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Promoting entrepreneurship education in doctoral programs: the INVENTHEI's Training for Innovation Driven Research program and its assessment proposal.

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Authors: Gerbaudo-González, N.¹, Feijóo-Quintas, S.², Gandoy-Crego, M.¹, Gutiérrez-Moar, M.C.³, Diz-López, M.J.³, Furtado, S.⁴, Gonçalves, G.⁵, Facal, D.^{2*}

¹ Department of Psychiatry, Radiology, Public Health, Nursing and Medicine, University of Santiago de Compostela, Santiago de Compostela, Spain.

² Department of Developmental and Educational Psychology, University of Santiago de Compostela, Santiago de Compostela, Spain.

³ Department of Pedagogy and Didactics, University of Santiago de Compostela, Santiago de Compostela, Spain.

⁴ Advanced Manufacturing Research Centre, University of Sheffield, Sheffield, United Kingdom.

⁵ Faculty of Engineering, University of Porto, Porto, Portugal.

* Facultade de Psicoloxía - Rúa Xosé María Suárez Núñez, s/n. Campus Vida.

15782 Santiago de Compostela, Spain.

+34 881 813 695

david.facal@usc.es


ORCID IDs

Gerbaudo-González, N.  orcid.org/0000-0002-6393-2329

Feijóo-Quintas, S.  orcid.org/0000-0002-4239-0559

Gandoy-Crego, M.  orcid.org/0000-0003-0193-8175

Gutiérrez-Moar, M.C.  orcid.org/0000-0001-8437-7160

Furtado, S.  orcid.org/0009-0008-3143-8976

Gonçalves, G.  orcid.org/0000-0001-7757-7308

Facal, D.  orcid.org/0000-0001-6230-0090

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Abstract

Education can be a central tool for stimulating entrepreneurship, establishing positive links between entrepreneurship education (EE), entrepreneurship performance and development of innovative ideas. Recognizing the pivotal role of doctoral programs within the education system, it becomes crucial for Higher Education Institutions (HEIs) to incorporate entrepreneurship education (EE) into these programs. Training for Innovation Driven Research program has been designed within the INVENTHEI project, and it is aimed to Ph.D. students in early stages of their research trajectories. The design thinking methodology underpins the practical approach of learning-by-doing. Each session focusses on a specific design thinking phase to train at least one of the six competences selected from the EntreComp framework: spotting opportunities, creativity, vision, mobilising others, planning and management, and learning through experience. In order to examine how the training is functioning regarding its goals or objectives, including whether program activities have been successfully designed and implemented, and if it has effects in the target population, various tools have been designed. These tools include observation checklists for continuous evaluation, rubrics to identify if the objectifiable products meet the basic requirements, and surveys with structured questionnaires to evaluate different aspects.

Keywords

Doctoral studies; entrepreneurship education; educative innovation, learning by doing.

Literature review

Higher education institutions (HEIs) play an increasingly important role in achieving economic and social development in the context of the knowledge culture. HEIs emerging third mission, strengthening commitment to society, economy, and industry, requires the definition of new educational models more dedicated to continuous learning, innovation, social engagement, and creativity (Saiz-Santos, Araujo-De la Mata, & Hoyos-Iruarrizaga, 2017). Promoting entrepreneurial skills allows HEIs to be engaged in partnerships, networks and business activities with companies and other external stakeholders (Plantec, Cabanes, LeMasson, Weil, 2019; Ripa, Landi, Cosimato, Turriziani, & Gheith, 2020). HEI-company links have been shown to be effective in promoting innovation outcomes at the company level. Jones and Corral de Zubielqui (2017) studied the effect of HEIs-companies' interactions on innovation outcomes using structural equation modelling. These authors analysed a sample of 153 small and medium companies and found that human resource transfer have a significant positive effect on innovation, with innovativeness being positively related to company performance.

Education can be a central tool for stimulating entrepreneurship, establishing positive links between entrepreneurship education (EE), entrepreneurship performance and development of innovative ideas. The development of a learning paradigm that includes students, academic and non-academic staff in innovation processes and underscores the value of pedagogical innovation has been identified as an ongoing need in higher education (Sauphayana, 2021; Stalheim, 2020). There is a consensus that HEIs should facilitate more collaboration and peer learning activities outside the classroom, positioning students as co-producers of their learning processes and including entrepreneurship competences into the academic curriculum. In line with this vision, the INnoVation and ENTrepreneurship in HEIs (INVENTHEI) project was conceived as part of the EIT's HEI Initiative: Innovation Capacity Building for Higher Education, launched by the European Institute of Innovation and Technology (EIT). With a consortium composed of eight entities, including six renowned European universities, INVENTHEI aims to address this need and assist partner HEIs in establishing the necessary practices, infrastructure, mechanisms, and networks.

INVENTHEI adopts an innovation-driven research approach to connect disciplines and departments through joint projects, foster collaboration with regional industries to develop Innovation and Entrepreneurship (I&E) training programs, establish partnerships with external organizations, and facilitate the growth of innovative companies to contribute to the internationalization of local innovation districts. The project analysed the challenges for educating for I&E (Miranda et al., 2022) and proposes the implementation of an Innovation Vision Action Plan (IVAP) by participating HEIs, encompassing activities that contribute to the pool of "excellent skills and talents" and promote more efficient innovation ecosystems in the manufacturing and health domains (Gonçalves et al., 2022). Furthermore, INVENTHEI has developed challenge-based learning and innovation-driven research programs that actively involve external organizations, engaging staff and students from various faculties and courses to develop transferable and soft skills, particularly in the field of I&E, while also fostering academic collaboration

with industry (Facal et al., 2022). This comprehensive approach promotes a dynamic and impactful learning environment that prepares individuals to thrive in the innovation-driven landscape of today's world.

Recognizing the pivotal role of doctoral programs within the education system, it becomes crucial for Higher Education Institutions (HEIs) to incorporate entrepreneurship education (EE) into these programs (Saiz-Santos et al., 2017). The prevailing knowledge culture emphasizes research that is both socially responsive and outcome-driven, prompting the emergence of new forms of doctorate training that encompass a broader range of skills essential for diverse professional pathways in research, academia, and industry (Mackie & Thongpravati, 2017). In addition to acquiring communication, teamwork, and management skills, doctoral students aspire to expand their social networks, reflect upon their professional experiences, and transform the nature of their future careers (Bastalich, 2010; Main, Wang & Tan, 2021). By integrating EE into doctoral programs, HEIs can effectively cater to these multifaceted aspirations, empowering students to unlock their full potential as researchers and professionals. This integration aligns with the broader vision of INVENTHEI, cultivating a comprehensive ecosystem that equips doctoral students with the necessary skills and mindset to navigate the complexities of today's socio-economic landscape.

Buss (2020) related the development of doctoral student's professional identities as researchers with the possible-selves (PS) theory. According to this theory, future views of self are linked to current views of self, highlighting a congruency of future views of self with overall current identity. Rippa et al. (2020) promoted a T-shaped approach for EE, promoting scientific skills, represented with the vertical stroke of the T, but also disposition for collaborating across disciplines and domains, represented with the horizontal stroke. This combination of knowledges would make PhD students prepared with the necessary skills to solve the complex problems that characterize current socioeconomic scenarios. Therefore, incorporating entrepreneurship education into doctoral programs not only equips students with the essential skills for research and academia but also cultivates their ability to address multifaceted challenges and contribute to socioeconomic advancement.

According to these approaches, innovation and EE plans offered to doctoral students must include social competences, leadership, identity development, self-awareness, planning, vision, task orientation, reflections on the connections between research and practice, and a climate open to change and error friendly (Buss, 2020; Greene, Patrick, Romano, Aiken, & Richmond, 2016; Rippa et al., 2020; Sverdlik, Hall, McAlpine, & Hubbard, 2018; Ute, Hulsheger, Anderson, & Salgado, 2009).

Educational assessment, and specifically the evaluation of competencies, must play a central role in EE. Ute et al. (2009) observed that relationships between team process variables and innovation differ substantially depending on measurement methods (self-ratings vs. independent ratings of innovation) and measurement levels (individual vs. team innovation). Relationships are stronger for team than individual innovation, and considerably stronger if self-ratings of innovation are employed, compared with

independent ratings or objective measures of innovation.

Conceptual framework

According to Mackie & Thongpravati (2017), the aim of a contemporary Ph.D. training should be to bring curricular elements together in parallel, integrative ways, including not only research but also innovation and creativity skills. In this regard, EE usually follows participatory and iterative methodologies such as Design Thinking (DT) and Lean Start-up (LS). DT is a methodology focused on generating innovation driven by the knowledge of what the target people want and need in their lives, and what they like or dislike through a participatory creative process (Brown, 2008). LS is focused on testing concepts with the recipients of the innovation with the objective of validating the needs, the solution proposed, and the business model developed through the process. It is associated with the concept of Minimum Viable Product, which implies the definition of a product with the least characteristics to cover the identified needs (Rasmussen & Tanev, 2016).

The Entrepreneurship Competence Framework (EntreComp) is a comprehensive, flexible, multi-purpose system designed to support and inspire action to improve entrepreneurship (Mccallum, Weicht, McMullan, & Price, 2018). It consists of three areas of competence that contain five competences each: 1) Ideas and Opportunities: Spotting opportunities, Creativity, Vision, Valuing ideas, Ethical and sustainable thinking; 2) Resources: Self-Awareness and Self-Efficacy, Motivation and Perseverance, Mobilizing Resources, Financial and Economic Literacy, and Mobilizing Others; 3) In Action: Taking the initiative; Planning and Management; Coping with uncertainty, ambiguity, and risk; Working with others, and Learning through experience. The EntreComp wheel offers an overview of the different but interconnected competences. Following the idea of designing new educational models to activate entrepreneurship competences in the academic curriculum of researchers, in our training the emphasis is placed on innovation skills directly linked to research capacity.

Training proposal

Training for Innovation Driven Research program has been designed within the INVENTHEI project, and it is aimed to Ph.D. students in early stages of their research trajectories. It consists of 32 hours of courses and 18 autonomous work (50 hours total), which is equivalent to 2 European Credit Transfer System (ECTS). The program has been designed to be flexible for students at any stage of their careers, including two different time slots: a 6 weeks training, with a weekly on-site session lasting four hours, and four additional online sessions of two hours (a kick-off meeting before the first face-to-face activity and three mentoring sessions in weeks two, four, and six); or a 3 days, with daily onsite seminars and the four online sessions distributed before, during and after the 3 days.

Training for Innovation Driven Research program pursues general and specific objectives. General

objectives are to help researchers to transfer the results of their projects or Ph.D. thesis to the society and to promote innovation and entrepreneurship among Ph.D. students and researchers. Specific objectives include to favour the development of innovative and entrepreneurial competences in Ph.D. students and researchers, to promote the development of innovative ideas based in research results, and, in a broader sense, to promote multidisciplinary research. Additionally, the following Learning Objectives are sought at the end of the training program: 1) Students will be able to identify short- and long-term future consequences of plans and decisions from an integrated scientific and ethical perspective, moving towards a sustainable society; 2) Students will use their scientific knowledge and research expertise towards new venture creation and growth using cross-disciplinary approaches; 3) Students will be able to transform practical experiences into research problems and challenges; 4) Students will be able to make decisions and lead based on a holistic understanding.

Training for Innovation Driven Research is governed by the principle of active, collaborative, and participatory teamwork. The methodologies used to carry out the training of the participants include challenge-based learning (Johnson, Smith, Smythe, & Varon, 2009), learning through experience (Kolb, 1984), DT (Brown, 2008), and LS (Rasmussen & Tanev, 2016). Socialisation and collaborative pedagogical approaches (Johnson & Johnson, 1983) are also considered. Each session of the Training for Innovation Driven Research program has different purposes and learning objectives related to theoretical concepts and specific competences to be developed (Table 1).

Table 1. Purposes, learning objectives, theoretical concepts. And specific competences of each session.

	Purposes	Learning objectives	Theoretical concepts	Competences
Kick-Off Meeting	Introduce the learning action.	Understand the purpose and goals of the training program for Innovation Driven Research. Familiarize with the learning materials and resources. Gain an overview of the topics and concepts to be covered.	Introduction of the Training for Innovation Driven Research	Spotting opportunities Vision
Session 1	Improve transferable skills.	Recognize the role of creativity, problem-solving, and critical thinking in innovation-driven research. Develop an awareness of the importance of innovation in research and its potential impact. Boost the value and personal interest in activities aimed at developing transferable skills. Assess personal strengths and areas for growth related to innovation-driven research.	Design Thinking methodology. Open innovation and open science. Knowledge transfer process and intellectual property. Sustainability.	Spotting opportunities Vision Planning and management
Session 2	Introduce tools for developing user-centred innovations.	Explore various tools and methodologies used in user-centred innovation. Understand the principles and frameworks behind user-centred design. Acquire the knowledge to apply these tools in developing innovative solutions align with user needs and preferences.	Co-creation Creativity	Spotting opportunities Creativity Vision Planning and management Learning through experience
Mentoring 1	Share preliminary ideas developed.	Generate and articulate preliminary ideas related to a specific context or problem. Share these ideas with others to gather feedback and insights. Refine and iterate on initial ideas based on the feedback received.	Sharing ideas: initiating the innovation process.	Vision Planning and management Learning through experience
Session 3	Define the market	Conduct market research to understand the target audience,	Value Proposition.	Creativity

	and the value generated.	<p>their needs, and preferences.</p> <p>Analyse market trends, competition, and potential opportunities.</p> <p>Define the unique value proposition of the product or service being developed and its potential impact on the market.</p>	<p>Business Model Canvas.</p> <p>Market and value generation.</p>	<p>Vision</p> <p>Planning and management</p> <p>Learning through experience</p>
Session 4	Define business needs.	<p>Identify and assess the specific needs and requirements of the business.</p> <p>Analyse internal processes, resources, and capabilities.</p> <p>Determine areas for improvement or innovation to address the identified business needs.</p>	<p>Business needs.</p> <p>Impact.</p>	<p>Creativity</p> <p>Vision</p> <p>Planning and management</p> <p>Learning through experience</p>
Mentoring 2	Improve the business model proposal.	<p>Evaluate and refine the business model based on market research and feedback.</p> <p>Identify revenue streams, cost structures, and value proposition.</p> <p>Enhance the feasibility, scalability, and sustainability of the business model.</p>	Business Model Canvas	<p>Mobilising others</p> <p>Planning and management</p> <p>Learning through experience</p>
Session 5	Develop a communication strategy.	<p>Understand the role and importance of communication in collaborative innovation.</p> <p>Gain knowledge of effective strategies for the dissemination of innovations and marketing communication.</p> <p>Learn the components and structure of a compelling Elevator Pitch.</p>	<p>Communication in collaborative innovation.</p> <p>Dissemination of innovations and marketing communication.</p> <p>The Elevator Pitch.</p>	<p>Creativity</p> <p>Vision</p> <p>Mobilising others</p> <p>Planning and management</p> <p>Learning through experience</p>
Mentoring 3	Pitches preparation	<p>Develop a persuasive pitch presentation that highlights the key aspects of the business or idea.</p> <p>Structure the pitch to engage and captivate the audience.</p>	Elevator Pitch presentation rehearsal	<p>Creativity</p> <p>Learning through experience</p>

		Practice and refine the pitch delivery to ensure clarity and confidence.		
Session 6	Pitches presentation	Deliver a well-prepared and engaging pitch presentation to an audience.	Elevator Pitch presentation.	Mobilising others
		Effectively communicate the value proposition, market potential, and business needs.		Learning through experience
		Respond to questions and feedback from the audience in a confident and knowledgeable manner.		

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Following the EntreComp framework (Mccallum et al., 2018), the Tuning project (González-Ferreras & Wagenaar, 2003) and the European Qualifications Framework (EQF) (European Commission, 2018), through this programme it is intended to train the following competences: 1. Spotting opportunities: ability to achieve a systematic understanding of the field of study along with the knowledge of skills and related research methods to analyse; 2. Creativity: being able to provide an enhancement of knowledge in their own field through the development of a creative and original research; 3. Vision: ability to envision a substantial research or creation process, as well as to develop a vision to make ideas happen and guide their own efforts; 4. Mobilising others, related to the capacity of communicating with the academic and scientific community along with the promotion of the scientific progress in the own field of each researcher within a knowledge-based society; 5. Planning and management, that include being able to design, elaborate, put into practise, and assume a substantial research or creation process; and 6. Learning through experience, that includes the abilities to conduct a critical analysis and assessment of new and complex ideas or situations, and to synthesize them and put the acquired knowledge into practise.

Training is blended, including on-site training sessions as well as online, complementary mentoring sessions. Each online session lasts two hours, and the on-site ones will last 4 hours (total course sessions: 32 hours), with also some hours aimed to autonomous work outside the online and on-site activities. The DT methodology underpins the practical approach of learning-by-doing. Each session will focus on a specific DT phase to train at least one of the six competences selected from the EntreComp framework. Phases of the DS methodology are iterative, with some sessions recommending returning to a previous phase to strengthen the process of competencies acquisition.

Assessment

The program evaluation consists of collecting, analysing, and using data to review the effectiveness and efficiency of the training action. It aims to examine how the training is functioning regarding its goals or objectives, including whether program activities have been successfully designed and implemented, and if it has effects in the target population.

For this purpose, various tools have been designed, including observation checklists for continuous evaluation, rubrics to identify if the objectifiable products meet the basic requirements, and surveys with structured questionnaires to evaluate different aspects. Table 2 lists each one of the instruments to be used at different times of the program: (1) enrolment, (2) baseline / pre-training, (3) training, and (3) post-training.

Table 2. Procedures for assessment and administration of measures.

	Enrolment	Baseline	Continuous Assessment									Post-training
			S1	S	M1	S3	S4	M	S5	M3	S6	
				2				2				
Informed consent or assent	X											
Enrolment form	X											
Prior knowledge Survey	X											
Competences self-perceptions Survey		X										X
Attendance			X	X	X	X	X	X	X	X	X	X
Satisfaction Survey			X	X	X	X	X	X	X	X	X	X
Empathy Map Rubric				X								
Judgement Panel Rubric				X								
Checklist on BMC development								X				
Elevator Pitch Rubric										X		
Checklist on EP presentation											X	
Attendees' appreciation Survey on EP											X	
Ideas development Scale												X
Knowledge acquisition Survey												X

During enrolment, within the Kick-Off Meeting, the first relevant data is collected for program evaluation. These include demographic information such as age, gender, level of studies, and occupation, included in an Enrolment Form, and participants' prior knowledge about innovation and entrepreneurship, collected through a specific Prior Knowledge Anonymous Survey. The rate of participants with previous knowledge of innovation and entrepreneurship will be the indicator resulting from this initial evaluation.

Baseline assessment involves knowing participants' self-perception on the six competences that will be trained during the program. For this purpose, it was designed a Competences Self-Perception Survey, sent through web forms, and designed to be completed quickly and briefly.

Throughout the training, from session 1 to session 6, a continuous assessment of students' commitment and satisfaction with the proposed activities has been designed, including attendance records, satisfaction survey, competences acquisition, and degree of proposed ideas development.

Competences acquisition is assessed using checklists of attitudes towards different tasks and rubrics on the elaboration of objectifiable products. Checklists include a Checklist on Business Model Canvas

development, to be applied in mentoring 2, and a Checklist on Pitches presentation, to be applied in session 6 (see Table 3). Rubrics to assess the acquisition and development of the different competences related to specific products include Empathy Map Rubric, Judgement Panel Rubric, Elevator Pitch Rubric (see Table 4). Finally, the degree of development of the proposed ideas is also assessed through the objectifiable products presented. the achievement progression of the different products would represent different degrees of development of the initial ideas (Table 5).

Table 3. Checklist on business model canvas and elevator pitch presentation

✓	Checklist on Business Model Canvas
	Positive attitude to accept the critical opinions and suggestions of the audience.
	Ability to make changes in its BMC based on the acquired knowledge.
	Positive interaction with the mentors.
	Positive interaction with the colleagues.
	Interest in the session.
	Active participation during its colleague's presentation (making comments, suggestions...).
✓	Checklist on Elevator Pitch presentation
	Positive attitude to accept the critical opinions and suggestions of the audience.
	Ability to answer the questions the audience posed.
	Positive interaction with the audience.
	Interest and excitement about the presentation.

Table 4. Rubrics en Empathy Map, Judgement Panel, Elevator Pitch Rubric

Empathy Map Rubric	Features to evaluate
Definition of the user	Name, age, gender, socioeconomic level, personality, problems, attitudes, hobbies...
What does the user think and feel?	What do you think the user think? Which are their beliefs and opinions? Are they in agreement with what he says? What preferences, concerns, dreams, and aspirations does the user have? What emotions have you identified? Are they manifested in what the user does?
What does the user hear?	What has the user perceived in his environment? What have people near or far told the user about the topic? What do the communication channels or influential people tell the user?
What does the user see?	How has the user seen their friends, relatives or acquaintances relate to the subject matter? How does the environment of the user act? What does the market offer that surrounds the user?
What does the user say or do?	Are there any significant phrases or words that the user used? Were they positive or negative? What actions or behaviors did you notice in the user? What attitude did he have?

Limitations or obstacles	What efforts the user makes or wants to avoid making? What frustrates the user when making them? What fears arise to the user when acting? What risks is the user not willing to take?
Opportunities and needs	What does the user want to achieve and what motivates him/her? What are their expectations when it comes to meeting them? How does the user measure the success of meeting their expectations?
Judgement Panel Rubric	Features to evaluate
Pros of the idea	Proper identification and definition of the advantages of the proposed idea respect to the meeting of the identified need.
Cons of the idea	Proper identification and definition of the inconveniences of the idea respect to the meeting of the identified need.
Deficiencies of the idea	Proper identification and definition of what is missing in the idea respect to the meeting of the identified need.
Brakes of the idea	Proper identification and definition of the features that slow down the idea to meet the identified need.
Elevator Pitch Rubric	Features to evaluate
Formal aspects	Language clear and precise Explanation is adjusted to the time limit.
Contents	<ul style="list-style-type: none"> - Establishment of the problem. - Presentation of the researcher. - Explanation brief and concrete of the problem, its impact, and derived needs. - Introduction of the solution. - Make clear the benefit users would obtain with the solution. - What difference does the product they are selling make? - Call to action.

Table 5. Ideas Development Scale

Rating code	Participant's achievements	Idea development degree
1	The participant has achieved the development of the Empathy Map and Judgement Panel.	Low
2	The participant has achieved the development of the Empathy Map and Judgement Panel, along with the Business Model Canvas.	Medium
3	The participant has achieved the development of the Empathy Map and Judgement Panel, along with the Business Model Canvas and the Elevator Pitch.	High

The final assessment involves knowing students' acquisition of entrepreneurial competences through to the training program. Two tools have been designed to assess it, the Attendees' Appreciation Survey about the elevator pitches presented, that give us information regarding the communication skills of the participants and the effectiveness of the elevator speeches created during the training, and the Survey of Knowledge Acquisition, an anonymous survey about innovation and social entrepreneurship knowledge. The rate of participants with subsequent knowledge and competences of innovation and entrepreneurship compared to the initial evaluation informs us about the training program's effectiveness in transferring

knowledge. Finally, the online Competences Self-Perception Survey is also applied after the training action to assess the impact of the training in the self-perception of the six competencies targeted.

Discussion and conclusion

Despite the growing relevance of EE, research about its influence at doctoral level and the effect of different pedagogical methods remains scarce (Rippa et al., 2020). Nevertheless, integrating EE into doctoral programs holds significant potential in fostering innovation capabilities and providing a platform for exploring academic entrepreneurship. In fact, the INVENTHEI project has highlighted the crucial role of developing PhD students as future entrepreneurs in stimulating social and economic activities, given the direct link between doctoral studies and knowledge generation within Higher Education Institutions (HEIs) (Feijóo-Quintas et al., 2023). Aligned with this perspective, the aim of this training proposal is to bridge this research gap and address the need for a comprehensive and tailored EE curriculum designed specifically for doctoral students. By implementing such a curriculum, this project seeks to provide doctoral students with the necessary knowledge and skills to thrive as entrepreneurial researchers.

In EE, and in general in higher education, discussion have moved from an academic paradigm to a training' paradigm where the HEIs are responsible for promoting the skills needed by cohorts of skilled professional researchers' (Mackie & Thongpravati, 2017). In this context of personalization and personalizing knowledge, it is discussed the need for standardized training. According to Mackie & Thongpravati (2017), the diversity of backgrounds and research goals would represent challenges in designing pre-existing trainings. This proposal follows a general, but also adaptable training scheme. Through the implementation of this initiative, students can acquire the necessary tools and knowledge to foster entrepreneurial mindsets, develop essential business skills, and effectively navigate the intricate landscape of academia and industry. This comprehensive training approach not only has the potential to enhance research competencies but also enables to leverage researchers' expertise and make significant contributions to society. Consequently, innovation becomes an integral component of ecosystem collaboration, as evidenced by the adoption of concrete methods and models. By actively addressing multifaceted challenges and engaging in socioeconomic advancement, doctoral students possess the capacity to generate substantial value and drive positive change. The proposal aligns with the results obtained during the second phase of the INVENTHEI project, where the implementation of a challenge-based learning approach emerged as an optimal strategy for integrating diverse stakeholders within the innovation ecosystem (Gerbaudo-González et al., 2023).

In EE evaluation, problems associated with self-report data and the susceptibility to response biases have been well documented. As most studies about EE have relied upon self-reports of both predictor and outcome variables, these findings have considerably overestimated the effect sizes between team-level variables and innovativeness (Ute, Hulsheger, Anderson, & Salgado, 2009). Accordingly, the assessment

proposal combines self-reported with objective data collection and judge-based assessment in different moments of the training process, looking for a comprehensive approach to the assessment process.

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