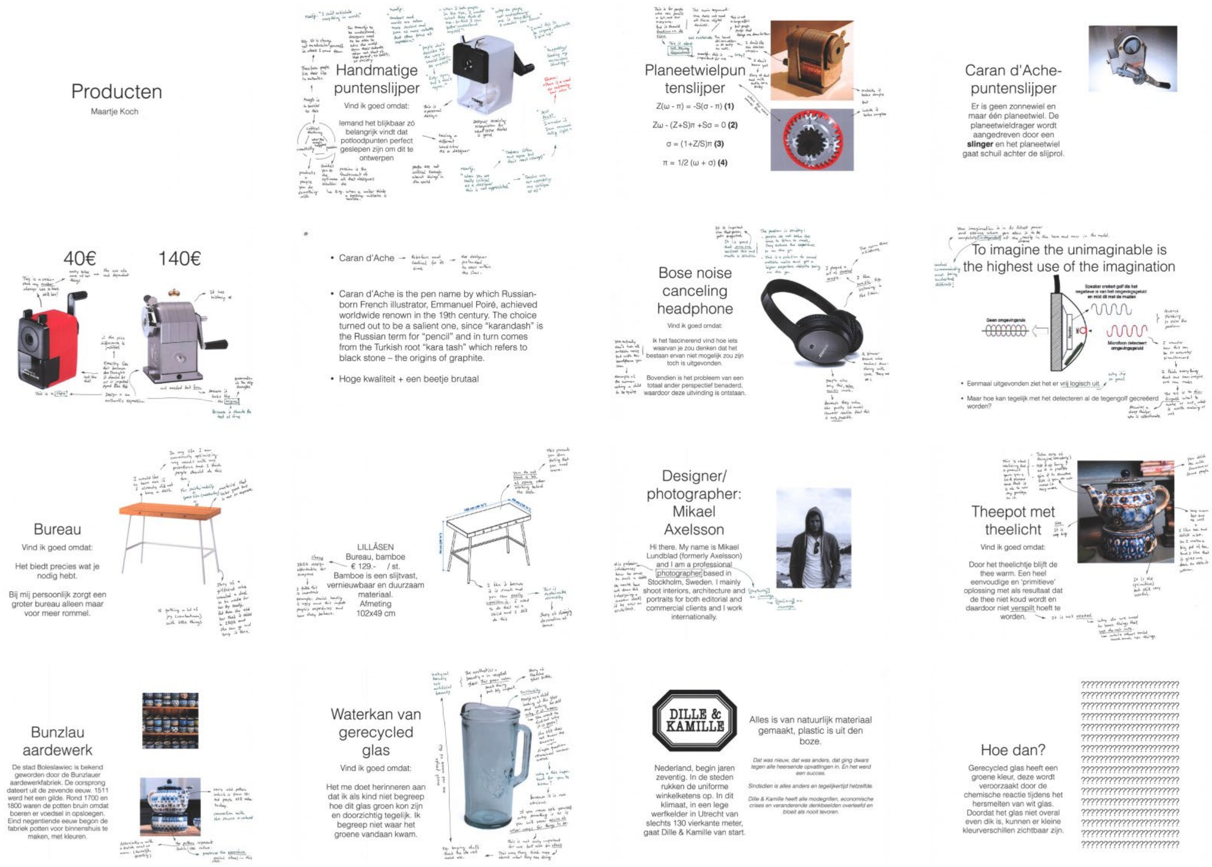


Figure 1 *The student's annotated good design board.*

3.2 Principle 2: good design is conscious

Integrity requires self-consciousness of the designer in the very act of designing, so pretention is avoided. Consciousness of self as a designer unlocks another level of thought with respect to ecology, in which and for which one is designing. This higher level of thought enables design that is not only good for society, but also the environment. An example of such a design is the LILLÅSEN Desk, designed by Mikael Axelsson for IKEA. The product has a strong form and specific function, namely a minimalistic workspace that discourages clutter and thus ensures concentration. Furthermore, the top is made from bamboo, a consciously chosen material to make desks more durable, renewable, and sustainable.

3.3 Principle 3: good design is the impossible made possible, imagined in freedom

If, and only if, designers are conscious about their environment will they see and hence have the opportunity to make the impossible possible. To be conscious is to acknowledge all that already exists in the world one resides. How can one create the impossible if one is not conscious of what is already possible? Exploration of this dichotomy involves the fantasy and unique vision of designers. Designers creatively combine their imagination with what already exists in the world. An expansive imagination is a precondition, yet not a sole prerequisite for good design. This is because, crucially, there should be no restriction on imagination or creativity. Any restriction implies an imposition that is by definition exogenous. Therefore, freedom is the foundation of imagination. The QuietComfort 35 II Wireless Noise Cancelling Headphones by Bose is a manifestation of this principle. Is it not illogical to think of an object that produces, and at the same time mutes sound? Yet a designer imagined this, and now this exists as a product.

Figure 2 The student's personal designer identity as a set of five principles for good design structured in a diagram that represents her vision for good design.

3.4 Principle 4: good design preserves cultural plurality

Material culture is the manifestation of realized imagination. Since not every individual has the same imagination, different cultures exist. A person's imagination is proof of their existence as a human being; their emerging sense of self within the world. The existence of different cultures together on Earth is important for people to have a sense of belonging. Both a sense of self and a sense of belonging are crucial for one's well-being. Take, for example, the Polish Boleslawiec 48 ounce teapot with warmer. By its existence in a context of production and consumption this product preserves a part of Polish culture. However, it is not only Polish culture that it safeguards, it also provides people from other cultures the possibility to celebrate the teapot within their own culture.

3.5 Principle 5: good design brings out the best in people

A design should add meaning so that people can live a happier life. Happy people have a higher tendency to be the best version of themselves. Bringing the best out in people is the foundation and simultaneously the result of the four previous principles (Principle 1-4). Designers can only bring the best out of people if, and only if, they manifest the best version of themselves in their design. The Caran d'Ache pencil sharpener is an example of this. The very fact that a device exists to sharpen pencils in a very precise way (Principle 1), indicates that the designer deliberately cares about detail (Principle 2). This impossibility made possible (the existence of a device to sharpen pencils in a very precise way) is imagined and manifested by the designer for others (Principle 3). Remaining almost unchanged ever since its existence, a cultural vein is preserved (Principle 4).

4. Agency of the student's personal designer identity

In this section we report a summary of the student's experiences, two years after beginning to sense her personal designer's identity with the researcher. Experiences are structured chronologically to reflect the process of moving through identity crisis to being in her element.

4.1 Acknowledging her (designer) identity crisis

The student's designer identity work session and derived principles for good design functioned as a mirror that projected and acknowledged the student's vision for good design to herself. Attaining this view gradually enabled the student to become more mindful about her being in the world and gaining confidence. In her words:

> "My sensed designer identity helped me understand my struggles within education. However, I did not know how I could use this identity in a proper way to prevent future struggles in education. But quitting the Industrial Design Engineering program also would not have helped. So I decided to do a minor offered by another faculty (Technology Policy and Management) which included a three month internship in Rwanda. Besides looking forward to trying something else, I wanted to put myself literally in a position that I could not escape

> easily. I thought this would motivate me enough to finish what I started. In hindsight, I realize how uninspired I actually was" (2nd author reflection, 2019).

Outside her usual routine, a space had opened to reflect upon her design identity and start taking action towards becoming the designer she wanted to become. Here is how she describes this experience:

> "In Rwanda I could not occupy myself with the same leisure activities as in the Netherlands. Besides, the workload was much lighter than what I was used to. So I had to, and had the time to, think about the things I actually would like to do. For example, seeing the Kitenge fabrics and the tailors in Rwanda inspired me to create a jumpsuit for myself. Eventually, enjoying this experience persuaded me to sign up for a high-quality couturier course, which I followed after the minor in the Netherlands. As the internship had a lot of disruptions, all the time I had nothing to do I would search for a graduate design program in tune with my vision. I really enjoyed this research since I became aware of the possibilities to pursue my principles for good design within education. I visited the open day of one of the schools after the minor" (2nd author reflection, 2019).

4.2 Practicing her personal designer identity in education

Returning to the Netherlands, the designer felt more in her element. She became more confident to practice her personal designer identity within her design education. Having a better sense of what kind of designer she wanted to become, made choosing elective courses much easier. Furthermore, she became more conscious about prioritizing her learning, and was able to focus on the development of skills and knowledge relevant to her for becoming a designer. This is what she says about one of the elective courses:

> "I decided to take an elective course relating to my principle 4 (good design preserves cultural plurality). In this course we had to design an intervention in the cultural relationship between humans and animals. Practicing my principles for good design, I designed a leopard printed t-shirt that manifests provocative issues concerning social and environmental problems caused by the fashion industry. The t-shirt would be for sale in a museum where the social and environmental issues are explained in order to raise awareness among people. Being inspired, people could then buy and wear the t-shirt to further spread this message in a joyful way and stand for a new attitude towards clothing. My intention was to design for a cultural impact that could enable a possible change in the fashion industry which may initially seem impossible. However, 'you cannot change the world' my teacher told me. I felt discouraged. A later conversation with my teacher made things more clear" (2nd author reflection, 2019).

4.3 Self-directing her designer identity development

After sensing her personal designer identity, acknowledging her crisis, and practicing her sensed designer identity, the student started to better understand the possibilities and limitations of her work within her design school. Clearly, her designer identity did not always resonate with the professional designer identity of the school. Having a stronger awareness of herself as a designer, she had no doubt anymore about becoming one. Her self-confidence enabled her to better process feedback and comments of her peers and teachers. Exploring her designer identity enabled her to realize that design is a broader area of expertise than professed in her current school. This is what she writes about her designer identity transition:

> "When I started studying Industrial Design Engineering I did not really think about why I want to become a designer. Following courses, I did not really care about grades as I often could not make any sense of the assessment of my projects. Five teachers told me that I should consider studying something else. I felt misunderstood and lonely. In hindsight, I realize that I did not really understand myself and the qualities of my work. Further developing my design identity within the undergraduate program, at the same time successfully completing courses, is going to be both challenging and risky. Nevertheless, my designer's identity work journey has been inspiring. I would like to further develop knowledge and skills relevant to my design identity. Fortunately, I am accepted to the MRes Communication Design Pathway graduate program at the Royal College of Art, a design school where I look forward to obtaining my graduate degree" (2nd author reflection, 2019).

5. Discussion and final words

With our work, we demonstrate that supporting students to sense their personal designer identity helps them to become aware of their potential and responsibility, and enables them in learning to articulate more clearly why they want to become a designer. Furthermore, designer identity work allows designers to find novel possibilities that are 'un-foreclosed' (i.e. not conforming to institutional standards), and that contribute to more personalized development. Related to this, an important insight from the student work in our case study was that her search for novel possibilities was not limited to the boundaries of a design school. Her growing self-awareness and self-confidence nurtured greater autonomy in education and career choices. Simultaneously, this affected how the student understood feedback from educators. The reflections indicate that the designer became able to discern, constructively, how criticism could be reframed to become constructive. This allowed her to develop her potential through focused and achievable actions.

Conflict and failure are inevitable when trying out and practicing design based on newly sensed principles (Krippendorff, 1995). During her studies, the student faced strong emotional confrontations that were overwhelming, and at times hard to overcome. It could be argued that the identity work described in this case study is an extreme example, in the sense that her commitment in wanting to become a designer led to her crisis. In that sense our case does not describe Fry's (2003a) 'majority of students' who are taught to conform to institutional standards in silence. While we have no access to the wisdom of said commitment, the student's case demonstrates how the identity work sessions were able to revive hopes and dreams, even at a moment where the student found herself confused by discouraging feedback. Still, what could be questioned in future research is how revived hopes and dreams can be supported and realized within educational curricula, and ultimately in professional practice.

When writing this paper, a major source of inspiration came from McDonnell (2016), who argued for a balanced view between a design student's personal and professional development (i.e. between students finding their own voice and the particular standards set by practitioners). However, this paper departs from McDonnell in that we approach the standards of professional design practice pluralistically and dynamically.8 First year undergraduate students are at the roots, not conforming to 'how things are', courageously embracing, 'how things ought to be' (Simon, 1969), and overcoming setbacks and crises. Some Design schools and their staff may resist, or not have the capacity to care for every personal ambition in design in an enriched way. As design grows in popularity, design education becomes stretched under demand. Design educators must avoid becoming desensitized to individual students in an effort to 'scale-up'.

Our vision is one of a design culture that feels alive to students and educators. Within this vision, design education provides authentic support for the development of a personal designer's identity. We believe this support is best seen as a co-designed act performed by students and educators, while practicing, learning, and educating design. First and foremost, this involves the co-design of educational spaces where hopes and dreams can be nurtured. Second, it involves co-designed processes, fashioned as ongoing critical dialogues, aimed towards transforming students' and educators' hopes and dreams to novel, yet acceptable standards.

6. References

Adams, R. S., Daly, S. R., Mann, L. M., & Dall'Alba, G. (2011) Being a professional: Three lenses into design thinking, acting, and being. *Design Studies*, 32(6), 588-607. https://doi.org/10.1016/j.destud.2011.07.004

Amacker, A. (2019). Surrendering to The Now. Improvisation and an embodied approach to serendipity. *The Design Journal*, 22(sup1), 1841-1851. https://doi.org/10.1080/14606925.2019.1595043

Baha, S. E., Dawdy, G., Sturkenboom N., Price, R. A., & Snelders, H. M. J. J. (2018). Good Design-Driven Innovation. In Storni, C., Leahy, K., McMahon, M., Bohemia, E. and Lloyd, P. (Eds.). (2018). *Proceedings of DRS2018: Catalyst*, Vol. 1, pp. 98-111. https://doi.org/10.21606/dma.2017.648

Bose. (n.d.). QuietComfort 35 wireless headphones II. Retrieved April 20, 2020, from https://www.bose.com/en_us/products/headphones/over_ear_headphones/quietcomfort-35-wireless-ii.html

Buchanan, R. (2001). The Problem of Character in Design Education: Liberal Arts and Professional Specialization. *International Journal of Technology and Design Education*, 11, 13–26. https://doi.org/10.1023/A:1011286205584

Caroline Weaver Pencil Enterprise. (n.d.). Pencil Sharpening Machine. Retrieved April 20, 2020, from https://cwpencils.com/products/pencil-sharpening-machine

Creswell, J. W. (2012). *Educational research Planning, conducting, and evaluating quantitative and qualitative research* (4th edition), Pearson.

Dall'Alba, G. (2009). Learning Professional Ways of Being: Ambiguities of becoming. *Educational Philosophy and Theory*, 41(1), 34-45. https://doi.org/10.1111/j.1469-5812.2008.00475.x

Daly, S. R., Adams, R. S., & Bodner, G. M. (2012). What Does it Mean to Design? A Qualitative Investigation of Design Professionals' Experiences. *Journal of Engineering Education*, 101(2), 187-219. https://doi.org/10.1002/j.2168-9830.2012.tb00048.x

8 Born from Jobsian 'crazy ones'; i.e. people committed to the higher level goals that underlie their design work, even when those goals are not shared by many others (Stanford News, 2005).

Dille & Kamille. (n.d.). Kan, groen gerecycled glas, inhoud 1,5 L. Retrieved April 20, 2020, from https://www.dille-kamille.nl/nl/glaswerk/kan-groen-gerecycled-glas-inhoud-1-5-l-5368.html

Dorst, K. (2003). *Understanding Design*. BIS publishers.

Dorst, K., & Reymen, I. (2004). Levels of Expertise in Design Education. In Lloyd, P., Roozenburg, N., McMahon, C. and Brodhurst, L. (Eds.). (2004). *Proceedings of E&PDE 2004: The Changing Face of Design Education*, Vol. 1, pp. 159-166.

Dow, S., Ju, W., & Mackay, W. (2009). Projection, Place and Point-of-view in Research through Design, in Price, S., Jewitt, C. and Brown, B. (eds.), *The SAGE Handbook of Digital Technology Research*, SAGE Publications Ltd., pp. 266-285. https://doi.org/10.4135/9781446282229.n19

Eckert, J. (2020). Why Design Schools Should Take the Lead in Design Education, in Raposo D., Neves J. and Silva J. (Eds.), *Perspective on Design: Research, Education and Practice*, Springer, Cham., pp. 3-15. https://doi.org/10.1007/978-3-030-32415-5_1

Escobar, A. (2017). *Designs for the Pluriverse: Radical Interdependence, Autonomy, and the Making of Worlds*. Duke University Press.

Escobar, A. (2018). Autonomous design and the emergent transnational critical design studies field. *Strategic Design Research Journal*, (11)2, 139-146. https://doi.org/10.4013/sdrj.2018.112.10

Exter, M. E., Gray, C. M., & Fernandez, T. M. (2019). Conceptions of design by transdisciplinary educators: disciplinary background and pedagogical engagement. *International Journal of Technology and Design Education*, 29(3), #-#. https://doi.org/10.1007/s10798-019-09520-w

Fleischmann, K. (2014). Design futures—future designers: give me a 'T'? *Studies in Material Thinking*, 11, 1-23. https://www.materialthinking.org/papers/160

Frayling, C. (1993). Research in Art and Design. *Royal College of Art Research Papers*, 1(1), 1-5.

Fry, T. (2003a). Touching the Wall of Silence: The Voice of Sustainment. *Design Philosophy Papers*, 1(3), 137-140. https://doi.org/10.2752/144871303X13965299301993

Fry. T. (2003b). Dead Institution Walking: The University, Crisis, Design and Remaking (Hot Debate). *Design Philosophy Papers*, 1(5), 267-282. https://doi.org/10.2752/144871303X13965299302712

Gaver, B., & Bowers, J. (2012). Annotated Portfolios. *Interactions*, 9(4), 40-49. https://doi.org/10.1145/2212877.2212889

Ghajargar, M., & Bartzell, J. (2019). What design education tells us about design theory: a pedagogical genealogy. *Digital Creativity*, 30(4), 277-299. https://doi.org/10.1080/14626268.2019.1677723

Ghassan, A. (2011). Full Circle: Balancing the Knowledge Equilibrium Between Newly-Enrolled Design Students and Their Design School. In Kovacevic, A., Ion, W., McMahon, C., Buck, L. and Hogarth, P. (Eds.). *Proceedings of E&PDE 2011: Design education for creativity and business innovation*, Vol. 1, pp. 1-9.https://www.designsociety.org/download-publication/30894/Full+Circle%3A+Balancing+the+Knowledge+Equilibrium+between+Newly-Enrolled+Design+Students+and+their+Design+School

Ghassan, A., & Bohemia, E. (2011). Notions of Self: Becoming a 'Successful' Design Graduate. In Roozenburg, N., Chen, L. L. and Stappers, P. J. (Eds.). *Proceedings of ISADR 2011: Diversity and unity*, Vol. #, pp. 1-9.

Giard, J. R. (1990). Design Education in Crisis: The Transition from Skills to Knowledge. *Design Issues*, VII(1), 23-28. https://doi.org/10.2307/1511468

Glasser, D. E. (2000). Reflections on Architectural Education. *Journal of Architectural Education*, 53(4), 250-252. https://doi.org/10.1162/104648800564662

Gray, C. M. (2014, June). Locating the Emerging Design Identity of Students Through Visual and Textual Reflection. In Lim, Y. K., Niedderer, K., Redström, J., Stolterman, E. and Valtonen, A. (Eds.). (2014). *Proceedings of DRS 2014: Design's Big Debates*, Vol. #, pp. #-#.

Halvorsen, B. (2016). *Design for serendipity: a Research through Design approach* (Master thesis). Retrieved from http://urn.nb.no/URN:NBN:no-56910

Hara, K. (2003). *Designing Design*. Lars Müller Publishers.

IKEA. (n.d.). LILLÅSEN Desk. Retrieved April 20, 2020, from https://www.ikea.com/us/en/catalog/products/90278277/

Isley, C. G., & Rider, T. (2018). Research-Through-Design: Exploring a design-based research paradigm through its ontology, epistemology, and methodology. In Storni, C., Leahy, K., McMahon, M., Bohemia, E. and Lloyd, P. (Eds.). *Proceedings of DRS2018: Catalyst*, Vol. 1, pp. 357-367. https://doi.org/10.21606/dma.2018.263

Jonas, W. (2007). Design Research and its Meaning to the Methodological Development of the Discipline, in Michel, P. (Ed.), *Design Research Now*, Birkhäuser Basel, pp. 187-206. https://doi.org/10.1007/978-3-7643-8472-2_11

Julier, G., & Kimbell, L. (2019). Keeping the System Going: Social Design and the Reproduction of Inequalities in Neoliberal Times. *Design Issues*, 35(4), 12-22. https://doi.org/10.1162/desi_a_00560

Kawakita, J. (1991). *The Original KJ Method*. Kawakita Research Institute.

Klemp, K. (2017). A New Approach to Design: Dieter Rams and the Birth of the Braun Design Ethos 1955-1961, in de Jong, C. W. (ed.), *Ten Principles for Good Design: Dieter Rams*, Prestel, pp. 50-73.

Kosonen, K. (2018). *Finding One's Own Way in Design - Reflections on Narrative Professional Identity* (PhD thesis). Retrieved from https://aaltodoc.aalto.fi/handle/123456789/31487

Krippendorff, K. (1995). Redesigning design; An invitation to a responsible future, in Tahkokallio. P. and Vihma, S. (Eds.), *Design: Pleasure or responsibility, University of Art and Design*, pp. 138-162. http://repository.upenn.edu/asc_papers/46

Lawson, B., & Dorst, K. (2009). *Design expertise*. Architectural Press.

Levesque, R. J. R. (2018). Adolescent Crisis, in Levesque R. J. R. (Ed.), *Encyclopedia of Adolescence*, Springer, Cham., pp. 94-96. https://doi.org/10.1007/978-3-319-33228-4

Manzini, E. (2015). *Design, When Everybody Designs: An Introduction to Design for Social Innovation*. The MIT Press.

Manzini, E. (2016). Design Culture and Dialogic Design. *Design Issues*, 32(1), 52-59. https://doi.org/10.1162/DESI_a_00364

Margolin, V. (2003). Re-Visioning Design Practice: Hot Debate. *Design Philosophy Papers*, 1(6), 353-356. http://dx.doi.org/10.2752/144871303X13965299303072

McDonnell, J. (2016). Becoming a designer: Some contributions of design reviews, in Adams, R. S. and Siddiqui, J. A. (Eds.), *Analyzing Design Review Conversations*. Purdue University Press, pp. 353-369. https://doi.org/10.5703/1288284315935

Mertz, P. (2019, June, 4). Wim Crouwel (Haak, T. Trans.) [Web log post], in Zijlstra, S. (Ed.), Dutch Graphic Roots. Retrieved April 20, 2020, from https://www.dutchgraphicroots.nl/?p=1414 (Original work published 2008, November)

Mewburn, I. (2010). Lost in translation: Reconsidering reflective practice and design studio pedagogy. *Arts & Humanities in Higher Education*, 11(4), 363-379. https://doi.org/10.1177/1474022210393912

Meyer, M. W., & Norman, D. A. (2020). Changing Design Education for the 21st Century. *She Ji: The Journal of Design Economics and Innovation*, 6(1), 13-49. https://doi.org/10.1016/j.sheji.2019.12.002

Micklethwaite, P. (2002). *What is Design? An empirical investigation into concepts of design in the community of design stakeholders* (PhD Thesis). Retrieved from http://eprints.hud.ac.uk/id/eprint/4673/

Parker, R. P., & Goodkin, V. (1987). *The Consequences of Writing: Enhancing Learning in the Disciplines*. Boynton/Cook.

Robinson, K., & Aronica, L. (2009). *The Element: How Finding Your Passion Changes Everything*. Penguin Putnam Inc..

Robinson, K., & Aronica, L. (2014). *Finding Your Element: How to Discover Your Talents and Passions and Transform Your Life*. Penguin Putnam Inc..

Scagnetti, G. (2017). A dialogical model for studio critiques in Design Education. *The Design Journal*, sup1, S781-S791. https://doi.org/10.1080/14606925.2017.1353024

Schön, D. (1983), *The Reflective Practitioner: How Professionals Think in Action*. Basic Books.

Schön, D.A. & Wiggins, G. (1992). Kinds of seeing and their functions in designing. *Design Studies*, 13(2), 135-156. https://doi.org/10.1016/0142-694X(92)90268-F

Simon, H. A. (1969). *The science of the Artificial*. MIT Press.

Smith, K. M. (2015). Conditions influencing the development of design expertise: As identified in interior design student accounts. *Design Studies*, 36, 77-98. https://doi.org/10.1016/j.destud.2014.09.001

Sonneveld, M. H., & Hekkert, P. (2008). Reflecting on Being a Designer. In Clarke, A., Evatt, M., Hogarth, P., Lloveras, J. and Pons, L. (Eds.). (2008). *Proceedings of E&PDE 2008: New Perspectives in Design Education*, Vol. 2, pp. 529-534. https://www.designsociety.org/publication/28147/Reflection+on+being+a+Designer

Stanford News. (2005). 'You've got to find what you love', Jobs says. Retrieved April 20, 2020, from http://news.stanford.edu/2005/06/14/jobs-061505/

Touch of Poland. (n.d.). 48 oz Tea Pot with Warmer. Retrieved April 20, 2020, from https://www.touchofpoland.com/products/48-oz-tea-pot-with-warmer

Tracey, M. W., & Hutchinson, A. (2013). Developing designer identity through reflection. *Educational Technology*, 53(3), 28-32. https://digitalcommons.wayne.edu/coe_aos/6/

Tracey, M. W., & Hutchinson, A. (2018). Reflection and professional identity development in design education. *International Journal of Technology and Design Education*, 28(1), 263-285. https://doi.org/10.1007/s10798-016-9380-1

Vagle, M.D. (2010). Re-framing Schön's call for a phenomenology of practice: a post-intentional approach. *Reflective Practice*, 11(3), 393-407. https://doi.org/10.1080/14623943.2010.487375

Van Winkel, C. (2005). *The Regime of Visibility*. Nai010 publishers.

Voûte, E., Stappers, P. J., Giaccardi, E., Mooij, S., & van Boeijen, A. (2020). Innovating a Large Design Education Program at a University of Technology. *She Ji: The Journal of Design, Economics, and Innovation*, 6(1), 50-66. https://doi.org/10.1016/j.sheji.2019.12.001

Winters, T. (2011). Facilitating Meta-learning in Art and Design Education. *International Journal of Art & Design Education*, 30(2), 90-101. https://doi.org/10.1111/j.1476-8070.2011.01685.x

About the Authors:

Ehsan Baha is a design practitioner, researcher, and educator. He is the founder of Meaningwise – a design consultancy specialized in Good Design-Driven Innovation. Ehsan is investigating designer identity as a foundation for pluralism in design.

Maartje Koch is an undergraduate student in Industrial Design Engineering at the Faculty of Industrial Design Engineering at Delft University of Technology. As a designer-researcher Maartje investigates how bringing out the best in herself can bring out the best in people.

Nick Sturkenboom is a Service Design Consultant at Keen Design and a part-time researcher at Meaningwise. Nick is concerned with Design-Led Digital Innovation, studied through the lens of Cultural Historical Activity Theory.

Rebecca Anne Price is an Assistant Professor of Transition Design at the Faculty of Industrial Design Engineering at Delft University of Technology. Based in the department of Design, Organization and Strategy, Rebecca investigates how design can advance sectors and industries through multi-levelled and networked innovation.

Dirk Snelders is Professor at the Faculty of Industrial Design Engineering at TU Delft, Department of Design, Organization and Strategy. His research interest lies in the organization and professionalization of design in relation to service innovation.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Partnerships in an industrial design studio: augmenting the master-apprentice model to inspire collaboration

Karen Tamara YEVENES[a]*, Jean PAYETTE[a], Sasha ALEXANDER[a], James Henry BERRY[a]

[a] Western Sydney University, Australia
*Corresponding author e-mail: k.yevenes@westernsydney.edu.au
doi: https://doi.org/10.21606/drs.2020.157

Abstract: The industrial design studio presents opportunities for students to learn a range of skills and knowledge that will equip them to enter professional practice. This paper presents the unfolding of a capstone studio where student teams undertake project-based learning, and where the instructor is both the master and a team-player. The question that is investigated is to what extent does an augmented master-apprentice teaching model impact student collaboration in the design studio, and can the model be used to drive positive learning outcomes. The study considers the design process of 14 student-teams studying industrial design at Western Sydney University (WSU) Australia, and the design process of an instructor-team comprised of four industrial design academics. The paper is an experiential account of a lighting project as undertaken by instructors and students and proposes a novel method for teaching professional practice through co-creation, collective cohesion and by behaviour-modelling of collaboration in action.

Keywords: collaboration; co-creation; industrial design pedagogy; master-apprentice

1. Introduction

This paper investigates if a modification in teaching methods, that is, the modelling of collaborative behaviour through a *community of practice* (the design studio) facilitates an understanding of professional practice in student participants. Professional practice in this case, is resolution of a project brief. There are several key questions to be addressed, namely what is the master-apprentice model used in teaching design process at WSU, and how is it augmented in the capstone studio? Further to this, there is a need to explore what is meant by *collaboration* in the design studio, and why is it important to offer students the opportunity to collaborate. Finally, the paper indicates how the enhanced master-apprentice model impacts the ability for students to produce successful design outcomes.

Definitions for the terms used in this paper are provided so that the authors' intentions are clear. The vocabulary used in describing these activities is important and should be used regularly with students so that the language of communal design is learnt, adopted and reinforced.

The term *co-creation* in this paper assumes the definition as described by Sanders and Stappers (2008) to describe any act of collective creativity, that is, creativity that is shared by two or more people (Sanders & Stappers, 2008 in Kvellestad, 2018). Sanders and Stappers explain that it is an instance of co-creation as it encapsulates many activities that are broadly used in design processes (Sanders & Stappers, 2008).

The term *collaborative learning* is defined by Emam, Taha and ElSayad (2019) as a teaching strategy that is applied with small teams of students of different levels of ability, and where all team members participate to deliver the assigned task (Emam et al., 2019, p. 164). This explanation of the concept applies well to the studio context explored in this paper as it supports the goal to facilitate student-centred learning, also established by Mattessich, Murray-Close, and Monsey (Mattessich et al., 2001 in Emam et al., 2019, p.164).

Cooperative design, participatory design and collective creativity have similar meaning in describing the activities undertaken in the capstone studio. Sanders and Stappers (2008, p.6) explain that these terms are interchangeable, and that participatory design has a long history as it has been commonly referred to as *collective creativity*. Sanders and Stappers cite Bodker (1996), asserting that there is evidence of the activity taking place in the 1970s in Norway, Sweden, and Denmark as part of the Collective Resource Approach, where workers developed workplace systems to improve productivity (Bodker, 1996 in Sanders & Stappers, 2008, p. 7).

Finally, to define *capstones* we will use the definition as presented by Lee and Loton (2015) in the *Office of Learning and Teaching's 2015 Report* on capstone curriculum design. The report refers to capstones as "substantial culminating learning experiences that take place in the final stage of an educational course, offering closure and a focus for the sense of achievement that comes with completion. From a quality assurance point of view, capstones can also provide a means of demonstrating course-level learning outcomes" (Krause et al., 2014; Rasul et al., 2009 in Lee & Loton, 2015).

This paper presents an overview of how the teaching method in the capstone studio endeavours to achieve the terms thus defined and within a *community of practice* (the design studio). Evaluations provided by students involved in the subject and product outcomes are used to show the value of the teaching model. The authors furthermore discuss ways to augment the master-apprentice teaching model in order to enhance the student experience in future iterations of the capstone design studio.

2. Background to the study

The motivation for this study stems from observations and outcomes of industrial design students progressing from their third to final fourth year of an undergraduate degree. Instructors in the program observed that students had a lack of understanding of *how to collaborate effectively* despite having group activities during their studies suggesting studio vocabularies are not standardised to promote recall and subsequent integration. This was exhibited by students that were not proactive in seeking advice on their projects, worked in isolation, and did not offer critique or guidance to their peers. Often, academic feedback was ignored, and it was thus considered that students may not have an adequate understanding of how collaboration should take place, what the benefits of collaboration could be, or how to adequately respond to input from stakeholders. There may be many reasons for the lack of engagement, however it was considered unviable to continue in this manner as students could not achieve competencies that would see them progress successfully into industry.

Firstly, if students are reluctant to work with others, that is peers, instructors, potential users, technicians, and industry experts, then they remain novices with a naïve view of the world and of the field into which they will eventually enter. This sets them up to fail in a profession that demands interactions with numerous stakeholders on any given project. In addition to this, students that do not have adequate experience in giving and receiving constructive feedback, will not be able to reach their full potential as professional designers.

To counter the problem, the academic team initiated an enhanced version of the master-apprentice model to encompass behaviour modelling. The goal was to model the benefits of co-creation to resolve design problems, through the design process, and with exemplary outcomes. Henceforth, the enhanced teaching model involved the academic team undertaking collective creativity, communal problem-solving, and co-creation of a lighting design imbued with emotional meaning, biomimetic symbolism, functional, and light physics attributes. The academic team collaborated by drawing on the strengths of each academic team member to create the design output. Students were able to observe how the academics worked as a team and students were encouraged to constructively criticise the academic team's biomimetic lighting concept. The capstone studio was thus redesigned to foster a stronger awareness of the value of synergistic partnerships to arrive at a robust solution.

3. The enhanced master-apprentice model

The capstone studio employs the master-apprentice model whereby students follow the example provided by the instructor. Budge (2016) asserts that the modelling of professional practice is essential and that students can learn behaviours, design literacy and cultural practice that cannot be learnt in another format (Budge, 2016, p245-248).

It is indisputable that the master-apprentice model has merit in providing students with a learning framework that facilitates cognitive understanding. Collins, Newman and Brown (1986) modelled much of their theories of cognitive apprenticeship on the master apprentice model (Collins, Brown, & Newman, 1986). Their work will be used in this paper to discuss the design studio processes and the relationship between the instructors and students in the capstone studio. The question that emerges here, is exactly what actions, behaviours and directions are the students 'following'.

In the case of design studios at WSU, students undertake a variety of tasks and processes of learning to discover new knowledge. They may observe a demonstration that provides step-by-step methods of inquiry or they may follow a worksheet or notes provided by teachers. At times, students mimic the work of their peers to ensure that they are doing the task at hand correctly. This study looks at whether students mimic or behave like their instructors in order to achieve at a professional level? Learning through imitative behaviour may thus create a new opportunity for instructors in the design studio to engage students in collaborative behaviour. Budge (2016) indicates that there are not many examples of *how* students form an identity of 'being a designer' (Flum & Kaplan, 2012 in Budge, 2016, p. 244). In contrast to the transmissive model of teaching, the academic team in the capstone studio devised their own product design object in order to demonstrate cohesion and professional cooperation between colleagues. This also presented the integrative nature of designers to imbed a lifetime's knowledge from many experiences toward the latest design iteration, leading to inspire the same evolving mindset of actions from the student cohort.

Leon de Bruin's extensive study of the master-apprentice model in pedagogy captures the many structural variations of the method as employed in design studios and other discipline areas (de Bruin, 2019). In contemporary design education, the master-apprentice model is adopted from Walter Gropius, founder of the Bauhaus, and later Laszlo Maholy-Nagy in the New Bauhaus in Chicago (Findeli, 1990). Gropius' constructivist manifesto was to inspire the German nation to work in unison to produce art, architecture and objects to reinvigorate the country after Germany's defeat in World War I (Trimingham, 2019). At the epicentre of all activity was a Master of Form (artist) and Master of Works (craftsman). Eventually, the role of artist was considered superior to the craftsman, and teaching roles evolved accordingly (Bürdek, 2015).

In order to ascertain how the master-apprentice model applies to the capstone studio, it is worthwhile considering its context in relation to the design process. In the capstone studio, project-based learning and collaboration in the design process replicates the process captured succinctly in Sanders and Stappers' illustration (Sanders & Stappers, 2008), shown in Figure 1.

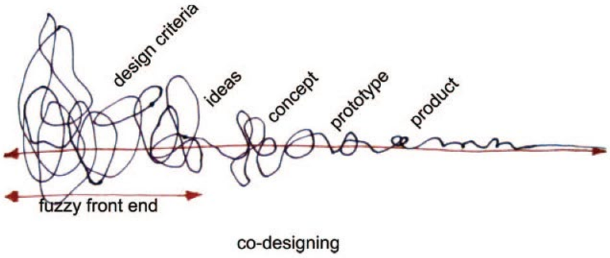


Figure 1 The growth in the front end [of the design process] as designers move closer to the

future users of what they design. Reprinted from "Co-creation and the new landscapes of design" by Elizabeth B.-N. Sanders & Pieter Jan Stappers, Co-Design, 2008, 4:1, 5-18, https://tinyurl.com/vacdgjh

The illustration in Figure 1, is useful as it represents the journey of co-design as pursued in the capstone studio and as facilitated by the master-apprentice model of teaching which has been extensively researched and established in the cognitive apprenticeship theory (CAT) of Collins, Brown, and Newman (Collins et al., 1986; Bandura, 1997, in de Bruin, 2019, p. 264).

The design studio process delineated in the following section provides a response to one of the research questions, that is how the master-apprentice model teaching method is augmented in the capstone studio at WSU.

4. Establishing the design criteria in the design studio

4.1 Design criteria for the student teams

Students were tasked to design a pendant light or table lamp in small groups comprised of three students (representing a 360-hour time pool including class time during the 12-week semester). The design brief to be completed was a lighting object (3D model) that is:

1. Biomimetic inspired with emphasis on iterative 3D processes
2. Involves ideation and application of additive manufacturing methods;
3. Emits adequate lux [lighting intensity] for a predefined space/place;
4. Ergonomically designed and safe for consumers;
5. Is fitted with a suitable technical package for optimal operation and durability.

Students are often apprehensive in undertaking group tasks as they fear discrepancies in workload, in the perceived commitment of individual group members, and differences in personalities and skill levels (Chang & Brickman, 2018). These are all considered valid concerns, however the role of the academic is to negotiate some of these doubts by setting the scene for collaboration through more trusted relationships. To alleviate some of the reservations, groups were self-assigned. Students were encouraged to imagine themselves working in a collaborative studio business, developing a corporate identity to be used throughout their task submissions also building designer and group identity. Student alliances were reinforced by establishing a brand, thus providing a sense of ownership over their projects.

4.2 Design criteria for the academic team

The academic team was comprised of four lecturers in industrial design, working on equivalent parameters as those delineated in the student design brief. The academic team adopted the corporate identity of Western Sydney University for all activities, as their motivation is to fulfil the goals set by the university.

The workload associated with undertaking this model is an interesting point to consider. The academic workload in the capstone studio is equivalent to four hours per week over a 12-week semester. Face-to-face teaching is delivered using a flexible lecture/studio/workshop format, providing students with a variety of learning scenarios. In most cases, at least two staff were always in attendance, rotating between either actively "doing" the academic project or helping students to achieve the learning objectives through their creative individual and group endeavours.

Wherever possible, the academic team modelled behaviours within the prescribed studio time and in front of the student cohort. When the academic's light was completed outside of class, this was considered equivalent to the workload time allowances provided for usual tutorial preparation activities within an academic teaching workload. A nominal percentage of project activity was undertaken outside the workload; however, the team members understood the benefits of the interaction and were willing to participate, nonetheless.

4.3 Augmented master-apprentice model (Design Criteria)

The design criteria imposed the same limitations to students and academics alike. Both groups needed to navigate barriers in group interaction with factors such as peer commitment, time constraints, external pressures, diversity of knowledge, and skill levels all playing a role in determining the success of a product. Collaborative endeavours are thus influenced by physical limitations, technical understanding, and knowledge in the design process.

In this early stage of design development, it is typical for instructors to define the project brief and then assist students in learning how to resolve the brief (Emam et al., 2019, p.164). This is generally done by limited *modelling, coaching* and *scaffolding* (Collins, 1989 in de Bruin, 2019), yet there is little evidence in the literature review undertaken by the authors where the instructors resolve the same collaborative project as their students and in parallel to the students. The augmented master-apprentice model thus provides a new model that encompasses, not only coaching, but active and immersed participation. Emam et al. (2019), indicate that "during early stages of a collaborative model, the instructor must help to develop the students' teamwork skills" (Emam, Taha, & ElSayad, 2019, p. 164), which is pivotal to the success of the capstone studio.

5. Concept and idea development in the design studio project

5.1 Concept and idea development in the student teams

Information gathering was assumed through desk research and a self-directed field trip to local lighting showrooms or exhibitions. This task was intended to encourage group-bonding by sharing of contact information and identifying availability to meet outside of class time.

Informed by the field trip, the next stage was to ideate through drawing. Observations found that several student teams were perplexed with the brief; many of them had not designed organic objects and did not understand the notion of ‘modularity’. During this *articulation* phase (Collins, 1989 in de Bruin, 2019) refinement in the understanding of concepts and procedures (de Bruin, 2019, p. 265) was necessary and some teams needed in-depth consultations with instructors to ascertain the meanings of these terms, hence groups returned to research rather than moving forward with the drawing phase. The in-depth consultations were useful in this collaborative studio, as it presented scope for *co-thinking.*

Observations furthermore indicated that student groups assigned the drawing role to one group member that they perceived as having the greatest competency in drawing. Drawing presents a method by which to communicate creativity though visualisation. This is an example of inclusivity and synergy, as abstract verbal ideas are translated into a two-dimensional form of communication.

5.2 Concept and idea development in the academic team

In parallel to the students’ field trip, academics also gathered sources of inspiration by undertaking desk research, field trips and the collection of physical lighting examples.

The academic team undertook a process of creating conceptual sketches for the lighting design, delegating this task to the academic with expertise in hand-drawing. The Master augmented inputs were characterised by the shared in-class and summarised extra-curricular class experiences outlined below (see also Table 1):

The concepts were generated in front of students, so students could witness the academics doing visual searches, preparing drawing equipment, and generating thumbnail sketches and more resolved sketches.

Students were encouraged to offer feedback and suggestions for improving the designs. Beyond output standards, students were involved in decision making as teams whereby unexpected, yet welcomed, thoughts, ideas and alternate solutions could surface.

The exhilaration for students becoming masters rather than apprentice even for a moment was high during the *Critique-of-Masters* sessions and provided a sense of arrival to the design profession where co-creative methods respect design career experience yet reach out for new contributions from all team members via a dynamic hierarchy.

During this idea-generation phase, the academic staff team also participated in email exchange to share progress sketches and resolve product detailing issues for manufacturing.

5.3 Augmented master-apprentice model (concepts & idea development)

In some design studio learning scenarios, the learning is transmissive as academics direct the flow of knowledge to students. In cognitive apprenticeship, students undertake activities in *articulation* and *reflection* such as explaining their findings to instructors and peers (Collins, 1989 in de Bruin, 2019. p. 265). As an augmentation to this process, the capstone academic team also shared their field trip experiences, exemplifying breadth of research and stimulating creative thinking. To model teamwork, lectures were undertaken in a team-teaching format with two or more academics presenting content related to the topic. Students were continually invited to offer insights, evaluations, reflections and input during lectures and studio time.

It is significant to note that the email exchanges between academics that were shared with the cohort included at times, examples of negative feedback concerning aesthetic development, technical issues, and foreseeable manufacturing problems. The students were surprised to read the academic team's correspondence and of the willingness of the academics to change the design many times in order to continually improve the outcome. This accelerated student confidence and noticeable change in some student team member's mindsets through engaged activity and design progression.

6. Prototyping and product outcomes in the design studio project

6.1 Prototype and product outcome by the student teams

The student teams were encouraged to produce a lighting object that was of suitable quality for display in the WSU 26th Annual graduate exhibition, *Widevision*. Initial prototyping was undertaken by students by forming extruded polystyrene foam into three-dimensional form studies or by producing scale models using 3D printing methods.

Successful teams in the capstone studio were able to establish a strong group-work ethic, producing models of a high resolution to communicate the concept with members contributing equally to the product design process and outcome. In some cases, teams worked outside of the required class time, at one another's homes, or in the university makerspace/workshop to complete a quality product. In a few cases, student groups worked beyond the scope of the teaching semester. This demonstrates the essence of social learning, as espoused in Lave and Wenger's *communities of practice* (Lave & Wenger, 1989 in Cox, 2005) where participants are working alongside peers that have like-minded goals, or as a "mutual participation in practice" (Cox, 2005, p. 529).

6.2 Prototype, product outcomes and methodological influence by the academic team

The ultimate goal for the participating academics was to create a physical model of the team's lighting design and to model collaborative behaviour so that students could understand how collaboration occurs in a design studio, as students had not yet participated in the 10-week design industry placement following this subject. The academic team's initial aim was to present a design solution in an equivalent timeline and using the same project constraints given to students.

In producing the final light, the academic team experienced some of the problems encountered by students. Namely, financial constraints and availability of 3D printing resources.

6.3 Augmented master-apprentice model (Prototype and product outcome)

During tutorials, the academic team were working on the CAD model real-time, with shared-screen projection in the classroom to show design resolution. The academics demonstrated examples of design iteration, manufacturing considerations, and steps in creating 3D CAD models for the academic light object. Once again, email exchanges between staff were projected on screens as evidence of ongoing feedback and how the design is pushed to ensure quality and manufacturability.

The role of master-apprentice was enhanced in scope to demonstrate and exemplify cooperation, communal decision-making, strategies for overcoming barriers, group negotiation skills, and actioning feedback. The intention is that students observe the synergy of working in teams and model the behaviour undertaken by staff to meet the design phase milestones.

7. Meaning and relevance of 'collaboration' in the design studio

The meaning of collaboration in the design studio comprises many activities as presented in the above narrative and matches the definition established earlier in this paper. It as a teaching strategy that is applied with small teams of students of different levels of ability, and where all team members participate to deliver the assigned task (Emam et al., 2019, p. 164). If we return to the initial definition, we see that students and academic teams in the capstone studio achieved all the elements prescribed, with the added non-tangible [but present] activity of modelling professional behaviour, that is, how to 'be' a designer.

Modelling of such behaviour by both students and academics reinforces the theories of *communities of practice* and situated learning (Lave and Wenger, 1991 in Cox, 2005, p. 528) and may be used to cultivate a rich learning experience through social learning where individuals with common interests, skills and knowledge participate in achieving a communal goal. The theory conceived by Lave and Wenger is explored in several studies of organisational learning, and in higher education pedagogy (Artemeva, 2006; Cox, 2005), and fittingly applies to design studio teaching. The application of *communities of practice* for industrial design studio learning is very useful as this capstone studio exemplifies working in teams to resolve a group design challenge and the co-created outcome is derived from the combined efforts of all team members.

Table 1 below, is a summary of specific examples of behaviour modelling in the capstone studio:

Table 1 Examples of academic behaviour modelling in the capstone studio

Design Process	**Opportunities for student observation**
Research phase	Activity undertaken by academics during tutorials: • Academics undertake visual searching (using search engines such as Google) to inspire design concepts • Visual searches are projected on screen so students can see how the research process • During the lecture, academics also share images of their own site visits, exhibition visit and visual research findings
Conceptual development phase	Activity undertaken by academics during tutorials: • Academic staff are prepared with suitable equipment to undertake the conceptual drawing phase • Academics sit with students at student tables to draw initial ideas; soliciting feedback from colleagues and students throughout the process • Drawings are displayed on tables for feedback/critique, demonstrating the range of work and quantity of work that can be achieved in limited time frame • Staff and students select the most viable lighting design to pursue • Academic emails (between staff) are shared with students via screen projections during tutorials to show e-collaboration process
3D CAD modelling phase	Activity undertaken by academics during tutorials: • The academics share CAD models with students via screen projections to show how the model is generated; CAD model is updated in 'live' mode during the tutorials • Academics provide ongoing feedback to each other to suggest how the design can be improved. • Academic emails (between staff) are shared with students via screen projections during tutorials to show e-collaboration process
Technical package resolution	Activity undertaken by academics during tutorials: • The academics share screen projections to show searches for suitable technical package • Academics provide ongoing feedback to each other to suggest potential technical packages • Academic emails (between staff) are shared with students via screen projections during tutorials to show e-collaboration process
3D printing phase	Activity undertaken by academics during tutorials: • The academics share screen projections to show development of final lighting solution • The academics consulted with technical staff on 3D printing requirements during tutorial time; students could observe these meetings. The costs of model-making were shared with students.

Positive working relationships is crucial to the learning environment to ensure students are confident enough to seek advice and are proactive in responding to feedback. Where students did not attend classes regularly or did not participate in critiques, the projects did not fully develop, and in some cases, groups were not able to achieve the milestones defined in their own project timelines.

In the self-evaluations conducted by the student teams, groups were asked to reflect on their experience in the studio subject and to consider what they had discovered during their journey through the project. A sample of comments was obtained from six student groups, shown in Table 2.

Table 2 Student Groups-Self evaluations

Student Groups	**Self-Evaluations**
Group A	What have we learnt in this unit: • To create an aesthetically pleasing design • We could see it in a boutique • The piece is flexible and could be mounted on the standing frame and also to the ceiling with additional hooks that could be placed on top of the frame If we were to do the project again, how would our work change: • We would choose a softer brightness bulb • Make the modules longer • Make more modules • Hook the modules instead of threading through the frame
Group B	We have learnt the following in this unit: • The importance of keeping a process diary/portfolio/ journal • Teamwork and job distribution New skills that we have learnt: • Vacuum forming • CNC machining • Laser Cutting • Soldering

Group C	There were many challenges faced during the project. Exploring the particular themes of organic and natural forms was a new experience and a unique way to design. The process of simulating real world production was also a new challenge and required much more consideration and detail when designing the product. While a challenging project throughout, overcoming these challenges and producing a final model brought great practice and new skills that can be utilized to advance our design careers. It granted us the experience of designing products in real world scenarios and allowed us to understand all the considerations related to a production. Overall, the light design we created is unique and interesting in many aspects and was not only a valuable experience to develop, but it is a piece worth showcasing to future clients to present the skills we possess. We have new insight into proper design projects and can carry the skills we learnt into future endeavors and continue designing and expanding our expertise.
Group D	As part of our design problem, our main goal was to meet the demands of the clients (our instructors). We were required to have a modular component repeating throughout the design and we have achieved this. From the onset we knew that we wanted to appeal to budding young entrepreneurs of ostentatious taste. We wanted our light to be utilized as Interior Mood Lighting, High-Scale Domestic Décor, Renewed Aesthetics for Offices, Hotels and Restaurants, as a means of Intrigue; a conversation-inducing piece at social events, and for it to provide general illumination to venues.

Group E	Good aspects of the project: • Our module was redesigned several times. • Our group tested every module by 3D printing 1 module piece out. • Reduced assembly part for 1 module. (From 3 pieces to 2) • We had really good communication throughout the semester. • Good team effect. Everyone did the work equally. Bad aspects of the project: • Printing took quite a bit of time, giving us less time to work on our final model. • We made a mistake at first by painting a module. • One of our test-modules showed that it was too thin and brittle. • Most people in our group had work causing less time for meet ups. What can be improved: • Bigger overall scale • Better cable management • Give 3D printing a bigger priority. • More meetups to finalize and work on our designs and models. • Better hook attachment design.
Group F	What went well in our project? • Good research technology • Concept development • For our project we went through various stages back and forth with the clients and the manufacturing room to produce our final design. What can we improve on in future? • Testing • Better prototypes • More collaboration with our client • Future possibilities? • Using improved manufacturing techniques • Various materials testing which may better suit our design

For six groups, their respective efforts in the capstone studio was open to public scrutiny at the annual *Widevision* exhibition, showcasing exemplary student work in the course. Visitors to the exhibition could speak directly with students and guests provided many positive comments on the finished models. The lighting works revealed a high level of care and competency and were demonstrative of the excellence that can be achieved through robust collaboration. Whilst the total number of exhibiting works is low, it is significant to note, that the objective of the capstone is to engage students in collaboration regardless of whether they completed the light or not. Table 3 below, indicates the number of exhibition-ready models.

Table 3 Number of Design Studio Teams and comments on exhibition-readiness.

Models/product output	**Student Groups**	**Comments/Reflections**
Total number of student lighting groups	14	Each group comprised of either 2 or 3 students.
Total number of exhibition-ready models, that is, models are complete and of high finished standard	6/14	These teams had excellent group collaboration; excellent channels of communication with staff; lights were completed to a high standard; excellent attention to detail; motivated group membership; excellent attendance in studio.
Total number of incomplete models with potential for exhibition upon completion	6/14	These teams were unable to print sufficient modules due to financial limitations; groups encountered model making problems; in some cases, the groups were not able to achieve milestones.
Total number of models complete (submitted for marking) but not ready for exhibition.	2/14	These teams submitted objects that were not resolved; technical package not tested for safety; team member attendance in classes was sporadic; limited communication with instructors; modules were not structurally sound; these two groups experienced external interruptions and could not meet milestone dates.

One of the questions we must ask ourselves as educators is why is it important to offer opportunities to collaborate in the design studio? In industrial design, the collaborative capstone studio prepares students to enter an industry that relies on empathy with humans from broad backgrounds, cultures and with diverse needs. As such, it is essential to equip students with the experiences where they must adapt to the dynamics of working in co-operation with peers and academics rather than relying on their own limited skills and knowledge. A successful "real-world" studio relies on the synergy between workers in order to drive the company's mission and goals, and hence the modelling of an academic *being* a designer brings many insights to the fore. If the instructor models professional practice and collaborative activity to undergraduates, then students will have improved confidence when working on "real-world" problems and in "real-world" teams.

8. Conclusions

There is much scope to further improve the student experience in the capstone studio. A retrospective survey of participants would help to further decipher methods for improving the subject, although the insights presented in Table 2, are a good starting point. Changes to the capstone studio could include co-design, where students and academics work on a combined project, the academic team could work towards submitting equivalent tasks with similar budget constraints as students, as well as more concrete decision-making strategies for negotiating ideas, and building collaborative skill sets such as how critiques unfold or how to negotiate competing ideas. Students could also undertake a more formal review of academic projects creating a sense of belonging to the profession, and 'being' designers. This activity elevates the student role to that of an emerging professional, where their judgements are informed, justified and valued.

This paper thus argues that by being engaged, immersed, and active in the design process, and by 'being' a visible designer, that the path to achieving a common goal is enriched. This synergy is paramount to success and encourages students to have pride in the output. This augmented master-apprentice model places the student-team at the epicentre of learning. With six out of 14 groups exhibiting their work, the model has shown measured success with room for enhanced outcomes in the next delivery. No works were selected for exhibition from the same capstone studio in previous years, hence the challenge is now to increase the number of exhibits for subsequent exhibitions.

The industrial design academics (instructors/clients) are active participants in making and negotiating outcomes. It is of note that the academic team's lighting design was not completed for the exhibition. The academic team gave preference to all student endeavours as a priority. The academics met to discuss the avenues for producing the light and it was determined that the academic light may result in a sense of undesirable 'competitiveness'. The academic team did not wish to draw attention to their own efforts but rather to elevate the works generated by the student teams.

What did the academic team learn in the process of undertaking this teaching approach? Academic staff modelling designerly behaviour through professional practice provided students assurance that continual conceptual and detail iteration informed by communal research and constructive critique was essential for successful project completion. This was quantified through attainment or non-attainment of exhibition ready status. The capstone studio tasks are not intended to redefine the roles of master and apprentice, rather the intention is to moderate the distinctions to maximise collaborative synergy through professional practice modelling. This resulted in heightened student confidence that is supported by informed design decision-making thus preparing students for employment and co-creative practice.

Acknowledgements: The authors wish to thank the Dean of Built Environment WSU, Professor Kerry London for supporting the capstone studio concept and Dr Lynn Berry, WSU Curriculum Advisor, for her guidance in re-invigorating the Industrial Design curriculum and for undertaking a preliminary review of this paper.

9. References

Artemeva, N. (2006). Communities of Practice: Learning, Meaning, and Identity: TCQ TCQ. Technical Communication Quarterly, 15(4), 505-507.

Budge, K. (2016). Learning to Be: The Modelling of Art and Design Practice in University Art and Design Teaching. International Journal of Art & Design Education, 35(2), 243-258. doi:10.1111/jade.12060

Bürdek, B. E. (2015). Design : History, Theory and Practice of Product Design. Basel/Berlin/Boston, SWITZERLAND: Walter de Gruyter GmbH.

Chang, Y., & Brickman, P. (2018). When Group Work Doesn't Work: Insights from Students. CBE life sciences education, 17(3), ar42-ar42. doi:10.1187/cbe.17-09-0199

Collins, A., Brown, J. S., & Newman, S. E. (1986). Cognitive Apprenticeship: Teaching the Craft of Reading, Writing, and Mathematics. In M. A. Bbn Labs Inc Cambridge (Ed.).

Cox, A. (2005). What are communities of practice? A comparative review of four seminal works. Journal of Information Science, 31(6), 527-540. doi:10.1177/0165551505057016

de Bruin, L. R. (2019). The use of cognitive apprenticeship in the learning and teaching of improvisation: Teacher and student perspectives. Research Studies in Music Education, 41(3), 261-279. doi:10.1177/1321103X18773110

Emam, M., Taha, D., & ElSayad, Z. (2019). Collaborative pedagogy in architectural design studio: A case study in applying collaborative design. Alexandria Engineering Journal, 58(1), 163-170. doi:https://doi.org/10.1016/j.aej.2018.03.005

Findeli, A. (1990). Moholy-Nagy's Design Pedagogy in Chicago (1937-46). Design Issues, 7(1), 4-19. doi:10.2307/1511466

Kvellestad, R. V. (2018). Design processes and co-activity in design education. Paper presented at the Catalyst, University of Limerick.

Lee, N., & Loton, D. (2015). Capstone curriculum across disciplines: Synthesising theory, practice and policy to provide practical tools for curriculum design (978-1-76028-536-4). Retrieved from http://hdl.handle.net/11343/119575

Mattessich, P. W. (2001). Collaboration--what makes it work (2nd ed. ed.). Saint Paul, Minn.: Saint Paul, Minn. : Amherst H. Wilder Foundation.

Sanders, E. B. N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. CoDesign, 4(1), 5-18. doi:10.1080/15710880701875068

Trimingham, M. (2019). Bauhaus 100. Theatre and Performance Design, 5(1-2), 2-5. doi:10.1080/23322551.2019.1606392

About the Authors:

Ms Karen Yévenes is a *Lecturer in Industrial Design* at WSU with publications in design education, patents in product innovation, and consultancy experience. She teaches 2D/3D visualisation and studio subjects and is currently undertaking a PhD in product design involving participant codesign processes.

Mr Jean Payette is a *Lecturer in Industrial Design* and has vast experience in academia and industry. His portfolio includes furniture design, lighting design, medical and biopharmaceutical equipment for which he holds several patents.

Dr Sasha Alexander is the *Director of Academic Program Industrial Design* at WSU. Previously an industrial designer in Europe and Australia has participated in funded research projects in health, IoT, forestry, industrial electrical and holds a PhD in Value Chains.

Mr James Berry is an awarded academic and industrial designer with 25 years of experience in design education in Australia and Japan; has expertise in eco-design, physical UX, entrepreneurship, and design for manufacture. His furniture is held in permanent collections including the National Gallery of Australia.

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

From Engagement to Empowerment: Exploring the Potential for Pedagogical Partnerships in Design

James Robert THOMPSON[a]*

[a] The University of Melbourne, Australia
*Corresponding author e-mail: james.thompson1@unimelb.edu.au
doi: https://doi.org/10.21606/drs.2020.194

Abstract: As the notion of co-creation, or productive partnerships between staff and students, achieves increasingly popularity across disciplinary and institutional contexts, the offshoot idea of students and staff partnering on pedagogical scholarship is gaining traction. In design education contexts, however, where the boundary between pedagogical scholarship and studio-based practice tends to be blurry, this model has yet to take hold. What might pedagogical partnerships in design look like, and what benefits might they offer to all constituent parties? This paper explores this topic, drawing connections between scholarship of design education and several well-established pedagogical partnerships around the world. The prospects of students and educators collaborating on pedagogical inquiry includes more authentic feedback loops for improving educational quality and relevance, as well as deepening students' agency in shaping their learning and development.

Keywords: pedagogical partnerships; scholarship of teaching and learning; design education; student agency

"What if equality...were to provide a point of departure? What would it mean to make equality a presupposition rather than a goal, a practice rather than a reward situated firmly in some distant future…?" (Ross, 1991, p. xix)

1. Introduction

Across levels and geographies of academia, the notions of co-creation, staff-student partnership, students as partners (SaP) and related objectives are increasingly promoted as priorities at various institutional levels (see Bovill *et al*, 2016). The mainstreaming of such concepts can be traced to the influence on education from business management trends (Urbick, 2012; Dollinger *et al*, 2018), as well as widespread concerns for diminishing student engagement, motivation and wellbeing (see Chemi and Krogh, 2017). As the author's own university administration argued in a recent set of internal documents, co-creation is a means to counter “the feeling that a student’s relationship with the University is transactional” and “the sense of disconnection and invisibility that is a genuine concern for many students.” Scholars have also noted that the popularity of co-creation can be attributed to it being adopted as a) a challenge to neoliberal academic culture (e.g., by empowering students and upending hierarchical, unilateral or transactional staff-student relations) and b) then appropriated by neoliberal institutional discourse (Matthews *et al,* 2018). This duality gives co-creation a chameleon-like quality. Hannafin *et al* (1997) also highlight the near-certain gap between an institution’s espoused theories and objectives, on the one hand, and its everyday educational practices, structures and environments as experienced by students.

Greater student involvement in decision-making and academic initiatives can also be understood as a form of collaborative decision-making that responds to ongoing changes in student expectations about education (Hsiao *et al.*, 2018). As confidence in conventional mechanisms for gauging student voice—such as student satisfaction surveys—is increasingly called into question, more active and authentic student involvement offers an effective alternative to improving teaching and learning quality. Finally, partnerships between staff and students present a potential cooperative, diplomatic channel to build empathy as a bulwark against emerging intergenerational antagonism, which may be manifesting in educational spaces. With so many factors contributing to the ubiquitous advocacy for co-creation, it is no wonder that it is now manifesting through an increasingly diverse array of spaces and practices (see Chemi and Krogh, 2017; Bovill *et al*, 2016).

One avenue for meaningfully involving students in academic affairs is through the scholarship of teaching and learning (SoTL), wherein learning and teaching praxis itself becomes the object of inquiry. Although some argue that, “Good [SoTL] practice requires engaging students in the inquiry process” (Felten 2013: p. 123), or that “To be the scholarship of teaching and learning...it has to include students as final partners in that inquiry” (Bass 2013), involving students as research *partners* rather than mere subjects represents a radical shift from convention. As a subcategory of activity within co-creation and SaP, “pedagogical partnerships” or “co-creating learning and teaching” are an emerging and innovative mode of praxis that involves students contributing to teaching and learning as consultants, co-researchers, representatives and/or pedagogical co-designers (Bovill *et al*, 2016). The partnerships referenced throughout this paper serve as valuable examples for these learning and teaching-related manifestations of co-creation in higher education.

Within design-based learning environments, it would appear that sustained pedagogical partnerships have yet to come to fruition. Certainly, co-creation has reached a level of broad acceptance in design practice and design research (Sanders & Stappers, 2008). Design thinking has also been applied to develop pedagogical models based on co-creation (Androutsos & Brinia, 2019; Hakio & Mattelmäki, 2019). Marshalsey and Sclater (2018) describe one of the few reported one-off instances of co-created learning and teaching research in the design fields. Whilst sustained pedagogical partnership models are far from achieving mainstream status elsewhere, their lack of adoption in design contexts is somewhat unsurprising given that SoTL in design fields tends to occupy a minor position to other modes and areas of scholarship (Tovey, 2013). Given the positive outcomes identified in other fields, however, it is worth asking: What might pedagogical partnerships look like in design? And what benefits might they offer—to design students, to teaching practice and to design pedagogy-focussed research?

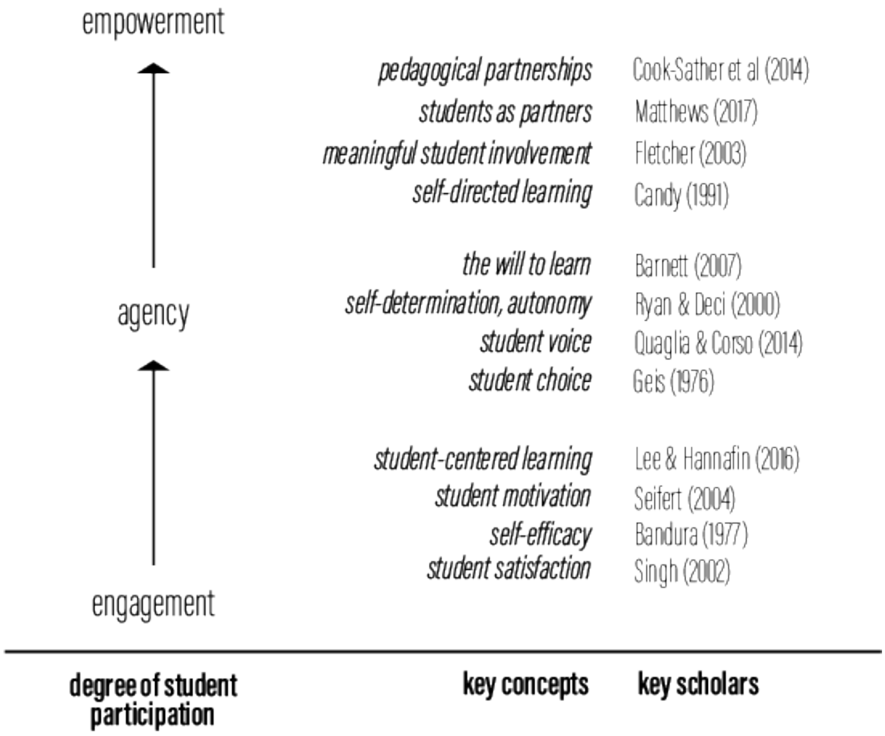


Figure 1 Key concepts and scholars along the spectrum of engagement-agency-empowerment.

Simply extending co-creation to teaching and learning domains is not in itself a particularly convincing argument. However, for those seeking more authentic modes of design student engagement, agency or empowerment, limiting applications of co-creation to *non*-pedagogical areas of scholarship would restrict students' degree of engagement in their education (see Figure 1). Certainly, opening the metaphorical doors to the scholarship of teaching and learning, not to mention handing over the keys, is unknown territory for most academics. In an effort to ease anxiety and address scepticism on the subject, the next sections draw upon recent publications of successful pedagogical partnerships to identify key benefits and challenges. The paper then concludes by reflecting on the potential benefits and challenges of adopting pedagogical partnerships in design education contexts.

2. The basis of pedagogical partnerships

Chemi and Krogh (2017) define co-creation broadly as "the process of creative (original and valuable) generation of shared meaning and development" (p. viii). This conceptual umbrella then covers the suite of overlapping and nested terms—such as students-as-partners, student-staff partnerships, partnership learning communities and pedagogical partnerships—a common characteristic of these being a commitment to staff and students collaborating on teaching and learning activities through non-traditional social relations (see Mercer-Mapstone et al, 2017). Thus, a primary driver of these partnership is to:

> "[redefine] the roles of student and faculty not only in relation to one another but also in relation to the institutions within which we work. Partnership redefines processes and therefore our approach to analysis, pedagogical practice, and research in ways that emphasize affirmation as well as create opportunities for change." (Cook-Sather *et al*, 2014: p. 6-7)

Building on this radical basis, Matthews (2017) formulates an understanding of SaP:

> "Students as partners (SaP) is a metaphor for university education that challenges traditional assumptions about the identities of, and relationships between, learners and teachers. Through the surprising (to some) juxtaposition of 'student' and 'partner,' this metaphor imagines and makes way for respectful, mutually beneficial learning partnerships where students and staff work together on all aspects of educational endeavours. SaP offers hope for students and staff seeking relational approaches to learning—built on and through dialogue—that enable shared responsibility and joint ownership for teaching, learning, and assessment" (p. 1).

Figure 2 represents the various teaching and learning-related activities that can emerge through partnership learning communities, once certain relational features, such as those noted by Matthews above, have been established. The focus in this paper is specifically on engaging design students in SoTL, given that other initiatives and models for co-creation are already quite established (e.g., consulting student representatives on curriculum redesign or collaborative design research between staff and students).

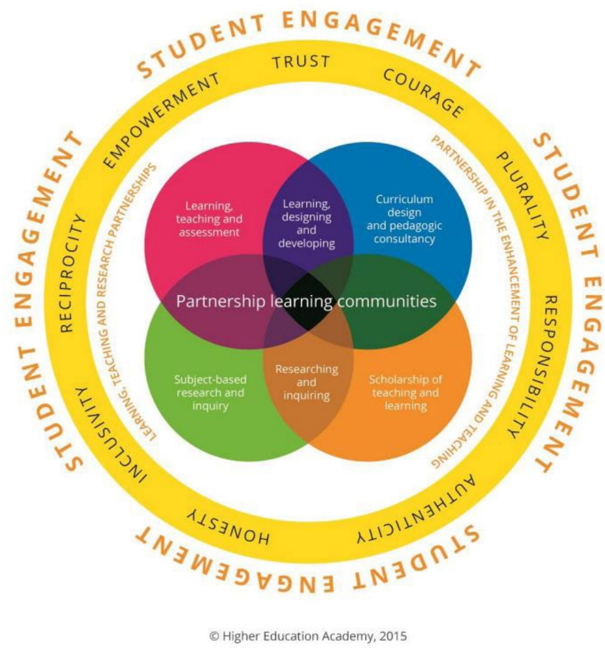


Figure 2 Model of Students as Partners from Healey et al *(2014).*

Rather than conceiving them as independent activities, pedagogical partnerships are considered inherently linked to the scholarship of teaching and learning. For instance, Abbot (2019) makes the argument for active student participation in SoTL:

> "The origins and continued heart of [SoTL] is individual instructors seeking a deeper understanding of their classroom practices in a desire to promote deeper learning. But as the field grows, we recognize the necessity of engaging students more significantly than as addendums to SoTL…When we study teaching and learning, we have an *ethical obligation* to make our work accessible to everyone who is participating in these shared purposes of higher education. If we are examining student learning, shouldn't students be able to read and respond to such research?...The key questions of SoTL – what is happening in the classroom? what and how are students learning? are our teaching efforts effective? – cannot be answered without student input, and often these questions can be better answered with student partnership."

She then continues her argument, drawing on her own experience:

> "As both a SoTL scholar and a student myself, SoTL inflects my classroom experiences, my capacity to engage, and my ability to learn. My engagement in SoTL has helped me understand and articulate what supports my learning, and has given me the space to advocate for my peers and myself. It has also helped me become an ally to my faculty, as I can better interpret learning goals and hold myself more accountable in our shared learning. If teaching and learning cannot happen without students, how can SoTL?"

Involving students in pedagogical inquiry can also be driven by a desire to increase student agency and responsibility in their learning. Lee and Hannafin (2016) propose a conceptual framework for student-centered learning called "Own it, Learn it, Share it" that could be applied to student-driven SoTL research. In this framework, they recommend that students:

> "a) develop ownership over the process and achieve personally meaningful learning goals; b) learn autonomously through metacognitive, procedural, conceptual, and strategic scaffolding; and c) generate artifacts aimed at authentic audiences beyond the classroom assessment" (p. 707).

Granting this level of agency to students does not necessarily mean surrendering the expertise and authority associated with being an experienced educator. In other words, successful partnerships are built on equity as opposed to equality. Pre-empting sceptics, Cook-Sather *et al* (2014) note several important distinctions when it comes to considering power dynamics within partnerships:

> "In student-faculty collaborations, we need to acknowledge that our roles, expertise, responsibilities, and status are different. And they should be. Partnership does not require a false equivalency, but it does mean that the perspectives and contributions made by partners are equally valued and respected and that all participants have an equivalent opportunity to contribute…[S]tudying and designing teaching and learning in partnership with students does not mean that we simply turn the responsibility for conceptualizing curricular and pedagogical approaches over to students, nor does it suggest we should always do everything they recommend to us. Rather, it means that we engage in a more complex set of relationships involving genuine dialogue with students." (p. 7-8)

Noting the importance of team- and trust-building to the success of such partnerships, Cook-Sather *et al* (2014) write, "Partnerships rarely emerge suddenly in full bloom; instead, they grow and ripen over time as we engage with students" (p. 6). This points to the need to design mechanisms within the cycles and structures of universities that foster and sustain partnerships beyond individual projects. Let us now examine those programs that have achieved sustained success.

3. Established Pedagogical Partnerships

This section reviews two existing programs—one in the United States and one in Sweden—as paradigmatic initiatives in pedagogical partnerships. These widely cited examples have been selected as models from which lessons might be drawn for translation to design contexts. Whilst these are certainly not the only instances of this type of practice, they are two of the most widely cited. In addition to the four examples below, other publications of case studies include Woolmer (2016), Healey *et al* (2014), Little (2012) and Werder & Otis (2010). Further institutional examples for reference are included at the end of this section.

3.1 Students as Learning and Teachers (SaLT) Program, Bryn Mawr and Haverford Colleges (USA)

https://www.brynmawr.edu/tli/SaLT-Program

The SaLT program, which has been in existence since 2006, is part of the Andrew W. Mellon Teaching and Learning Institute at Bryn Mawr and Haverford Colleges. Cook-Sather (2013), the Institute's director and founder of SaLT, describes the program as students and staff partnering to explore pedagogical practice, which

> "constitutes a form of 'radical collegiality' (Fielding, 1999) through which students are full partners with faculty in analyses and revisions of pedagogical practice" (p. 187).

Undergraduates enrolled at Bryn Mawr or Haverford College apply to become paid consultants and collaborate with staff on projects to improve teaching quality. The process and objectives are set collaboratively by each partnership, but Cook-Sather (2013) provides an example of the type of duties that a student might perform:

> "Each week, the student consultant observes her faculty partner's classroom using a clinical form of observation notes, with columns for time, observations, and reflections. She shares her observation notes with her partner and meets weekly with him or her to discuss what is working well and what might be revised. She might also conduct mid-semester or other forms of feedback gathering and work with her faculty partner to develop or revise various aspects of the course." (p. 188)

This work is then typically formulated as a scholarly output of some kind and disseminated, for instance, through the Institute's own open-access journal *Teaching and Learning Together in Higher Education*, which has published several issues dedicated to student-authored articles (see Volume 1, Issues 21 and 26).

Whilst not all educators are immediately receptive to being observed by student-analysts, as it puts them in a vulnerable position, partnerships based on empathy, transparency and shared objectives show clear benefits for staff seeking to improve the quality and relevance of their teaching practice. In terms of academic development for teaching staff, Cook-Sather (2013) argues that such a partnership model serves as a "threshold concept" with staff experiencing it as "troublesome, transformative, irreversible, and integrative" (p. 187). Thus, pedagogical partnerships have "the power to transform the way educators understand the teaching and learning process and their role in it" (King & Felten, 2012, p. 5).

The benefits for students also extend beyond merely an improved experience of learning. Engaging in pedagogical partnership has the potential to radically shift ideas of education, prompting an expanded sense of agency. As one student who participated in such projects put it, this kind of work is "good for higher education because it helps disrupt the traditional hierarchy that exists in higher education, and that's good because it helps promote student learning, and that's the goal of higher education" (Abbot, 2013). Another student argues that this kind of work "is the future, or should be the future, of higher education because this sort of collaborative work in being able to create a classroom that is…co-created, co-taught, co-learned is so much more beneficial for students and professors in terms of what works best" (Burke, 2013).

3.2 Active Student Participation, Uppsala University (Sweden)

https://www.uu.se/asp

Under the heading of active student participation (ASP), the University of Uppsala offers a range of modes for students to engage in roles traditionally left to academics:

> "Active student participation imagines learning as a shared venture between educators and students. It invites students to support, empower, and challenge each other's learning, as well as helping them to be co-creators in planning, facilitating, and evaluating courses within higher education" (Barrineau *et al*, 2019).

Generally, the emphasis on ASP is on student-led teaching and peer learning, with most partnerships including some form of course evaluation and/or course design and development. Barrineau and Anderson (2018) describe the 25-year existence of the University's Centre for Environment and Development Studies (CEMUS), which offers student-coordinated course offerings as a model of student-driven education. In this case, students and alumni are hired as employees and granted "an unusual amount of power over decision-making in the design and implementation of interdisciplinary education" (p. 16). In this case, it is a student-initiated partnership; thus, rather than students being invited to participate in a partnership, students invite academics on a term-by-term basis to participate in the course offering. For their part, faculty members tend not to play an active or strong role in course development, delivery or evaluation. To sustain itself from year-to-year, CEMUS has developed a model that does not rely on senior educators for organisational survival. In addition to the student coordinators, a core team of alumni provides "organisational support, continuity, and representation" (p. 3) and sits on the "work group" that includes students, teachers, and external stakeholders.

While recognising a sense of empowerment, CEMUS coordinators also feel as though they occupy ambiguous and liminal identities within the institution, an ambiguity that they claim offers "the freedom to be experimental and risk failure" (p. 23). Also, with no "expert in charge" of the subject, student enrolled are positioned to adopt more responsibility towards engagement and learning. However, Barrineau and Anderson (2018) warn that, "increased student control of curricula does not necessarily increase the success of partnership" (p. 26). They describe the many challenges continue to face the program, many of which surround relationships and roles of parties involved. As a model of student-driven education, it does however suggest a largely untapped realm for pedagogical innovation.

Three more recently formed programs, each sharing an ethos with those described above, are:

- Teaching and Learning Partnership Projects, University of Queensland (Australia) https://itali.uq.edu.au/about/projects/students-partners
- ChangeMakers Program, University College London (UK) https://www.ucl.ac.uk/changemakers/about-ucl-changemakers
- Student Partners Program, McMaster University (Canada) https://teaching.mcmaster.ca/student-partners-program

4. The potential of pedagogical partnerships in design

In pursuit of translating pedagogical partnerships to design contexts, it is germane to consider the particularities of the latter. Scholars have identified two longstanding challenges facing students in conventional design education contexts: first, the tacit nature of its pedagogical practices and second, an over-reliance on a power imbalance between tutor and novice (see Dutton, 1989; Stevens, 1998; Mewburn, 2011). These are particularly acute in the "dynamic and contested field" of architecture (Webster, 2008: p. 68), as well as its allied, professional, studio-based disciplines, characterised as they are by ritualised practices and hero worshipping (Anthony, 1991; Cuff, 1991; Webster, 2005). Though not a silver bullet, pedagogical partnerships offer an avenue for making some headway in addressing both challenges.

4.1 Design's Tacit Pedagogy

The first challenge, the unspoken quality of design's pedagogical practices, has attracted criticism from scholars and students alike (Yanar, 2007; Willenbrock, 1991). Students from secondary education backgrounds often enter university-level design courses relatively unfamiliar with unstructured modes of learning, and the "culture shock" can be bewildering and frustrating (Thompson, 2019). Generations of studio tutors have preferred to let design learning remain a mysterious enterprise, unwilling or unable to reconcile the subjective nature of design artefacts from the objective demands to deliberate and assess them (Coyne and Snodgrass, 1991). On the other hand, attempts to directly explain the embodied and experiential nature of design learning can prove insufficient or counterproductive, justifying the use of metaphors like "coach" or "personal trainer" to clarify roles with reference to students' non-academic lives (Adams *et al*, 2016). Particularly in professional design fields like architecture, scholars have also noted the problematic existence of a "hidden curriculum" through which students are socialized into the norms of the profession (see Dutton 1989):

> "Apart from teaching skills and providing knowledge, [architecture schools] provide the social induction that the young architect-to-be must have. Every profession inculcates a value system into its students, although most of these values remain obscured and unsaid...Ways of acting, of talking, of dressing: attitudes, dispositions, and tastes must all be instilled…More than in many other jobs, success in architecture relies less in 'knowing' and more in 'being.'" (Stevens, 1999: p. 55)

In examining "the more tacit, more intricate evolution of an individual through a sequence of distinct periods" of architectural education, Cuff (1991) argues that,

> "Normally, these developmental phases are not described explicitly, even to the novice, but reveal themselves only during the process of becoming" (p. 116).

A further complication, as Yanar (2007) emphasizes, is that whatever pedagogy a given design educator espouses and what teaching approaches they actually practice are often at odds with one another. One value of pedagogical partnerships in this regard would be for more senior students to serve as translators, working to develop tools and activities that make the design process more explicit and critically expose the "hidden curriculum" to incoming cohorts. Although there are ostensibly legitimate reasons that a student might decide not to pursue a career in design after embarking on a design course, unnecessary frustration and anxiety stemming from educators unwilling to elucidate the oddities of design education should not be one of them.

4.2 Design Education's Hierarchical Social Relations

The second key challenge of conventional approaches to design education is its hierarchical social relations. As Mewburn (2011) discusses, the desk crit, the basic unit of social interaction between instructor and student in a design studio, is haunted by the power relations fundamental to this form of role-play "in which the student plays the 'novice architect,' while the teacher takes on various other roles such as 'experienced architect,' 'client' or 'consultant'" (p. 364). Mewburn then points to a key critique of this model published since Schön's seminal work:

> "Within this performance lies always the possibility for replication of the old master/apprentice model which some argue is a powerful way of 'disciplining' undergraduate students into particular professional mores (Cuff, 1991; Webster, 2005 & 2007)." (p. 364).

Despite studio culture's reputation as collaborative, and whilst some pedagogues have experimented with fostering alternative social relations (see Hamilton, 2018), studios remain in contradiction by and large authoritarian spaces where tutors adopt identities of experts or masters, possessing the disciplinary knowledge and skills that students are in deficit

(Ioannou, 2018; Quinlan *et al,* 2007). As Rancière's (1991) story of *The Ignorant Schoolmaster* revealed, this myth-based "infantilising" model of education legitimises the authority of the instructor as a way of maintaining wider social relations. To Rancière, this model is indefensible from the standpoint of learning or social justice, serving as an obstacle to the student's emancipation in both realms.

In upending persistent apprenticeship-based power relations, pedagogical partnerships offer a means of extending the collaborative spirit of design and co-creation into pedagogical realms. Although examples exist of design educators and students partnering on short-term pedagogical initiatives, a valuable opportunity remains for establishing sustained partnership models like those outlined in the previous section. Such sustained praxis could build the critical mass and momentum necessary to challenge largely subconscious social relations and socializing forces that have built up over generations of educational practice.

5. Conclusion

The process of building effective pedagogical partnerships must be approached thoughtfully, to be sure. Those who have established successful models of this kind are quick to caution anyone who believes the process will be smooth or easy. On the other hand, the potential benefits are undoubtedly appealing. The more ambitious of these include the complete reimagining of design education and the authentic empowerment of design students. Again, the argument here is that it is not enough for students and staff to engage in design-based co-creation whilst refraining from or resisting partnering on the scholarship of teaching and learning. It is dubious to believe that design students and educators would be able to operate outside pre-existing, hierarchical social relations on design- and/or research-based activities without dedicated space and time for pulling back the curtain on design's pedagogical practices. If real empowerment of students requires that their agency be directed toward active contribution to pedagogical practice, no excuse warrants our failure to even explore how students might achieve greater control over the apparati that inform learning and teaching values, policies and practices.

Acknowledgements: Thanks goes to my colleagues in the Built Environment Learning and Teaching (BEL+T) group at the University of Melbourne for their insightful feedback on drafts of this paper.

6. References

Abbot, S. (2013). Why integrate student voices in SoTL? *Center for Engaged Learning at Elon University*: https://tinyurl.com/s28eeb9

Abbot, S. (2019). What does SoTL have to do with students? *Center for Engaged Learning at Elon University*: https://tinyurl.com/vjf55kn

Adams, R.S., Forin, T., Chua, M., & Radcliffe, D. (2016). Characterizing the work of coaching during design reviews. *Design Studies* 45: 30-67.

Androutsos, A. & Brinia, V. (2019). Developing and piloting a pedagogy for teaching innovation, collaboration, and co-creation in secondary education based on design thinking, digital transformation, and entrepreneurship. *Educational Sciences* 9 (113).

Anthony, K. H. (1991). Design Juries on Trial: The Renaissance of the Design Studio. New York: Van Nostrand Reinhold.

Barrineau, S., and Anderson, L. (2018). Learning 'betwixt and between': opportunities and challenges for student-driven partnership. *International Journal for Students as Partners,* 2(1), 16-32.

Barrineau, S., Engström, A., and Schnaas, U. (2019). *An Active Student Participation Companion.* Uppsala University: https://tinyurl.com/wj5a4a6

Bass, Randy (2013). Why integrate student voices in SoTL? Center for Engaged Learning at Elon University: https://tinyurl.com/s28eeb9

Bovill, C., Cook-Sather, A., Felten, P., Millard, L., Moore-Cherry, N. (2016). Addressing potential challenges in co-creating learning and teaching: overcoming resistance, navigating institutional norms and ensuring inclusivity in student-staff partnerships. *Higher Education* 71: 195-208.

Bovill, C. (2014). An investigation of co-created curricula within higher education in the UK, Ireland and the USA. *Innovations in Education and Teaching International*, 51:1, 15-25, DOI: 10.1080/14703297.2013.770264

Burke, H. (2013). Why integrate student voices in SoTL? Center for Engaged Learning at Elon University: https://tinyurl.com/s28eeb9

Candy, P. (1991). *Self-Direction for Lifelong Learning.* San Francisco: Jossey-Bass.

Chemi, T., and Krogh, L. (2017). *Co-Creation in Higher Education: Students and Educators Preparing Creatively and Collaboratively to the Challenge of the Future*. Rotterdam: Sense Publishers.

Cook-Sather, A. (2014). Student-faculty partnership in explorations of pedagogical practice: a threshold concept in academic development. *International Journal for Academic Development,* 19(3): 186-198. DOI: 10.1080/1360144X.2013.805694

Cook-Sather, A. (2017). How pedagogical partnerships can build a sense of belonging, create a trusting classroom community, and spark hope. Teaching and Learning Together in Higher Education, 22(1).

Cook-Sather, A., Bovill, C., and Felten, P. (2014). *Engaging Students as Partners in Learning and Teaching: A Guide for Faculty.* San Francisco: Jossey-Bass.

Cook-Sather, A., Matthews, K.E., Ntem, A. & Leathwick, S. (2018) What we talk about when we talk about Students as Partners. *International Journal for Students as Partners*, 2(2), 1-9.

Cook-Sather, A., Alden Schlosser, J., Sweeney, A., Peterson, L.M., Wright Cassidy, K., & Colón García, A. (2018). The pedagogical benefits of enacting positive psychology practices through a student-faculty partnership approach to academic development. International Journal for Academic Development, 23(2): 123-134. DOI: 10.1080/1360144X.2017.1401539

Coyne, R. & Snodgrass, A. (1991). Is Designing Mysterious? Challenging the dual knowledge thesis. *Design Studies,* 12(3), 124-131.

Cuff, D. (1991). *Architecture: The story of practice*. Cambridge, MA: MIT Press.

Dollinger, M., Lodge, J., & Coates, H. (2018). Co-creation in higher education: towards a conceptual model. *Journal of Marketing for Higher Education,* 28(2): 210-231.

Dutton, T. A. (1989). Design and studio pedagogy. Journal of Architectural Education, 53(1), 16-25.

Felten, Peter. (2013). Principles of good practice in SoTL. Teaching & Learning Inquiry, 1(1), p. 121-125.

Fielding, M. (1999). Radical collegiality: affirming teaching as an inclusive professional practice. *The Australian Educational Researcher,* 26(2): 1-34.

Geis, G.L. (1976). Student participation in instruction: student choice. *The Journal of Higher Education,* 47(3): 249-273.

Hakio, K. & Mattelmäki, T. (2019). Future skills of design for sustainability: an awareness-based co-creation approach. *Sustainability* 11 (5247).

Hamilton, O. (2018). Commoning interior design pedagogy. *Interiors,* 9(2): 122-139.

Hannafin, M.J., Hannafin, K.M., Land, S.M., and Oliver, K. (1997). Grounded practice and the design of constructivist learning environments. *Educational Technology Research and Development,* 45(3): 101-117.

Healey, M., Flint, A., and Harrington, K. (2014). Engagement through partnership: students as partners in learning and teaching in higher education. The Higher Education Academy: https://tinyurl.com/r287ztr

Hsiao, F., Zeiser, S., Nuss, D., & Hatschek, K. (2018). Developing effective academic accomodations in higher education: a collaborative decision-making process. *International Society for Music Education,* 36(2): 244-258.

Ioannou, O. (2018). Opening up design studio education using blended and networked formats. *International Journal of Educational Technology in Higher Education,* 15(47).

King, K., & Felten, P. (2012). Threshold concepts in educational development: An introduction. *Journal of Faculty Development*, 26: 5–7.

Lee, E., and Hannafin, M.J. (2016). A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it. *Educational Technology Research and Development,* 64(4): 707-734.

Little, S. (Ed.) (2011). Staff-Student Partnerships in Higher Education. London: Continuum.

Marshalsey, L. & Sclater, M. (2018). Supporting students' self-direction experiences of studio learning in Communication Design: the co-creation of a participatory methods process model. *Australian Journal of Educational Technology,* 34(6): 65-81.

Matthews, K.E. (2017). Five propositions for genuine students as partners practice. *International Journal for Students as Partners, 1(2).*

Matthews, K. E., Dwyer, A., Russell, S, & Enright, E. (2018). It is a complicated thing: leaders' conceptions of students as partners in the neoliberal university, *Studies in Higher Education.* DOI: 10.1080/03075079.2018.1482268

McKinney, K. (2012). Increasing the impact of SoTL: Two sometimes neglected opportunities. *International Journal for the Scholarship of Teaching and Learning, 6*(1). Retrieved from https://doi.org/10.20429/ijsotl.2012.060103

Mercer-Mapstone, L., Dvorakova, S.L., Matthews, K.E., Abbot, S., Cheng, B., Felten, P., Knorr, K., Marquis, E., Shammas, R., & Swaim, K. (2017). A systematic literature review of students as partners in higher education. *International Journal for Students as Partners,* 1(1): 1-23.

Mewburn, I. (2011). Lost in translation: reconsidering reflective practice and design studio pedagogy. *Arts and Humanities in Higher Education*, 11(4), 363–79.

Quaglia, R. J. & Corso, M.J. (2014). *Student Voice: The instrument of change.* Thousand Oaks: Corwin.

Quinlan, A., Corkery, L., Marshall, N. (2007). Positioning the design tutor's presence in the design studio for successful student design learning. *Connected: International Conference on Design Education,* University of New South Wales: Sydney.

Rancière, J. (1991) The Ignorant Schoolmaster: Five Lessons in Intellectual Emancipation. Stanford University Press.

Ross, K. (1991). Translator's introduction. In Rancière, J. *The Ignorant Schoolmaster.* Stanford University Press.

Sanders, E. B.-N. & Stappers, P.J. (2008). Co-creation and the new landscapes of design. *Co-Design* 4(1): 5-18.

Stevens, G. (1998). *The Favored Circle: The Social Foundations of Architectural Distinction.* Cambridge, MA: MIT Press.

Stevens, G. (1999). How the invisible stays that way. *Thresholds* 19: pp. 54-56.

Thompson, J. (2019). *Narratives of Architectural Education: From Student to Architect.* Abingdon, UK: Routledge.

Tovey, M. (2013). Design pedagogy special interest group of DRS. *DRS CUMULUS: 2nd International Conference for Design Education Researchers.*

Trigwell, K. (2013). Evidence of the Impact of Scholarship of Teaching and Learning Purposes. Teaching & Learning Inquiry 1(1): 95-105.

Urbick, B. (2012). Innovation Through Co-Creation: consumers can be creative. *Innovation Management:* https://tinyurl.com/u9dn3w8

Webster, H. (2008). Architectural eEducation after Schön: cracks, blurs, boundaries and beyond. *Journal for Education in the Built Environment*, 3(2), 63– 74.

Webster, H. (2005). A study of ritual, acculturation and reproduction in architectural education. *Arts and Humanities in Higher Education* 4(3): 265-282.

Werder, C. and Otis, M.M. (Eds.) (2010). Engaging Student Voices in the Study of Teaching and Learning. Sterling, VA: Stylus.

Willenbrock, L. L. (1991). An undergraduate voice in architectural education. In T. A. Dutton (Ed.), *Voices in Architectural Education: Cultural politics and pedagogy* (pp. 97– 120). New York: Bergin & Garvey.

Woolmer, C. (2016). Staff and students co-creating curricula in UK higher education: exploring process and evidencing value. Ph.D. Thesis: University of Glasgow.

Yanar, A. (2007). Knowledge, skills, and indoctrination in studio pedagogy. In *Design Studio Pedagogy: Horizons for the future* (pp. 63– 73). Gateshead: The Urban International Press.

About the Author:

James Thompson is a Lecturer in Teaching and Learning in the Built Environments Learning and Teaching (BEL+T) group at the University of Melbourne, where he works to improve teaching quality and the student experience within the Faculty of Architecture, Building and Planning. His doctoral research was at the University of Washington's College of Built Environments (Seattle, USA).

DRS2020
BRISBANE, 11–14 AUG
SYNERGY

Novice to Expert Real-time Knowledge Transition in the Context of X-ray Airport Security

Shahab HOGHOOGHI[a]*, Vesna POPOVIC[a]*, Levi SWANN[a]*

[a] Queensland University of Technology, Australia
*Corresponding author e-mail: shahab.hoghooghi@hdr.qut.edu.au
doi: https://doi.org/10.21606/drs.2020.315

Abstract: The X-ray screening task is one of the most critical parts of the security processes at airports. Improving this task is related to the knowledge of the screeners directly. This paper describes an investigation on real-time knowledge transition during security screeners' performance of the x-ray screening task at the airports. Using eye-tracking glasses, behaviours of 10 x-ray screeners, including novices and experts, were observed during the regular screening task.
Results show that there is a direct relationship between expertise and the amount of knowledge gained by and transferred to security employees. Experts demonstrated a superior ability to transfer knowledge to other security employees than novices.
Given the evidence of real-time knowledge transition that occurs during the screening task, this research proposed an intelligent interface to better facilitate the process of real-time knowledge transition. The interface should assist novices' learning process and their faster transition to becoming experts.

Keywords: novice to expert knowledge transition; x-ray screening task; expertise; intelligent interfaces

1. Introduction

The airport is a context in which many complex tasks are occurring. Security of airports is an issue that should be improved in the airports of the future. Security screening processes and security screeners are playing significant roles there. The high number of passengers and people in this environment make it challenging to manage security issues. In order to address this issue, a wide range of security measures have been applied since the 1960s (Figure 1).

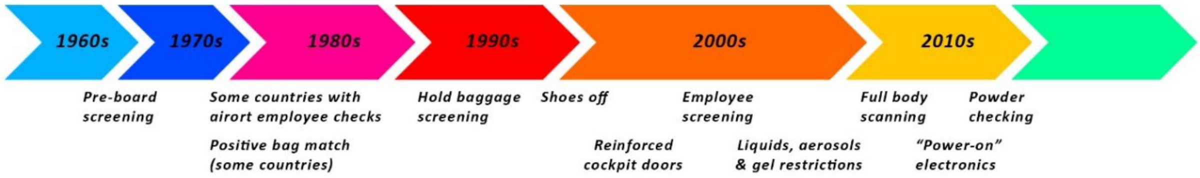


Figure 1 Security measures (Nugraha & Choi, 2016; Wong & Brooks, 2015)

Despite increasing security measures, the Federal Aviation Administration of America has found that more than 20% of prohibited objects were being missed by security screeners in 2000. Another compelling argument indicates that weak security controls result in the allowance of weapons and other prohibited objects (Seidenstat, 2004). Although security technologies have several direct effects on airports' security, the environment and training of operators play a critical role to increase the efficiency of the process (Harris, 2002). Today, it is inevitable that many of the security technologies should be operated by humans. It is accepted that security operators are an essential part of the airport security system, who provide the air travelling security (Swann, 2016). It is obvious that technologies assist human operators during the screening task, but using these devices requires a high level of knowledge. Achieving the highest performance from up-to-date and advanced security screening technologies is impossible without the human operators (Graves et al., 2011).They make the ultimate and the most important decisions during the screening process (Graves et al., 2011; Swann, 2016).

Knowledge and experience of screeners are known as vital factors which can affect the process of security screening. To successfully detect threat objects, it is essential for the screeners to possess specific knowledge of different objects and their appearance when represented by X-ray devices (Schwaninger et al., 2005). Studies indicate that experts possess superior visual knowledge, which improves the speed and accuracy of their threat detection compared to novices (Liu & Gale, 2011; Schwaninger et al., 2005; Swann et al., 2014). Graves et al. (2011) asserted that novice screeners are exposed to missing prohibited objects. These mistakes occur because of the mismatch between threats and harmless objects (Schwaninger et al., 2004). This happens due to using a lower amount of knowledge than the experts and thus decreases their effectiveness (Cokely et al., 2018). Although human errors are unavoidable in this context, high numbers of mistakes must be avoided (Babu et al., 2006). As screeners' performance is correlated with their knowledge, interface and equipment, security interfaces can assist the screeners, but extensive training and experience are required to achieve high performance (Cockburn et al., 2015). Gaining this experience sometime takes a long period of time.

Most of the time, novices are faced with a large amount of information which makes it hard for them to make correct decisions. They often experience difficulty because of their inadequate attention, as they are not able to interpret the required information and choose among different pieces of perceived data. It is also probable that novices use irrelevant information for a specific task instead of the key required knowledge (Endsley, 2018). The problems might exist during an interaction with unfamiliar devices. Failure of x-ray screeners in recognising threat objects reveals the importance of human operators' role even if the most expensive and up-to-date equipment is in use (Schwaninger, 2011b). The performance of expert operators also can diminish to novices when they use unknown equipment. It is argued that the interfaces are designed for experts which enable them to achieve a high level of performance but only after extensive training (Cockburn et al., 2015). Even when the equipment is used correctly, it is difficult to recognise the prohibited objects using security screening devices, such as x-ray, due to image-based factors such as unusual viewpoint, superposition effects, and bag complexity (Schwaninger, 2011a, 2011b). This presence of image-based factors can lead to further errors in the interpretation of threat objects.

The complexity of the screening task for novice screeners shows the importance of focusing on the learning approaches. By improving their knowledge and experience, they may make fewer mistakes, especially in uncertain and complex situations. Therefore, it is important to understand how the learning that facilitates novice to expert knowledge transition process occurs. The significance of training to expertise development is overviewed in Section 2.

2. Expertise

'Expertise' is defined as 'a high level of knowledge or skills' (Cambridge, 2018). The advanced ability and performance that enables someone to master a set of specific skills in order to surpass others, can be defined as expertise (Ericsson, 2014; Winegard et al., 2018). Bilalić and Campitelli (2018) believe that experts have a wider point of view than novices, which facilitates predicting results as well as improving and adapting themselves, in unpredictable situations. In complicated situations, experts demonstrate higher performance in thinking and identifying the best solution compared to novices (Kahneman & Klein, 2009).

A key aspect of expertise is knowledge development. Knowledge is a dynamic mechanism which can be developed by experiential learning (Orlikowski, 2002). It can be classified into two categories, tacit and explicit knowledge. Explicit or codified knowledge can be transmitted in formal and systematic language, which does not rely on experiencing of knowledge (Howells, 2002). So, the process of codifying and transferring explicit knowledge can be performed using systematic language tools, such as written materials (O'Dwyer et al., 2019). In comparison, tacit knowledge is acquired from experience in the environments where it will be needed later (Horvath et al., 1999; Sternberg, 2003). It is hard for users to quantify the exact content of their tacit knowledge and, therefore, this type of knowledge is hard to articulate (Collins, 2010; Grasseni, 2008; Horvath et al., 1999; Howells, 2002; Pérez-Luño et al., 2019), which can result in difficulty codifying and transferring it (O'Dwyer et al., 2019).Tacit knowledge is necessary for expertise development due to its critical role for intelligent behaviour in practical situations (Horvath et al., 1999). It is believed that tacit knowledge can be understood by differences between problem-solving efficiency of users, before and after of education (Ackerman & Lakin, 2018). It plays a critical role in predicting the competent performance in real practical situations (Sternberg et al., 1993), and is considered as one of the influential but not sufficient factors for efficient performance (Horvath et al., 1999). This shows the importance of training and skilled practice by means of everyday experience in each field of expertise.

Skilled practice is one of the influential factors in gaining knowledge and experience. The significance of training to develop expertise is undeniable (Baker et al., 2018). It is almost impossible to become an expert in any specific domain without concentrated training for thousands of hours (Cokely et al., 2018; Ericsson, 2018; Ericsson, Prietula, & Cokely, 2007). When these practice efforts happen carefully and consistently, changes in knowledge, abilities and skills will appear (Cokely et al., 2018). Users' skills can be developed by training and experience when combined with guidance of professionals (Grasseni, 2008).

Experts are often able to overcome many difficulties, such as decision making in complex tasks and uncertain environments, which they might be faced with (Ericsson & Towne, 2010). Their high level of knowledge, when combined with their experiences, demonstrates their ability to solve complex problems (Chi, 2006; Popovic, 2000). The performance of experts is superior to that of novices as they are able to use and encode the required information in a shorter period of time (Cokely et al., 2018; Moxley et al., 2012). Furthermore, novices use lower amounts of information than those of experts', which makes them less effective in complex tasks (Cokely et al., 2018). Cokely et al. (2018) believed experts can use a wider range of solutions when confronting a complex problem compared to those of inexperienced users. This can result in low efficiency of novices. For example, in security screening, task complexity can deteriorate a screeners' efficiency and accuracy (Swann et al., 2014). Hall (2002) argued that the complexity of the tasks in complex systems can increase the probability of failure. Given the complexity of the airport screening task, the effective transfer of knowledge to x-ray screeners is critical for the development of skilled expertise within this domain.

In order to understand how knowledge transition occurs in the process of x-ray screening at airports, it is essential to investigate knowledge utilisation and development in this context. To this end, it is necessary to focus on the behaviours of screeners and the learning approaches they use to become expert. Technologies can assist screeners to achieve this goal. Interfaces can act as a bridge between human and computers to facilitate the knowledge-based processes.

3. Intelligent interface, the bridge to knowledge transition

Intelligence can be defined as the capability of learning and understanding different phenomenon to make decisions and solve problems (Negnevitsky, 2005). The intriguing viewpoint of Artificial Intelligence (AI) indicates that computers can be intelligent. This intelligence enables computers to make decisions, learn, plan, and analyse information (Phillips-Wren, 2012), which provide the opportunity for machines to find the most appropriate results (Buchanan et al., 2018).

One area of research in AI is focusing on the systems which are related to human knowledge.

The AI enables computers to learn and to analyse an enormous amount of information as well as to recognise patterns for increasing efficiency beyond the human ability (Abu-Mostafa, 2012; Harari, 2017). Focusing on human expertise provides the possibility to design intelligent systems which are able to explain the human reasoning process (Buchanan et al., 2018). It is worthwhile for a machine to learn about each user and modify its functions to users (Jameson, 2008). To this end, a wide range of research has been conducted based on developing computer systems and interfaces to recognise human states and behaviours (Liao et al., 2006; Nasoz & Bayburt, 2009; Nasoz et al., 2010; Scheirer et al., 2002). Suchman (2006) argued that machines can assess situated actions by prediction of a user's actions and finding out the results of the actions taken. When a user performs an action, its effects can be mapped to the desired plan, which can result in an appropriate response by the system. For example, an intelligent machine can learn from the experts' actions when facing uncertain situations, then predict similar situations and support the novice users by representing prompts or some probable solutions.

This research focuses on the need to find an appropriate solution to transfer knowledge and experience from expert to novice x-ray screeners at an airport. The information and advice provided to users on how to use applications or perform a task is a challenge of an interface design (Jameson, 2008). Therefore, AI and its related tools can facilitate this process. Numerous investigations exist on how to design interfaces for both the novices and experts; however, designing an interface that is able to make the transition from novices to experts is still not developed (Cockburn et al., 2015). Using the results of this research, an intelligent (collaborative) interface can be proposed to help the novice x-ray screeners to perform similar to experts and to make a quick novice to expert transition.

4. Method

A reasonable amount of research has been conducted on the factors effective for developing the security screening process at airports (Graves et al., 2011; Swann, 2016; Swann et al., 2019; Swann et al., 2015). However, the knowledge transition from novice to expert during performing the real task has not been well investigated. This research addresses the following research question:

Research Question: What are the real-time learning approaches that could facilitate the novice to expert x-ray security screeners' transition?

Therefore, this research aims to find out the importance of real-time knowledge transition in the context of airport security. To do this, ten x-ray security screeners were observed while performing the x-ray screening task under normal conditions at the departure's security checkpoint of an International Airport. Participants were selected based on their experience. Five novice screeners were observed during this study who have the screening experience equal to 1 to 12 months. Five experts also participated in this research who have the screening experience between 36 and 108 months.

The duration of observations was between 10 to 20 minutes. Participants were asked to perform their normal screening task using visual stimuli consisting of x-ray images of real passengers' carry-on baggage. The participants were asked to wear Tobii eye-tracking glasses during the observation sessions (Tobii AB, 2014). Tobii eye-tracking glasses collected eye movement data, recorded video from the observers' visual perspective, and recorded audio of their verbal interactions. Eye movement data, in the form of saccades and fixations, was captured as an overlay on the recording video. This data facilitated the analysis of different actions and the knowledge of participants during the screening task.

5. Analysis

Video and verbal recorded data collected using Tobii eye-tracking glasses were coded in Noldus Observer XT v14 (Observer, 2013). A coding scheme, consisting of key behaviours and knowledge, was developed to analyse the data. The coding scheme identifies twelve behaviour categories and four knowledge categories. Behaviour categories include all the screeners' activities during the screening task (Table 1). The coding scheme is based on previous research conducted analysing activities and knowledge in airport security screening (Swann, 2016), and has been modified to analyse knowledge transition.

Four types of knowledge derived from the literature were included in the coding scheme (Table 2). In the analysis, each knowledge type was coded based on whether it was used by screeners, gained by screeners, gained by searchers, and if there was evidence of it being deficient knowledge. Each of these distinctions describes different applications of knowledge during the screening process.

Table 1 Behaviour categories

Behaviours	Description
Search	Visual interaction with stimuli displayed on the screen for the purpose of finding threats. Characterised by visual scanning and attention that was distributed to a number of areas within the visual stimuli.
Examine	Visual interaction with stimuli displayed on the screen for the purpose of inspecting the nature and quality of objects or areas of interest. Characterised by attention and focus on a specific object or area within the visual stimuli.
IEFs or Zoom	Interaction with stimuli displayed on the screen using Image Enhancement Functions (IEF) or zooming in and out the display for the purpose of better clarity in some areas of interest.
Object Glance	A quick look at the carry-on baggage.
Object Touch	Touching the carry-on baggage.
Object Manual Search	Manual search the baggage by the screener for the purpose of finding the threat which observed on the screen.
Ask Questions	Asking questions from searchers about the process or the probable threat.
Discuss	Discussing with other searchers for the purpose of solving a problem in finding a threat which was displayed on the screen.
Request Removal or Manual Search	Asking searchers to manual search the baggage or removing the threats which were displayed on the screen.
Request Re-run	Making a request for re-run the objects for the purpose of implementing X-ray in another angle to have better clarity.
Talking with Passengers	Talking with passengers with the purpose of finding out what they are carrying or informing them about the process of screening.
Downtime	Activities that are performed while not actively screening. For example, waiting for the machine to resume or socialising.

Table 2 Knowledge types

Knowledge Modifiers	Descriptions
Perceptual	Explicit knowledge about objects and concepts (Millar, 2000).
Procedural	Knowledge of actions and processes in a specific domain (De Jong & Ferguson-Hessler, 1996).
Situational	Knowledge of problem situations or knowledge of when and where to access some specific facts (De Jong & Ferguson-Hessler, 1996; Popovic, 2003).
Strategic	Knowledge used during problem solving and knowledge acquisition processes (De Jong & Ferguson-Hessler, 1996; Popovic, 2003).

6. Results

The analysis was performed on the data gathered during observations on five novice and five expert x-ray screeners at the airport. The results focused on different types of knowledge applied during the twelve types of behaviour.

Collected data has been analysed during problem-solving phases. Problem-solving phases are comprised of activity used to support search and decision making. This includes the examination of unknown objects as well as interactions with other staff and the interface functions to gain more information (Swann et al., 2019). All the behaviours and knowledge during the problem-solving process may be interspersed with each other while search and downtime (periods of inactivity) are usually performed as isolated activity (Figure 2).

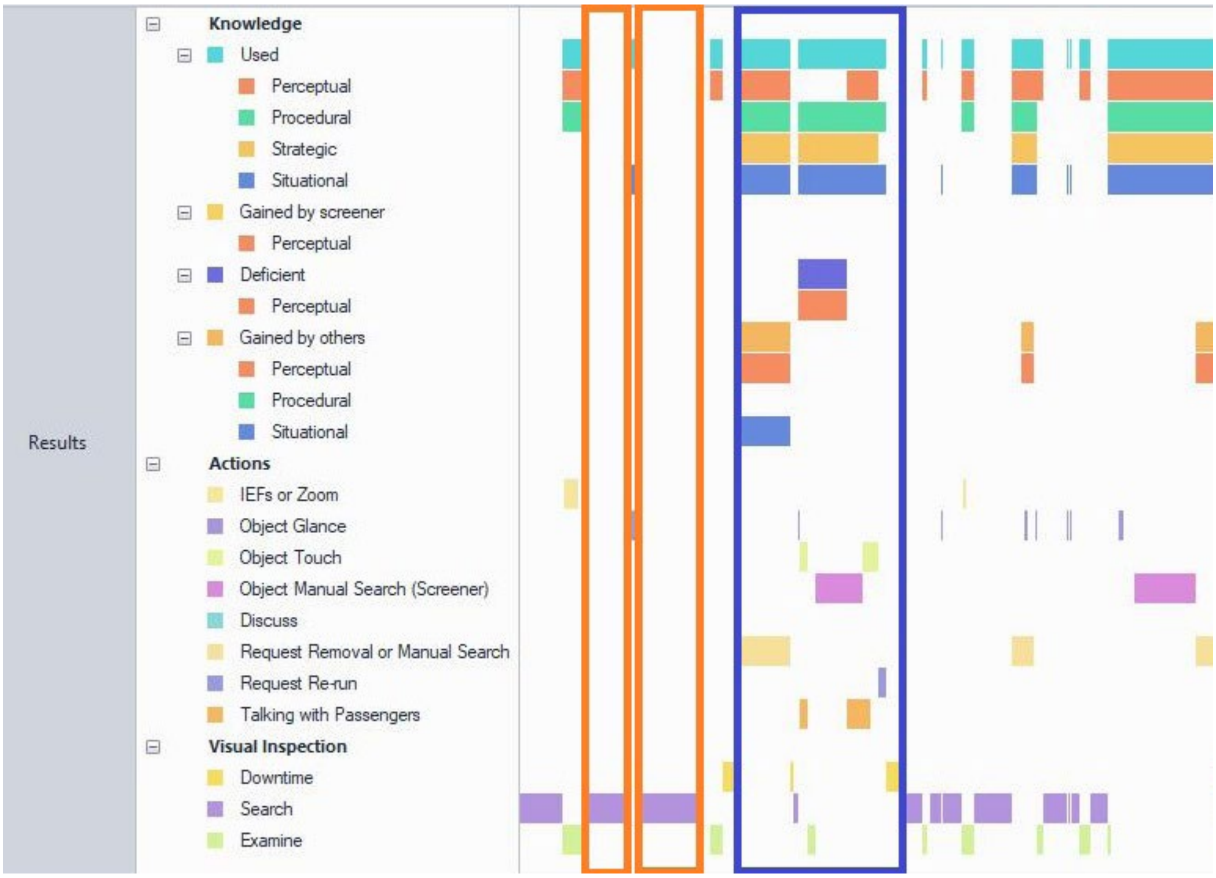


Figure 2 *Participants behaviours and their knowledge application during different activities. The orange box shows isolated activities which are not interspersed with other activities or knowledge. The blue box shows problem-solving activities and application of knowledge that may happen simultaneously.*

Different types of knowledge have been coded during the screening task for both the novices and experts. Collected data has been analysed based on the total problem-solving time (time of all the activities excluding search and downtime) and knowledge application. Therefore, the reported percentages express the average percentage of time each action or knowledge was used during problem-solving activity. The findings focus on the knowledge that can be gained by the screeners and the knowledge screeners transfer to the searchers, the security employees who performs baggage manual search, both during the screening task. Here, a searcher is a security employee who performs baggage manual search and other actions at the instruction of the x-ray screener.

Data reveals that during problem-solving phases, novices gained perceptual, procedural, situational and strategic knowledge, whereas experts only gained perceptual and situational knowledge. The highest amount of knowledge gained by the novice screeners is allocated to situational knowledge, which occurred during 4.10% of problem-solving activity. It was followed by perceptual knowledge, which was 3.12%. The results show lower percentages for these two categories for the expert screeners which were 1.04% and 2.14% respectively. Also, novices gained 0.75% of procedural and 0.32% of strategic knowledge when experts gained none of these types of knowledge during problem-solving phases (Figure 3).

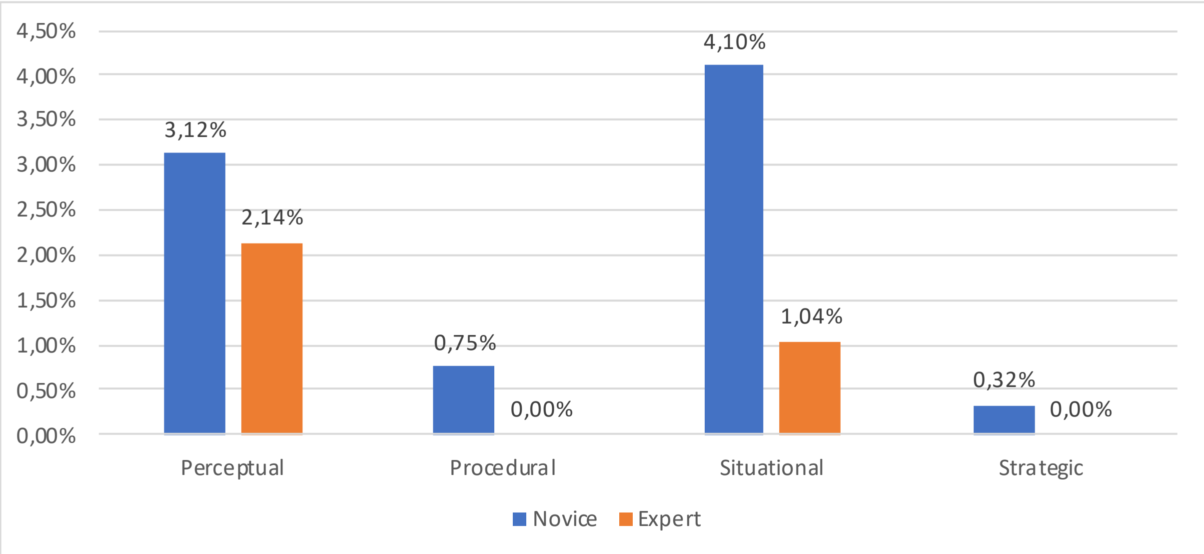


Figure 3 Knowledge gained by screeners

Screeners interact with other staff, primarily with searchers, during problem solving. Therefore, it is possible for the screeners to transfer knowledge to the searchers by explaining a task or a process. Figure 4 illustrates the knowledge transferred to searchers by screeners. The results show higher transferring rate for perceptual, procedural and situational knowledge when an expert was performing the screening task. Experts transferred perceptual knowledge in 11.71% of problem-solving activity, whereas the rate for novices was 10.63%. Results also show 3.31% and 2.22% of procedural knowledge transfer by the experts and novices respectively. Although results indicated that experts also transfer situational knowledge in 11.73% of their problem-solving activity, novice screeners did not transfer of this type of knowledge.

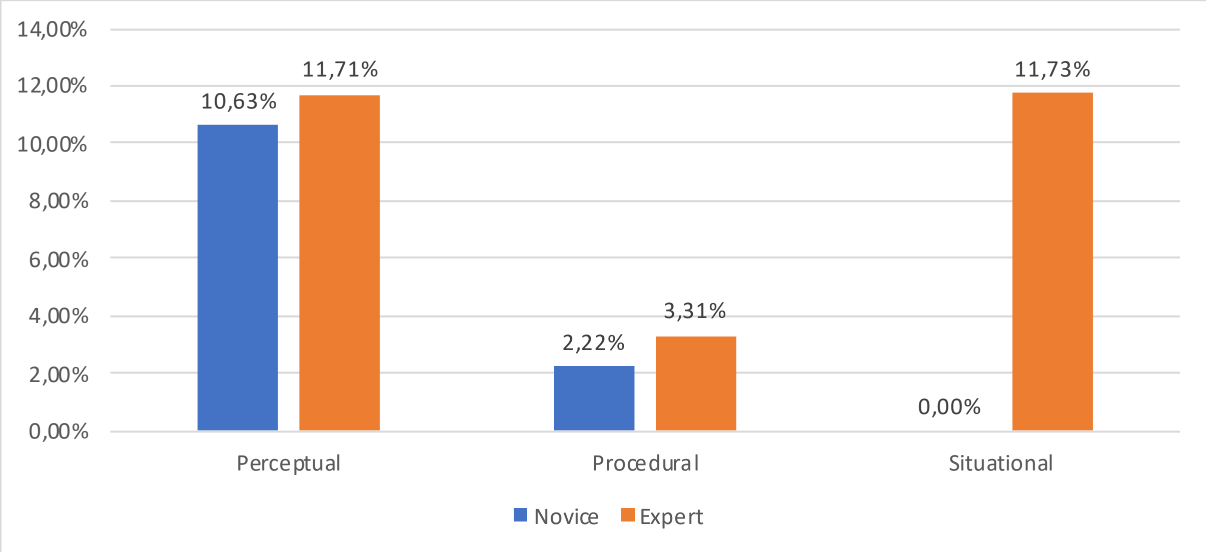


Figure 4 Knowledge transferred to searchers by screeners

Figure 5 shows human interaction during real-time knowledge transfer. These interactions include asking a question from a searcher, discussing, requesting removal or manual search, as well as requesting re-run of bags through the X-ray. These interactions provide important instances for knowledge transfer for screeners.

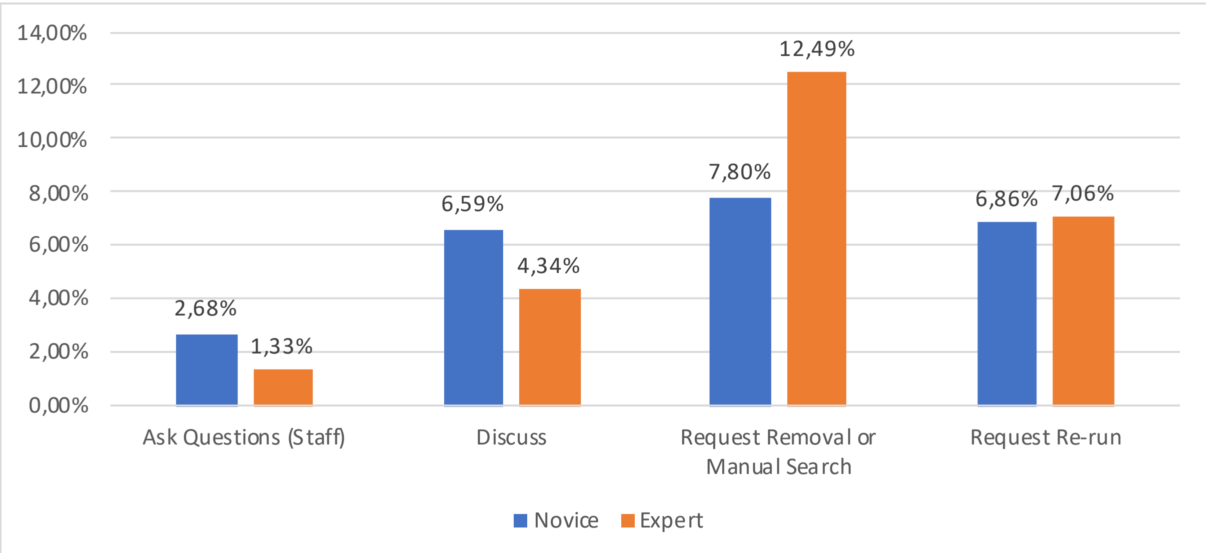


Figure 5 Human interactions between screeners and searchers

Results show that novices experienced higher percentages when asking questions (2.68%) and discussing (6.59%) than experts who spent 1.33% and 4.34% of their problem-solving time on these interactions (Figure 5). In contrast, experts spend more of their interactions with searchers requesting manual search or removal of objects (12.49%) than novices do (7.80%). Both the novices and experts allocate most of their interaction time with searchers requesting removal or manual search.

The results of this investigation can be used in designing an intelligent interface to make a transition from novices to experts and enhance the learning process. This is discussed further in sections 7 and 8.

7. Discussion

It is understood that experts are better at solving problems than novices because of their accessibility to a higher amount of knowledge. Their knowledge enables them to identify patterns and perform specific actions when they confront a problematic situation (Salas et al., 2010). On the other hand, novices have access to a lower amount of knowledge. Novice and expert accessibility to a different type of knowledge has been investigated previously (De Jong & Ferguson-Hessler, 1996; Friege & Lind, 2006; Swann et al., 2014). This paper has expanded on this understanding by looking at real-time learning approaches for developing knowledge.

Specific knowledge categories were analysed. They were defined to understand the knowledge gained and transferred during real-time learning, which could be a facilitator of the novice to expert transition. Results indicate the importance of real-time learning approaches for security screeners when performing a real screening task. It can be understood from the results of this study that novice screeners can gain a higher amount of knowledge during the screening process. According to the results, experts have a higher capability to transfer knowledge to other searchers compared to novice screeners. Another compelling argument is that collaborative interactions between screeners and searchers play an important role in knowledge transfer. Both the novice and expert screeners allocate almost a quarter of their problem-solving time to communicate with searchers for the purpose of asking questions, discussing, requesting removal or manual search, and requesting re-run. Therefore, it is an important part of the problem-solving process to focus on a solution to improve the real-time knowledge transition during human interactions.

We argue that understanding and emphasising real-time learning could accelerate novice to expert transition. An intelligent collaborative interface could be a way of achieving this goal. Problem solving and decision making are considered as one of the most complex tasks which can be facilitated using intelligent collaborative interfaces. Interfaces could help novice operators to gain the required knowledge in a very short time.

8. Intelligent interface - future scenario

Airport security screeners should possess sufficient knowledge and skills that are suited to the systems they are using (Harris, 2002). This research has contributed new knowledge about real-time learning, in the context of airport x-ray security screening. The transfer of situational knowledge from experts was identified to be of particular importance. It is essential for understanding encountered situations and acting effectively. Understanding this knowledge transfer can be applied in the design of an intelligent interface to facilitate fast novice to expert knowledge transition.

Enhancing the process of knowledge transition has the potential to improve the screening process by better equipping screeners to deal with problem solving situations and improving identification of threat objects. We propose an intelligent interface, which is expected to assist the novice screeners during problem-solving activities. To foster the efficiency of x-ray screening and training, the proposed interface focuses on providing real-time training. The interface would learn from the actions of experts when interacting with unpredictable or uncertain situations. Then, the system could suggest relevant actions to the novice screeners who encounter similar situations when using the interface without any necessity to ask from other employees. For example, when a novice screener faces a cluttered bag, improving the clarity of the contents is desirable. Similar pattern is being used in chess computer programs in which searching millions of position can be resulted in offering the most optimal solution for the candidate moves (Cokely et al., 2018). The intelligent collaborative interface could suggest relevant actions based on those typically performed by experts in similar situations. This indicative functionality is demonstrated in the following scenario.

8.1 Scenario: Expertise transfer- expert to novice screeners

James, an expert screener with seven years of experience, is using an intelligent interface to detect threats and transfer his knowledge and experience to other screeners with a lower level of expertise. During screening passengers' baggage, he suspects a sharp object among within baggage characterised by medium density clutter. He calls a searcher, describes the situation and requests the baggage to be re-run at a specific angle to improve the clarity of the image. When the baggage comes through at a new angle James is easily able to confirm that the object is a sharps threat. He calls the searcher to have the object removed and disposed. This process is automatically captured by the intelligent interface and transferred to the system database. This includes cataloging details of image context (sharps, medium density clutter) as well as procedure applied (re-run, request for removal). Catalogued information and images are used as learning material to assist identifying similar situations.

Madeline, a novice screener, frequently encounters similar situations as cluttered bags are common in airport screening. She has difficulty with these, often asking for object removals resulting in false decisions and delays as each bag requires manual search. The system recognises baggage with similar characteristics as those stored in memory. When Madeline experiences difficulty with luggage of medium or lower density clutter, it draws on examples of experts problem-solving strategies, such as re-running at a new angle, and prompts Madeline to use these. This enables Madeline to gain experience applying strategies to better overcome baggage, and it reduces delays caused by frequent manual searches. This enables Madeline to gain experience applying effective strategies and facilitate faster transition to an expert. She is better able to independently overcome difficult situations and reduce delays caused by frequent manual searches.

The findings and implications of this research can also be applied to other complex domains which need transferring knowledge to novice users in a very short time. Utilising this system can eliminate long and expensive training sessions before starting any task. The scenario of this collaborative interface supports this vision.

9. Conclusion and future work

The focus of this research is finding out the real-time learning approaches which can facilitate the novice to expert x-ray security screeners' transition. To this end, this research focused on the behaviours of screeners and their application of knowledge during the screening task.

Results of this research show the knowledge gained and transferred in real time for the novice and expert x-ray screeners during problem-solving phases in the screening task. Accessibility to a higher amount of knowledge and experience by experts resulted in transferring a higher amount of knowledge to the searchers. However, novice screeners gained more knowledge compared to the expert screeners during problem-solving phases. Based on these findings, our future work will focus on an intelligent interface design to facilitate the process of knowledge transition from novice to expert x-ray screener. In addition, methods, findings and the future interface can be used in many other domains, especially group working tasks, which have a correlation with knowledge. Activities and cognitive processes in every context can be visualised and the relationships between interactions and knowledge transitions can be realised. This research is significant as it opens a vision for a design of a novel collaborative interface to support faster novice to expert transition and their operations in complex and uncertain environments.

Acknowledgements: This research forms part of the work undertaken by the project "Monitoring Intuitive Expertise in the Context of Airport Security Screening" (LP140100221) which is funded by the Australian Research Council Linkage Project scheme. The authors also acknowledge the contributions made by the aviation industry partners involved in this project.

10. References

Abu-Mostafa, Y. S. (2012). Machines that think for themselves. *Scientific American,* 307(1), 78-81.

Ackerman, P. L., & Lakin, J. M. (2018). Expertise and individual differences. *Handbook of giftedness in children* (pp. 65-80): Springer.

Babu, V. L. L., Batta, R., & Lin, L. (2006). Passenger grouping under constant threat probability in an airport security system. *European Journal of Operational Research*, 168(2), 633-644.

Baker, J., Hodges, N. J., & Wilson, M. J. (2018). Collecting and Assessing Practice Activity Data: Concurrent, Retrospective, and Longitudinal Approaches. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance (*2 ed., pp. 257-270). Cambridge: Cambridge University Press.

Bilalić, M., & Campitelli, G. (2018). Studies of the Activation and Structural Changes of the Brain Associated with Expertise. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (2 ed., pp. 233-254). Cambridge: Cambridge University Press.

Buchanan, B. G., Davis, R., Smith, R. G., & Feigenbaum, E. A. (2018). Expert Systems: A Perspective from Computer Science. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (2 ed., pp. 84-104). Cambridge: Cambridge University Press.

Cambridge. (2018). *Cambridge online dictionary.* Retrieved April 8, 2018 https://dictionary.cambridge.org/dictionary/english/expertise

Chi, M. T. (2006). Two approaches to the study of experts' characteristics. *The Cambridge handbook of expertise and expert performance,* 21-30.

Cockburn, A., Gutwin, C., Scarr, J., & Malacria, S. (2015). Supporting novice to expert transitions in user interfaces. *ACM Computing Surveys* (CSUR), 47(2), 31.

Cokely, E. T., Feltz, A., Ghazal, S., Allan, J. N., Petrova, D., & Garcia-Retamero, R. (2018). Skilled Decision Theory: From Intelligence to Numeracy and Expertise. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (2 ed., pp. 476-505). Cambridge: Cambridge University Press.

Collins, H. (2010). *Tacit and explicit knowledge*. University of Chicago Press.

De Jong, T., & Ferguson-Hessler, M. G. (1996). Types and qualities of knowledge. *Educational psychologist*, 31(2), 105-113.

Endsley, M. R. (2018). Expertise and Situation Awareness. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance (*2 ed., pp. 714-742). Cambridge: Cambridge University Press.

Ericsson, A. K., & Towne, T. J. (2010). Expertise. *Wiley Interdisciplinary Reviews: Cognitive Science*, 1(3), 404-416.

Ericsson, K. A. (2014). Expertise. *Current Biology,* 24(11), R508-R510.

Ericsson, K. A. (2018). The Differential Influence of Experience, Practice, and Deliberate Practice on the Development of Superior Individual Performance of Experts. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (2 ed., pp. 745-769). Cambridge: Cambridge University Press.

Ericsson, K. A., Prietula, M. J., & Cokely, E. T. (2007). The making of an expert. *Harvard business review,* 85(7/8), 114.

Friege, G., & Lind, G. (2006). Types and qualities of knowledge and their relations to problem solving in physics. *International Journal of Science and Mathematics Education,* 4(3), 437-465.

Grasseni, C. (2008). *Learning to see: World-views, skilled visions, skilled practice.* 9, 151.

Graves, I., Butavicius, M., MacLeod, V., Heyer, R., Parsons, K., Kuester, N., . . . Johnson, R. (2011) The role of the human operator in image-based airport security technologies. Vol. 338. *Studies in Computational Intelligence* (pp. 147-181).

Hall, K. H. (2002). Reviewing intuitive decision-making and uncertainty: the implications for medical education. *Medical education,* 36(3), 216-224.

Harari, Y. N. (2017). Reboot for the AI revolution. *Nature News,* 550(7676), 324.

Harris, D. H. (2002). How to really improve airport security. *Ergonomics in Design,* 10(1), 17-22.

Horvath, J. A., Forsythe, G. B., Bullis, R. C., Sweeney, P. J., Williams, W. M., McNally, J. A., . . . Sternberg, R. J. (1999). Experience, knowledge, and military leadership. *Tacit knowledge in professional practice* (pp. 53-72): Psychology Press.

Howells, J. R. J. U. s. (2002). Tacit knowledge, innovation and economic geography. 39(5-6), 871-884.

Jameson, A. (2008). Adaptive interfaces and agents. *The human-computer interaction handbook: Fundamentals, evolving technologies and emerging applications*, 305-330.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: a failure to disagree. American psychologist, 64(6), 515.

Liao, W., Zhang, W., Zhu, Z., Ji, Q., & Gray, W. D. (2006). Toward a decision-theoretic framework for affect recognition and user assistance. International journal of human-computer studies, 64(9), 847-873.

Liu, X., & Gale, A. (2011). Air Passengers' Luggage Screening: What Is the Difference between Naïve People and Airport Screeners? Paper presented at the International Conference on Engineering Psychology and Cognitive Ergonomics.

Millar, A. (2000). The scope of perceptual knowledge. Philosophy, 75(1), 73-88.

Moxley, J. H., Ericsson, K. A., Charness, N., & Krampe, R. T. (2012). The role of intuition and deliberative thinking in experts' superior tactical decision-making. Cognition, 124(1), 72-78.

Nasoz, F., & Bayburt, M. (2009). Affectively intelligent user interfaces for enhanced e-learning applications. Paper presented at the International Conference on Human Centered Design.

Nasoz, F., Lisetti, C. L., & Vasilakos, A. V. (2010). Affectively intelligent and adaptive car interfaces. Information Sciences, 180(20), 3817-3836.

Negnevitsky, M. (2005). Artificial intelligence: a guide to intelligent systems: Pearson Education.

Nugraha, R. A., & Choi, J. (2016). Body Scanners within Airport Security Systems: Security or Privacy Issue? The Aviation & Space Journal, 15(3).

O'Dwyer, M., Costin, Y., & Hynes, B. (2019). Explicit and tacit knowledge transfer in entrepreneurial education: the Method Approach The Role and Impact of Entrepreneurship Education: Edward Elgar Publishing.

Observer, N. (2013). Noldus information technology. Wageningen, Netherlands.

Orlikowski, W. J. J. O. s. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. 13(3), 249-273.

Pérez-Luño, A., Alegre, J., Valle-Cabrera, R. J. T. A., & Management, S. (2019). The role of tacit knowledge in connecting knowledge exchange and combination with innovation. 31(2), 186-198.

Phillips-Wren, G. (2012). AI tools in decision making support systems: a review. International Journal on Artificial Intelligence Tools, 21(02), 1240005.

Popovic, V. (2000). Expert and novice user differences and implications for product design and useability. Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Popovic, V. (2003). Expert and Novice Users Model and their Application to the Design Process. Paper presented at the Journal of the Asian Design International Conference.

Salas, E., Rosen, M. A., & DiazGranados, D. (2010). Expertise-based intuition and decision making in organizations. Journal of management, 36(4), 941-973.

Scheirer, J., Fernandez, R., Klein, J., & Picard, R. W. (2002). Frustrating the user on purpose: a step toward building an affective computer. Interacting with computers, 14(2), 93-118.

Schwaninger, A. (2011a). Increasing efficiency in airport security screening. Proceedings of AVSEC World 2004, November 3-5.

Schwaninger, A. (2011b). Training of airport security screeners.

Schwaninger, A., Hardmeier, D., & Hofer, F. (2004). Measuring visual abilities and visual knowledge of aviation security screeners. Paper presented at the Security Technology, 2004. 38th Annual 2004 International Carnahan Conference on.

Schwaninger, A., Hardmeler, D., & Hofer, F. (2005). Aviation security screeners visual abilities & visual knowledge measurement. IEEE Aerospace and electronic systems magazine, 20(6), 29-35.

Seidenstat, P. (2004). Terrorism, airport security, and the private sector. *Review of Policy Research,* 21(3), 275-291.

Sternberg, R. J. (2003). *Wisdom, intelligence, and creativity synthesized*: Cambridge University Press.

Sternberg, R. J., Wagner, R. K., & Okagaki, L. J. M. o. e. c. (1993). *Practical intelligence: The nature and role of tacit knowledge in work and at school.* 205-227.

Suchman, L. A. (2006). *Human-machine reconfigurations plans and situated actions* (2nd ed. ed.). Cambridge ;: Cambridge University Press.

Swann, L. (2016). *The role of intuitive expertise in airport security screening.* Queensland University of Technology.

Swann, L., Popovic, V., Blackler, A., & Thompson, H. (2019). Airport Security Screener Problem-Solving Knowledge and Implications. *Human factors,* 0018720819874169.

Swann, L., Popovic, V., Blackler, A. L., & Kraal, B. J. (2014). Airport security screeners expertise and implications for interface design.

Swann, L., Popovic, V., Thompson, H., Blackler, A., & Kraal, B. (2015). Relationships between user experience and intuitiveness of visual and physical interactions. Paper presented at the *Proceedings of the 6th IASDR (The International Association of Societies of Design Research Congress).*

Winegard, B., Winegard, B., & Geary, D. C. (2018). The Evolution of Expertise. In A. M. Williams, A. Kozbelt, K. A. Ericsson, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (2 ed., pp. 40-48). Cambridge: Cambridge University Press.

Wong, S., & Brooks, N. (2015). Evolving risk-based security: A review of current issues and emerging trends impacting security screening in the aviation industry. *Journal of Air Transport Management,* 48, 60-64.

About the Authors:

Shahab Hoghooghi received his Bachelor of Mechanical Engineering in 2011 and Master of Industrial Design in 2014. He started his PhD, majoring in industrial design at Queensland University of Technology, in 2018. His research investigates on novice to expert knowledge transition in the context of x-ray screening.

Vesna Popovic is an Adjunct Professor, School of Design, Queensland University of Technology, Brisbane, Australia. Her research focus is within experience and expertise, and human-centred design. Vesna has published widely and is a recipient of many Awards.

Levi Swann (PhD) is a Lecturer in Industrial Design at Queensland University of Technology. His research explores interactions among humans, technology and their broader environments. Current focus areas include human factors, expertise, technology forecasting and scenario development.