The Role of the STEM Teacher in Transversal Training in Innovation and Entrepreneurship: A Case Study at a Chilean University

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Abstract

A Chilean University has implemented a training program in innovation and entrepreneurship for its engineering students, mainly using lectures. However, the impact of this training may be influenced by the attitude and approach of teachers in other subjects and levels. This case study will explore how the role of STEM teachers can strengthen or weaken transversal training in innovation and entrepreneurship. The perception of students and teachers about the importance of these competencies will be analyzed, as well as the coherence between the formal curriculum and the hidden curriculum about innovation and entrepreneurship. The results of this study will contribute to a better understanding of how to create an educational environment that effectively fosters the training of innovative and entrepreneurial professionals aligned with the demands of the current labor market. This study aims to analyze the perception of STEM teachers about their role in transversal training in innovation and entrepreneurship and to evaluate their alignment with the expectations of the university. An exploratory approach was adopted using the Delphi Method and Cronbach's Alpha. A panel of experts composed of STEM teachers, university representatives, and labor market experts was selected. A questionnaire was designed to explore teachers' perceptions and institutional expectations. The results reveal that teachers consider specific knowledge, skills, and attitudes essential to promote innovation and entrepreneurship. In addition, they describe various pedagogical practices and perceive variable institutional support. Discrepancies were identified between teachers' perceptions and university expectations. The findings suggest improving the alignment between teachers' perceptions and institutional expectations. Teachers recognize the importance of innovation and entrepreneurship, but there's a misalignment between their perceptions and institutional expectations, especially in supporting the integration of innovative practices. Experienced teachers often feel less need for professional development in innovation, while those struggling with integration report lower confidence, leading to a potential cycle of diminished self-efficacy. Recommendations are proposed to strengthen transversal training in innovation and entrepreneurship.

Keywords: STEM Education, Innovation and Entrepreneurship, Transversal Training, Teacher Perception, Higher Education Curriculum

Introduction

Implementing a training program in innovation and entrepreneurship for engineering students at a Chilean university raises critical questions about the broader educational environment, particularly the role of STEM teachers. The effectiveness of such programs is often contingent upon educators' attitudes and pedagogical approaches across various subjects and levels. This case study aims to explore how STEM teachers can either strengthen or weaken transversal training in innovation and entrepreneurship, focusing on the perceptions of both students and teachers regarding the importance of these competencies. Furthermore, it will examine the alignment between the formal and hidden curricula, which can significantly influence the educational outcomes related to innovation and entrepreneurship. Curriculum alignment is a foundational concept in education that posits a direct relationship between what is taught and assessed. Research has shown that effective curriculum alignment can lead to improved student achievement, as it ensures that the instructional methods and assessments are coherent with the intended learning outcomes [1]. This principle is particularly relevant in STEM education, where the integration of various disciplines is essential for fostering innovation and entrepreneurship. The alignment between the formal curriculum, which outlines the intended learning outcomes, and the hidden curriculum, which encompasses the implicit values and norms conveyed through teaching practices, is crucial for creating an educational environment conducive to developing entrepreneurial competencies [1].

Teachers' perceptions regarding their role in fostering innovation and entrepreneurship are pivotal. A study conducted in Turkey highlighted that teachers view innovative practices as integral to the educational system rather than isolated initiatives [2]. This perspective underscores the importance of embedding innovation within the broader educational framework, which aligns with the case study's findings. Teachers' beliefs about promoting these competencies can significantly influence their pedagogical practices and academic climate. For instance, if teachers perceive innovation as a critical component of their teaching, they are more likely to adopt instructional strategies that encourage creativity and entrepreneurial thinking among students [2].

Moreover, the role of professional development in equipping teachers with the necessary skills to integrate innovation and entrepreneurship into their teaching cannot be overstated. Research indicates that effective professional development programs focused on STEM education can enhance teachers' understanding and implementation of integrated curricula[3], [4]. Such programs provide teachers with the content knowledge required to teach these subjects and foster a collaborative environment where educators can share best practices and strategies for promoting innovation. This collaborative approach is essential for addressing the discrepancies identified between teachers' perceptions and institutional expectations regarding the teaching of innovation and entrepreneurship [5].

The findings from the case study reveal that while teachers recognize the importance of specific knowledge, skills, and attitudes essential for promoting innovation and entrepreneurship, a variable level of institutional support exists for these initiatives. This misalignment between teachers' perceptions and the university's expectations can hinder the effective implementation of

transversal training programs [6]. For instance, if teachers feel unsupported in their efforts to integrate innovation into their curricula, they may be less likely to engage in practices that foster entrepreneurial competencies among students. This highlights the need for universities to provide adequate resources and support systems that empower teachers to embrace innovation in their teaching practices [7].

Furthermore, the hidden curriculum plays a significant role in shaping students' perceptions of innovation and entrepreneurship. The informal messages conveyed through classroom interactions, teacher attitudes, and institutional culture can either reinforce or undermine the formal curriculum [8]. For example, if teachers demonstrate a lack of enthusiasm for innovative practices or fail to model entrepreneurial behaviors, students may internalize these attitudes, leading to a diminished interest in pursuing entrepreneurial ventures [8]. Therefore, STEM educators need to be aware of the impact of their attitudes and behaviors on students' learning experiences and outcomes.

Considering these findings, it is evident that improving the alignment between teachers' perceptions and institutional expectations is crucial for enhancing transversal training in innovation and entrepreneurship. Recommendations for strengthening this alignment include providing targeted professional development opportunities that focus on the integration of innovation into STEM education, fostering a collaborative culture among educators, and ensuring that institutional policies support innovative teaching practices [9]. Additionally, universities should actively engage teachers in the curriculum development process to ensure that their insights and experiences are reflected in the formal curriculum, thereby creating a more cohesive educational framework [10]The following research question arises: How do STEM teachers' perceptions and pedagogical practices influence the effectiveness of transversal training in innovation and entrepreneurship among engineering students, and what are the implications for aligning institutional expectations with teachers' attitudes and approaches?

Methodological framework

This study adopts an exploratory approach to investigating STEM teachers' perceptions of their role in fostering innovation and entrepreneurship. The methodology is structured around the Delphi Method and the application of Cronbach's Alpha to ensure the reliability and validity of the findings. The following sections detail the components of the methodology, including participant selection, data collection, and analysis procedures.

Delphi Method

The Delphi Method is a structured communication technique that relies on a panel of experts to achieve a consensus on a specific topic. In this study, a panel was composed of STEM teachers, university representatives, and labor market experts selected for their relevant experience and knowledge in education and entrepreneurship. The selection process involved identifying individuals who have demonstrated expertise in innovation and entrepreneurship education, ensuring a diverse representation of perspectives. This method is particularly effective in educational research, as it gathers insights from multiple stakeholders, facilitating a comprehensive understanding of the issues [11].

The Delphi process involved several rounds of questionnaires, where participants provided their opinions on the importance of innovation and entrepreneurship competencies, as well as their perceptions of institutional support and alignment with curriculum expectations. Each round was designed to refine the responses based on feedback from previous rounds, ultimately leading to a consensus on key themes and recommendations for enhancing transversal training in innovation and entrepreneurship [12].

Questionnaire Design

A questionnaire was developed to explore the perceptions of STEM teachers regarding their role in promoting innovation and entrepreneurship. The questionnaire included closed questions to capture quantitative data. The closed-ended questions were designed to assess the perceived importance of various competencies related to innovation and entrepreneurship and the level of institutional support perceived by the teachers. Open-ended questions allowed participants to elaborate on their experiences and provide insights into their pedagogical practices and challenges faced in integrating innovation into their teaching [2].

To clarify the process of thematic analysis, we would like to elaborate on how we derived themes from the questionnaire data. Given the exploratory nature of this study and the lack of a directly applicable pre-existing coding framework, we adopted an inductive approach. This involved thoroughly reviewing the responses to open-ended questions, allowing themes to emerge organically from the data. The major themes that emerged from this analysis were:

Perceived Role of STEM Teachers in Fostering Innovation and Entrepreneurship: This theme explores how STEM teachers view their responsibility in developing these competencies in their students. For example, teachers who strongly agreed with statements like "One of my roles as a STEM teacher is to encourage innovation and entrepreneurship in my students" and disagreed with statements like "I face significant difficulties when trying to integrate innovation and entrepreneurship into my teaching practice" were categorized as having a strong sense of their role in fostering these competencies. Conversely, those who expressed difficulties or a lack of clarity about their role were classified accordingly.

Perceived Institutional Support for Innovation and Entrepreneurship: This theme examines how teachers feel supported by the university in their efforts to integrate innovation and entrepreneurship into their teaching. Teachers who strongly agreed with statements like "The university provides me with the necessary support to implement innovative activities in my classes" were seen as having high perceived institutional support. In contrast, those who expressed a need for more resources or disagreed with such statements were categorized as having lower perceived support.

Challenges to Implementing Innovation and Entrepreneurship: This theme identifies teachers' barriers to integrating these elements into their courses. Analysis of responses revealed difficulties such as lack of time (e.g., agreement with "Lack of time is an obstacle to implementing entrepreneurship activities in my classes"), lack of knowledge/skills, difficulty of assessment, and concerns about curriculum alignment.

<u>Teacher Attitudes and Beliefs about Innovation and Entrepreneurship:</u> This theme explores teachers' underlying beliefs about the importance of these competencies and their role in education. Teachers who strongly agreed with statements like "Students need to develop entrepreneurial skills to face the challenges of today's working world" were considered to have a strong emphasis on these competencies. At the same time, those who were neutral or disagreed were seen as placing less importance on them.

A pilot test was conducted with a small group of STEM teachers to ensure the questionnaire's validity. Feedback from the pilot test was used to refine the questions for clarity and relevance. The final version of the questionnaire was distributed to the selected panel of experts, who were invited to complete it anonymously to encourage honest responses.

Data Collection

Data collection was conducted in two phases. The first phase involved the distribution of the initial questionnaire to the panel of experts. Participants were given a specified timeframe to complete the questionnaire, after which the responses were collected and analyzed. The second phase involved follow-up rounds, where the results from the first round were summarized and shared with the participants. This iterative process allowed participants to reconsider their responses, considering the group's feedback, fostering a deeper discussion on the themes emerging from the data [13]. These steps also include a thorough literature review to identify key constructs related to innovation and entrepreneurship in STEM education, consultation with experts in the field during questionnaire development, and a pilot test with STEM teachers to refine the questions for clarity and relevance. The final version of the applied questionnaire is presented in Appendix 1

Reliability and Validity

Cronbach's Alpha was calculated to assess the reliability of the questionnaire. This statistical measure evaluates the internal consistency of the questionnaire items, ensuring that they reliably measure the same underlying construct. A Cronbach's Alpha value of 0.70 or higher is generally considered acceptable for social science research, indicating that the items are sufficiently correlated to be grouped [14]. The analysis of the pilot test data provided preliminary insights into the questionnaire's reliability, which was subsequently refined based on the results.

Data Analysis

The data collected from the questionnaires were analyzed using quantitative and qualitative methods. Quantitative data were subjected to statistical analysis to identify response trends and patterns. Descriptive statistics were used to summarize the participants' perceptions regarding the importance of innovation and entrepreneurship competencies, as well as their views on institutional support [2],[13].

Ethical Considerations

Ethical considerations were paramount throughout the research process. Participants were informed about the purpose of the study, the voluntary nature of their participation, and their

right to withdraw at any time without consequence. Informed consent was obtained from all participants before data collection. Additionally, measures were taken to ensure the confidentiality and anonymity of the participants, with all data being stored securely and used solely for research purposes [15].

Results

Sample composition

A survey with the corresponding questionnaire was administered to 64 engineering professors/teachers from a Chilean private university. The questions included perceptions of teachers' roles in promoting innovation and entrepreneurship, knowledge and skills, institutional support, and difficulties integrating innovation into teaching practice. The responses were scored using a 5-point Likert scale.

Correlations between variables

The analysis reveals several noteworthy correlations among various factors influencing teachers' perceptions and experiences regarding innovation in education. A moderate positive correlation of 0.64 indicates that teachers who perceive their role in innovation as significant also recognize a corresponding enhancement in their knowledge and skills (Fig. 1). Furthermore, a correlation of 0.40 suggests that increased perceptions of institutional support are linked to a greater acceptance of the teaching role in fostering innovation. Interestingly, more experienced teachers (correlation of 0.33) report a heightened sense of institutional support. Yet, this experience also correlates negatively (-0.52) with the perceived need for development in innovation skills, implying that seasoned educators may feel less urgency for further training in this area. Additionally, teachers encountering challenges in integrating innovation report a negative correlation of -0.47 with their perceived knowledge and skills, indicating that difficulties may undermine confidence in their capabilities. Conversely, a positive correlation of 0.45 means that greater institutional support aligns teaching activities more closely with university innovation objectives (Fig. 2). Lastly, a correlation of 0.43 shows that teachers who feel competent in assessing innovation competencies also perceive themselves as possessing greater knowledge and skills in this domain.
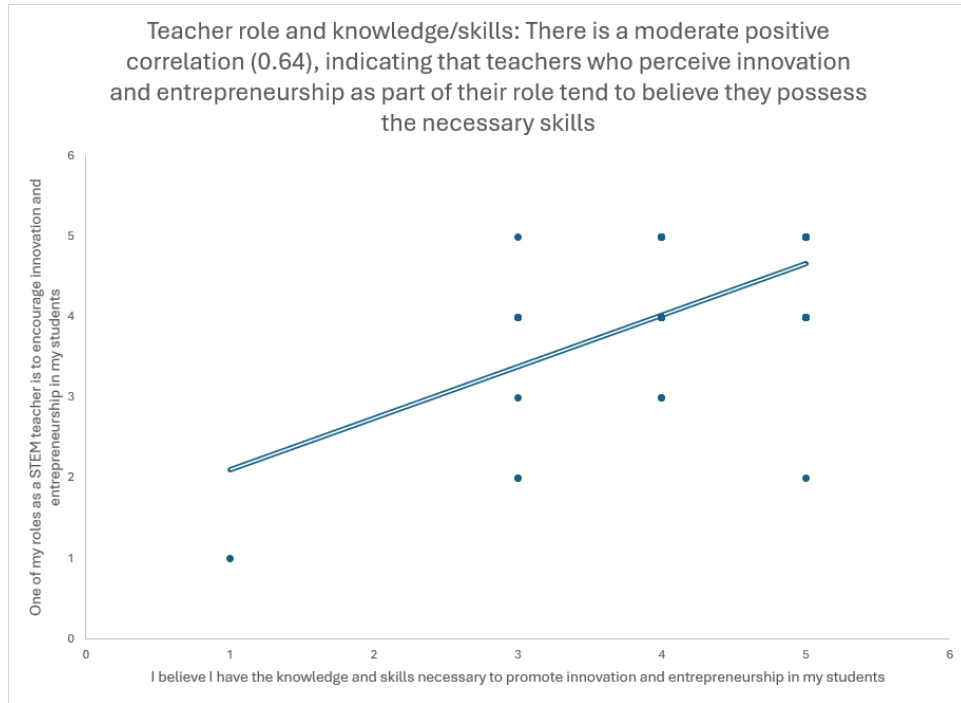
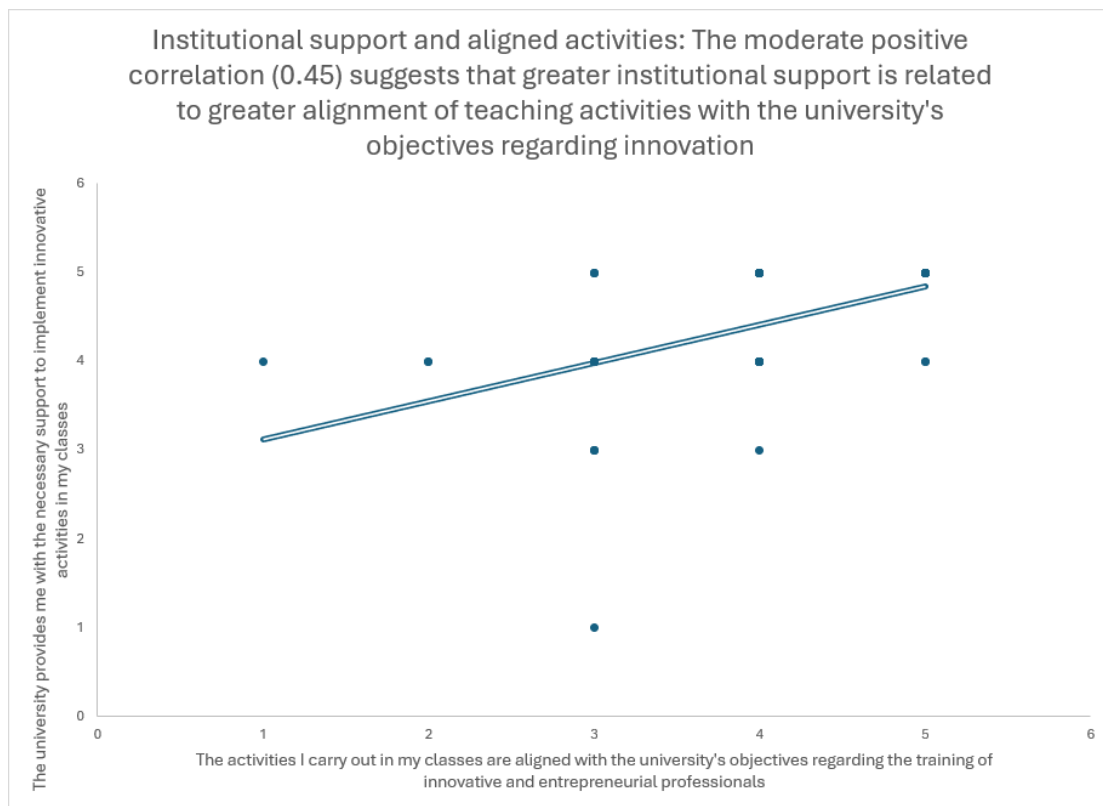Fig. 1: Relation between teacher role and knowledge/skills

Fig. 2: Relation between institutional support and aligned activities.

Perception of the teaching role

The findings indicate a strong consensus among teachers regarding their responsibilities in promoting innovation and entrepreneurship within the educational framework. Specifically, 86.4% of teachers affirm that fostering innovation is a fundamental aspect of their role, highlighting a collective commitment to enhancing educational practices. Additionally, 65.2% of teachers employ diverse pedagogical strategies aimed at stimulating critical thinking among students, suggesting an active engagement in methodologies that encourage analytical and innovative thought processes. This data underscores the importance teachers place on their roles as facilitators of innovation and critical thinking, essential skills in contemporary education.

Institutional Support and Difficulties

The overall perception of institutional support among teachers is predominantly positive; however, there remains room for improvement to bolster this support further. Teachers acknowledge the assistance provided by their institutions but express a desire for enhanced resources and backing, particularly in the context of integrating innovative practices. Moreover, those teachers who encounter significant challenges in their teaching roles indicate a need for additional support mechanisms. This suggests that while institutional support is valued, targeted interventions may be necessary to address educators' specific difficulties, facilitating a more effective implementation of innovative teaching strategies.

Discussion

The survey results suggest a general alignment between the perception of STEM teachers and the expectations of the university regarding their role in the training of innovative and entrepreneurial professionals. However, some points were identified to be considered to strengthen training in this area:

Implications of the negative correlations found

The negative correlations found in the analysis are particularly interesting because they reveal possible areas of attention for the university. Let's look at the two main ones:

Years of experience and knowledge/skills (-0.52): This correlation suggests that teachers with more experience tend to perceive a lower need for development in innovation skills. This may be due to several factors, such as resistance to change, lack of time to update, or the belief that their previous experience is sufficient. The implication is that UNAB should design professional development programs that are attractive and relevant for experienced teachers, emphasizing the importance of constant updating in a rapidly evolving educational environment. Incentives could be offered, such as recognition, release of teaching hours to participate in workshops, or the possibility of leading innovation projects.

Difficulties and knowledge/skills (-0.47): This correlation indicates that teachers who face more problems integrating innovation tend to feel they have less knowledge and skills. This can generate a vicious circle, where a lack of confidence limits the implementation of innovative practices, perpetuating the perception of inability. The university should identify teachers'

difficulties (lack of resources, time, support, etc.) and offer concrete solutions. This could include tutoring, spaces for collaboration between peers, access to technologies, and pedagogical resources.

Recommendations to strengthen teacher training

To strengthen teacher training in innovation and entrepreneurship, the university could consider the following recommendations:

Continuing professional development programs: These programs should be designed considering the specific needs of teachers, including those with greater experience. Topics such as active learning methodologies, integration of emerging technologies, design of learning experiences that foster creativity and critical thinking, and assessment of innovation competencies should be addressed.

Communities of practice: Encourage the creation of communities of practice where teachers can share experiences, collaborate on projects, and learn from each other. These communities can be organized by disciplinary or interdisciplinary areas and supported by expert facilitators or mentors.

Incentives for innovation: Recognize and reward teaching innovation initiatives through competitions, publications, or allocation of resources for projects. This will motivate teachers to explore new ideas and share their best practices.

Access to resources and technologies: Ensure teachers have access to the resources and technologies necessary to implement innovative practices in their classrooms. This includes software, hardware, educational platforms, and flexible learning spaces.

Improve institutional support for teachers

Institutional support is essential for teachers to integrate innovation into their practice. UNAB can strengthen this support in the following ways:

Committed leadership: University authorities must demonstrate a clear commitment to innovation in teaching and support faculty initiatives.

Dedicated resources: Allocate specific resources for innovation in teaching, such as project funding, scholarships for teacher training, and support staff hiring.

Collaborative spaces: Create physical and virtual spaces that facilitate collaboration between teachers, researchers, and students.

Culture of innovation: Promote an institutional culture that values experimentation, creativity, and risk-taking in teaching.

Feedback mechanisms: Establish mechanisms so teachers can receive feedback on their innovative practices and contribute to continuously improving training programs.

Strategies to address the difficulties faced by teachers

To address the difficulties faced by teachers when integrating innovation, UNAB can implement the following strategies:

Needs assessment: Conduct a diagnosis to identify teachers' specific difficulties in each area or department.

Specific training: Offer training to address the identified difficulties, such as managing digital tools, designing innovative learning activities, or managing time.

Personalized support: Provide customized support to teachers who require it through tutoring.

Conclusions

The study on implementing a training program in innovation and entrepreneurship for engineering students highlights the critical role of STEM teachers in shaping educational outcomes. The findings indicate that teachers generally recognize the importance of fostering innovation and entrepreneurship, with a significant majority affirming their responsibility in this area. However, the study also uncovers a misalignment between teachers' perceptions and institutional expectations, particularly regarding the support for integrating innovative practices into the curriculum. This misalignment is evidenced by the negative correlations identified, such as the tendency of more experienced teachers to feel less need for professional development in innovation skills, which may stem from resistance to change or a belief that their existing knowledge suffices. Additionally, teachers facing difficulties integrating innovation reported feeling less confident in their knowledge and skills, suggesting a cycle of diminished self-efficacy that could hinder the adoption of innovative teaching practices.

To address these challenges, the study recommends several strategies to enhance the alignment between teachers' perceptions and institutional support. These include developing targeted professional development programs that cater to the specific needs of teachers, particularly those with more experience, and fostering communities of practice that encourage collaboration and sharing of best practices among educators. Furthermore, the study emphasizes the importance of institutional commitment to innovation, advocating for dedicated resources and a supportive culture that values experimentation and creativity in teaching. By implementing these recommendations, the university can create a more cohesive educational environment that effectively promotes innovation and entrepreneurship among engineering students, ultimately leading to improved educational outcomes.

In conclusion, the research underscores the necessity of aligning institutional expectations with teachers' attitudes and pedagogical practices to enhance the effectiveness of transversal training in innovation and entrepreneurship. The findings suggest that while teachers are willing to embrace their roles in fostering these competencies, systemic support and professional development are crucial to overcoming barriers and ensuring that innovative practices are effectively integrated into the educational framework. This alignment will benefit teachers and

significantly enhance students' learning experiences and outcomes, preparing them for the demands of a rapidly evolving professional landscape.

Future work

As this study was primarily descriptive, focused on understanding the current landscape of teacher perceptions and practices within the university, currently, this is the first step for a follow-up study that would involve implementing some of the suggested strategies (e.g., professional development programs, increased institutional support) and then assessing their impact on teacher practices, student learning outcomes, and the overall entrepreneurial ecosystem within the university. This longitudinal approach would provide valuable evidence regarding the long-term effects of our proposed interventions.

While our current study focused on one university to gain an in-depth understanding of the internal dynamics, future research could expand the scope to include a national or regional benchmark. This would allow for a broader analysis of the factors influencing the integration of innovation and entrepreneurship in STEM education across different institutional contexts, potentially revealing best practices and areas for improvement across the higher education sector.

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Appendix 1: Applied Questionnaire

1.- Email address;

2.- Your gender;

3.- What is your main discipline (engineering, humanities, social sciences, other)?;

4.- How many years have you been teaching?;

5.- Experience range;

6.- How many years have you been a teacher at UNAB? (consecutive or not).;

7.- Educational level in which you teach;

8.- Academic position;

9.- How many subjects are you teaching at UNAB this quarter/semester?;

10.- How many teaching hours do you teach each week?;

11.- What department do you belong to?;

12.- One of my roles as a STEM teacher is to encourage innovation and entrepreneurship in my students;

13.- I consider that I have the knowledge and skills necessary to promote innovation and entrepreneurship in my students;

14.- I use various pedagogical strategies to stimulate critical thinking and problem-solving in my students;

15.- The university provides me with the necessary support to implement innovative activities in my classes;

16.- The activities I carry out in my classes are aligned with the university's objectives regarding the training of innovative and entrepreneurial professionals;

17.- I face significant difficulties when trying to integrate innovation and entrepreneurship into my teaching practice;

18.- I would have more resources to improve my ability to foster innovation and entrepreneurship;

19.- Please specify if you answered "Other" to the previous question.;

20.- I would like to receive specific training in active methodologies and tools to promote innovation and entrepreneurship;

21.- I actively collaborate with other teachers and departments to foster an environment of innovation at the university;

22.- I can effectively assess the development of innovation and entrepreneurship skills in my students;

23.- I believe that engineering students should have more opportunities to participate in research and development projects;

24.- I believe that the curriculum of my subject encourages creative and critical thinking;

25.- I feel prepared to advise my students in the development of business ideas;

26.- The evaluation of innovation and entrepreneurship skills is a complex and challenging task to measure;

27.- The university provides different opportunities to students for their entrepreneurship and innovation projects;

28.- Students show interest in developing innovative projects;

29.- Lack of time is an obstacle to implementing entrepreneurship activities in my classes;

30.- I believe that the university should offer more business incubation programs for students;

31.- I would like to participate in continuing education programs to improve my skills in mentoring and coaching entrepreneurs;

32.- I consider peer assessment to be a valuable tool to encourage innovation and entrepreneurship in students;

33.- I consider that all subjects, regardless of their area, have the opportunity to contribute to the development of entrepreneurial skills in students;

34.- I incorporate elements of entrepreneurship in my classes, even if it is not the main objective of the subject;

35.- I believe that collaborative projects between different subjects would be an excellent way to encourage innovation and entrepreneurship;

36.- Students need to develop entrepreneurial skills to face the challenges of today's working world;

37.- The evaluation of entrepreneurial skills should be an integral part of the evaluation of all subjects;

38.- Extracurricular activities (clubs, projects, etc.) are essential to complement entrepreneurship training;

39.- I feel comfortable advising students in developing their entrepreneurial ideas, even though it is not my area of expertise;

40.- I believe that the university should offer more resources to support teachers in integrating entrepreneurship into their classes;

41.- I believe that the university should offer more resources to support teachers in integrating innovation into their classes;

42.- Students need to develop an entrepreneurial mindset to be successful in any professional career;

43.- Students need to develop an innovative mindset to be successful in any professional career;

44.- Entrepreneurship training should begin from the first years of university;

45.- I believe that I can foster creativity and critical thinking in my students, even if innovation is not an explicit objective of my subject;

46.- I believe that I can integrate elements of innovation into my classes through minor modifications in my activities and assessments;

47. I would like to have more tools and resources to incorporate innovative activities in my teaching, but I don't know where to find them.

48.- I believe that students are capable of developing innovative skills in any subject if given the opportunity;

49.- Lack of time is an obstacle to incorporating innovative activities in my workload;

50.- I am concerned that introducing elements of innovation in my subject may compromise the fulfillment of the program objectives;

51.- I consider that the evaluation of innovative skills is subjective and difficult to measure;

52.- I would like the university to offer more continuing education opportunities for teachers on topics of technological innovation;

53.- I believe that collaboration with other teachers can enrich students' learning experiences and encourage innovation;

54.- I am motivated to explore new ways of teaching and learning that promote creativity and critical thinking in my students;

55.- We would appreciate any comments you may have regarding the topics discussed in this survey;