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Meeting reality: Learning with collaborative and multidisciplinary approach

M. Ileana Ruiz-Cantisani[1]; Imelda Loera-Hernández[1]; Vianney Lara-Prieto[1,2]
[1]Tecnologico de Monterrey, Mexico, miruiz@tec.mx , iloera@tec.mx
[2]Institute for the Future of Education, Tecnologico de Monterrey, México, vianney.lara@tec.mx

***Abstract*—Today's world faces frequent global challenges due to human, environmental, and technological factors. Multidisciplinary collaboration in engineering, science, and technology programs aims to generate innovative solutions to increasingly complex problems. Soft skills promote collaboration on complex, multidisciplinary projects. Effective communication, agile project management, and facilitation skills are essential for meeting project, challenge, or problem objectives. A qualitative case study at a private university highlights the development of soft skills through interdisciplinarity. Senior engineering students work collaboratively to solve real challenges, enhancing their communication and teamwork abilities, and recognizing their own and their peers' strengths. Participatory decision-making methodology and technology help students develop these competencies and solve the real-world challenges, which will benefit their future careers. The methodology is qualitative approach, using the case study method to analyze two generations of students from different engineering programs in a multidisciplinary course, with a challenge-based learning strategy, developing soft skills. The instruments used were reports with reflections linked to the lessons learned and proposals obtained as a team, as well as the evaluation of soft skills. Analysis of the results allows us to observe how students learn to value social skills from the perspective of different academic programs while also becoming aware of their own abilities (both disciplinary and personal), leading them to find innovative solutions to the challenges they face.**

Keywords—Educational Innovation, Higher education, multidisciplinary collaboration, Soft Skills, Challenge based learning.

I. INTRODUCTION

The challenges of today's world call for skills that encourage teamwork and the blending of different fields of study. Students pursuing degrees in engineering, science, and technology are expected to cultivate a range of soft skills in addition to their disciplinary aptitudes. These skills are crucial for effectively addressing the intricate challenges they will encounter in professional settings, within companies and organizations. These challenges require multidisciplinary collaboration to design and develop new systems, equipment, processes, and solutions.

Higher education institutions with competency-based and active learning educational models promote complex problem solving from different perspectives in various ways, including promoting engineering, sciences and technology (STEM) to design from a multidisciplinary approach, emphasizing not only disciplinary knowledge but also the use of soft skills. This leads to the creation of communities that transform or design change in organizations [1], and to create rich learning environments that prepare students for real-world challenges. [2]

The purpose of the research is to describe the case study of how a private university provides its STEM students with this multidisciplinary approach emphasizing the development of soft skills, its results, and the type of challenges that arise in teams using agile project management and participatory decision-making methods. The research questions are: What are the results of using challenge-based learning with a multidisciplinary approach in the formal curriculum of undergraduate STEM programs? What types of challenges are developed? And what is the impact of learning participatory methods for collaborative decision-making on the development of soft skills?

II. LITERATURE REVIEW

Recent research has shown the growing importance of multidisciplinary collaboration in engineering education to prepare students for the complexity of real-world problems [3,4,5]. Using the challenge-based learning method with a multidisciplinary approach allows students to observe the contributions and perspectives of each discipline and their own personal skills and knowledge as they are brought together to solve a complex problem. Collaboration across disciplines not only enriches the educational environment but also enhances students' ability to integrate diverse perspectives, apply theoretical knowledge to practice, and develop transversal competencies such as problem-solving, critical thinking, and communication [3,6]. According to [5], when students from applied physics and mechanical engineering participated in Challenge-Based Learning (CBL) activities, their disciplinary approaches fostered complementary problem-solving strategies, demonstrating the value of disciplinary diversity in team-based projects.

However, successful multidisciplinary collaboration requires intentional structuring and facilitation. As [3] notes, adapted communication strategies are essential throughout all project stages to overcome both technical and cultural barriers.

Adapting language to different audiences and fostering openness to feedback are critical factors for achieving shared understanding and effective collaboration. Furthermore, [6] emphasizes the need for educators and institutions to align curricula, foster interdisciplinary partnerships with industry, and provide project-based learning opportunities that integrate multiple disciplines.

The integration of communication training within engineering curricula has become a central concern for educators seeking to enhance students' readiness for professional practice [7]. Communication in multidisciplinary teams is not only about transmitting technical information clearly but also about adapting to diverse disciplinary languages, expectations, and problem-solving frameworks. [5] discusses how assessing and reinforcing technical communication skills ensures that students can transfer academic competencies into professional contexts. Their study shows that robust evaluation systems, such as validated rubrics and industry assessments, support the consistent development of communication competency. Moreover, communication serves as a bridge between disciplinary knowledge and collaborative innovation. [8] found that informal communication, trust-building, and participatory decision-making were key elements in fostering effective knowledge co-creation within innovation labs that connected students, educators, and industry professionals.

Challenge-Based Learning is a pedagogical approach that enables the development of multidisciplinary and communication skills. It immerses students in real, open-ended challenges that require collaboration, reflection, and iterative problem-solving. [5] demonstrated that CBL facilitates cross-disciplinary learning by allowing students to engage in real challenges that apply diverse expertise, while fostering teamwork and adaptability. Similarly, [4] found that CBL projects involving collaboration with industry partners helped students connect theoretical knowledge with real-world applications, enhancing both communication and professional competencies.

In addition to CBL, Agile Project Management (APM) principles can be applied in educational settings to promote iterative progress, reflective practice, and team communication. For instance, [9] proposed an iterative and inclusive design process for immersive learning environments that incorporated participatory design and universal design for learning principles, ensuring accessibility and adaptability through multidisciplinary collaboration. Participatory Decision-Making (PDM) further complements these frameworks by emphasizing the co-creation of knowledge and shared ownership of learning outcomes. As shown in [8], involving educators and students in participatory processes enhances alignment between academic content and industry needs, while building trust and agency among participants. Similarly, [10]'s "STEM-squared" network demonstrates how collaborative, systems-based, and participatory approaches can transform institutional cultures toward inclusivity and sustainability across multiple STEM disciplines. Moreover, educational reforms in engineering, such as those integrating AI literacy, benefit from multidisciplinary collaboration among diverse stakeholders, innovative teaching methods, and optimized assessment systems that mirror the dynamics of collaborative, project-based work [11].

The success of these initiatives depends on institutional support, faculty development, and alignment between academic and industry goals [4,9,11]. When educators themselves engage as co-learners in participatory environments [8] and adopt inclusive, iterative methodologies [9], they model the same communicative and collaborative competencies expected of their students. These studies converge on the idea that multidisciplinary collaboration is a powerful educational strategy for developing communication and teamwork skills in engineering education. These approaches not only align learning with real-world contexts but also promote adaptability, inclusivity, and shared responsibility in solving complex challenges.

III. METHODOLOGY

The methodology is qualitative approach [12,13], using the case study method to analyze two generations of students from different engineering programs in a multidisciplinary course, with a challenge-based learning strategy, developing soft skills, and using agile project management, communication, and participatory decision-making methodologies. The research phases consist of: (1) research design & sample, (2) case study description-the bounded system-, (3) instrument design and their application, (4) data analysis and conclusions. The sample consists of two groups from two academic periods, February-March 2025 and August-September 2025, with the participation of 60 students from different engineering programs. The instruments are the application of the participatory decision-making methodology, the students' reflection on their learning, and the evaluation of their soft skills that are sought to be developed in the course, from the perspective of a team of three faculty per group.

Participatory decision-making methodologies were used with the same trigger question, which was linked to students' interest in the characteristics of an ideal job. This topic generates interest among students, demonstrating how skills can lead to communication and consensus. The sample consists of two groups from multidisciplinary 8th-semester courses in engineering, science and technology programs at a private university in northern Mexico. These groups were taught in 2025, as shown in Table I describing the sample population. The groups were divided into teams, with 10 teams formed in group 1 and seven in group 2.

The academic programs in which the students were enrolled were: Chemical Engineers (12%), Industrial Engineers (12%), Mechatronics Engineers (6%), Mechanical Engineers (12%), Nanotechnology Engineers (16%), Computer Technology Engineers (12%), Innovation and Development Engineers (6%), Biomedical Engineers (15%), and Data Science and Mathematics Engineers (9%). This balance was achieved in both groups with few variations and allowed multidisciplinary teams to be formed to tackle the challenge presented by the educational partner.

Engineering students enrolled in an educational unit called Professional and Agile Project Management. To increase multidisciplinary collaboration, students from other schools, such as business or arts and humanities, are invited to share the challenge. Teams were formed in both groups to solve the challenge together (i.e., with students from both schools' programs). Identical schedules were created to allocate class time for the integration of the two groups. For the purposes of this case study, however, only engineering students are considered.

Definition of multidisciplinary and interdisciplinary collaboration has become an essential competency that engineering students must develop throughout their academic formation to effectively address the complex challenges of modern society.

TABLE I. RESEARCH´S SAMPLE

# Group	**Sample**			
	Period	***# of students Men***	***# of students Female***	***# of professors***
1	February-March, 2025	21	12	3
2	August-September, 2025	15	15	3

As part of the curricular design of the programs at this private higher education institution, students take a multidisciplinary learning block during the eighth semester of their program. This five-week block (course) presents a real-world challenge that must be addressed jointly by students and faculty members from at least two academic programs belonging to different schools. In this context, multidisciplinary courses foster the development of disciplinary, interdisciplinary, and transversal competencies, while also strengthening students' communication, teamwork, and collaborative problem-solving skills across disciplines [14].

This research presents a case study on the multidisciplinary approach to professional and agile project management, implemented by the School of Engineering and Sciences. To transcend the limitations of single-discipline perspectives, engineering students, organized in multidisciplinary teams, develop competencies related to professional and agile project management (Learning Block 1). Within this framework, students collaborate with peers from other areas of knowledge (Learning Block 2) including International Business, Organizational Development, Entrepreneurship, Digital Design and Arts, and Music Production, among others to address a real-world challenge proposed by an external industry or educational partner. Fig. 1 illustrates the structure of this collaborative framework, highlighting the connection between the professional and agile project management block and other participating programs. The results presented show the impact on engineering students of this collaboration between STEM disciplines and interacting with another group of students from another faculty. It is important to clarify that each group is independent in terms of its management and professors, but they carry out the same challenge with mixed teams, so the time allocated to the challenge is spent working together. Each group has different but complementary learning modules, and in those spaces, they are separate groups. However, engineering students continue to work as a team.

Finally, regarding the soft skills that the assessment aims to measure, students are informed that these are defined as "the process of building agreements and interactions among diverse groups and individuals, based on communication that takes into account the differences and unique abilities of others".[14] The rubric used evaluates elements such as: (a) Communicates effectively within groups, (b) meets the established agreements, and (c) collaborates effectively within the work team. The lowest level of compliance occurs when communication is limited and agreements are not honored, resulting in poor collaboration within the team.

IV. RESULTS

To understand the origin and development of multidisciplinary collaboration, it is essential to identify the core elements that sustain and articulate the efforts of the various stakeholders involved in addressing the assigned challenge.

A. *Purpose*

The primary objective is to solve a real-world challenge proposed by a company or a civil society organization—referred to as the educational partner. This challenge is co-designed by the faculty members responsible for participating in learning blocks in collaboration with the educational partner, ensuring alignment between the learning outcomes, the content of each block, and the real needs of the professional context. The challenge presented to each group, according to the educational partner, is described below.

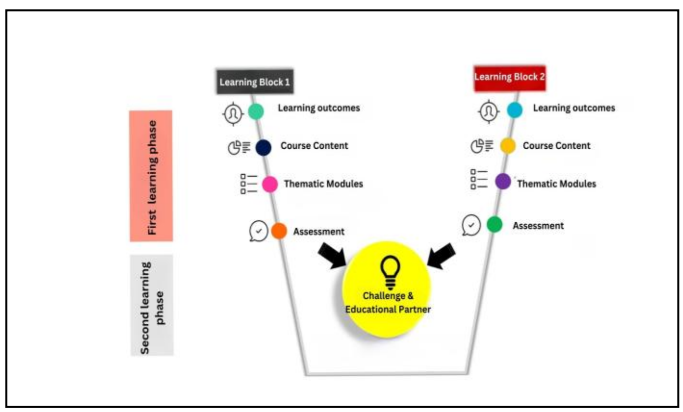

Fig. 1. Collaborative Framework Structure [14]

Challenge 1. The first analysis phase took place between February-March 2025. The proposed challenge focused on the application of Artificial Intelligence (AI) and was described as follows: In today's technological landscape, Artificial

Intelligence represents a fundamental tool for enhancing operational efficiency and enabling data-driven decision-making. This challenge aimed to address the following question: How can we use AI to improve our company's key processes—commercial, production, supply chain, logistics, and human resources—while ensuring their viability and sustainable adoption by staff?

Challenge 2. The second analysis phase was conducted between August-September 2025. The proposed challenge centered on the use of sonification to create meaningful experiences and was described as follows: Sonification is a technique that enables the representation of data through sound. Its value lies in its ability to detect patterns, variations, and trends that might go unnoticed in visual representations, especially when handling large datasets or real-time data. This challenge invited participants to explore the following question: How can we use sonification to represent the activation of pancreatic beta cells in auditory experiences that raise awareness among patients about the importance of health and diabetes?

B. People

The challenge-solving process involves students and faculty members from the participating academic blocks, who contribute complementary perspectives from their respective areas of expertise. Meanwhile, the educational partner provides relevant information regarding the problem, its context, and the expected outcomes of the collaboration. Table II shows the stakeholder involved to solve the challenge described above in each academic period.

TABLE II. STAKEHOLDER INVOLVED TO SOLVED THE CHALLENGE OF REAL-WORLD

Academic Period	***Participants***
February-March 2025	• Learning Block 1: Students from the School of Engineering and Sciences enrolled in the academic program of Mechatronics Engineering, Biomedical Engineering, Chemical Engineering, Industrial and Systems Engineering, Biotechnology Engineering and Computer Engineering. Faculty members from the Department of Industrial Engineering also participated. • Learning Block 2: Students from the School of Business enrolled in the undergraduate program of Organizational Development, guided by faculty members from the School of Business. • Educational Partner: Company from the steel industry.
August-September 2025	• Learning Block 1: Students from the School of Engineering and Sciences, enrolled in the academic program of Mechatronics Engineering, Biomedical Engineering, Chemical Engineering, Industrial and Systems Engineering, Biotechnology Engineering and Computer Engineering. Faculty members from the Department of Industrial Engineering also participated. • Learning Block 2: Students from the School of Humanities enrolled in the Bachelor's in Music Production program, guided by faculty members from the School of Humanities. • Educational Partner: Obesity Research Institute.

C. Infrastructure

The collaboration relies on both physical and virtual environments that facilitate disciplinary and multidisciplinary work. The courses share class schedules, dedicating 60 hours to synchronous multidisciplinary activities over a five-week period. Collaborative sessions are conducted in person to promote engagement, interaction, and collective knowledge construction. Digital collaboration is facilitated through tools such as Canvas, OneDrive, and Microsoft Teams, while communication is maintained through Zoom, instant messaging, and institutional email.

D. Cognitive Approach, Commitment and Interdisciplinary Work

The pedagogical model adopted is Challenge-Based Learning (CBL), which actively engages students in addressing real-world and meaningful problems connected to their professional and social contexts. This approach promotes reflection, knowledge application, and innovation. The effective alignment of purpose, people, and infrastructure requires sustained coordination of tasks and an active commitment to interdisciplinary collaboration. The CBL pedagogical framework, combined with participants engagement, enables the integration of diverse concepts, methodologies, and practices, fostering creative, sustainable, and contextually relevant solutions.

The elements described above are formally integrated in the design of the multidisciplinary course to ensure coherence within the academic program. This structured approach allows STEM students to interact with other fields of knowledge and develop a holistic understanding of real-world problems while strengthening their communication and collaboration competencies. Collectively, these elements promote the development of innovative technological solutions that are contextually grounded and socially relevant.

The learning objectives of the course are the development of communication skills, collaborative work and project management (project planning and execution / control). The course objectives are to build agreements and interactions between different groups and people, based on communication, and to analyze problems with an integrated vision from the inter and transdisciplinary.

E. Practical Knowledge

Two of the modules for developing knowledge and skills for the challenge are: (a) Adding value to the business and (b) Collaborative management with social intelligence. The purpose of the first module is to strengthen the understanding that the main purpose of projects is to add value to customers, users, team members, and other stakeholders. The second module aims to develop knowledge and skills to foster agreements and interactions among project members by considering communication differences and skills in a multidisciplinary context.

One of the skills is learning how to design a participatory process that allows for the different perspectives of the project's stakeholders to be considered. In this exercise, the use of nominal techniques and trigger questions related to the students' reality promote attention and engagement in the course. This was the case with the question, "What characteristics does your ideal job have?"

Through the nominal group technique, we ensure the participation of everyone present in both generating ideas and making decisions when prioritizing. What lessons did students from different STEM disciplines learn? And as an interesting conclusion, what are the characteristics of the ideal work of a group of candidates graduating from STEM programs?

The main lessons learned were obtained from the students documented reflections. The lessons learned by group 1 are: (1) Social intelligence is a fundamental skill for effective people management and communication. (2) As learning experience, social intelligence and the use of tools to promote the participation of different stakeholders in a project are relevant to define how meetings will be held, how to make them effective, communication strategies, and which experts and stakeholders to consider. (3) Applying participatory decision-making ensures that all perspectives are considered, which fosters commitment and the quality of decisions. (4) Participatory sessions provide a space for open dialogue that allows participants to share ideas and concerns, strengthening their sense of belonging and trust.

The lessons learned by group 2 are: (1) Social and emotional intelligence strengthens communication, organization, and collaborative decision-making. Clear rules and effective meetings improve efficiency and commitment. Communication ensures technical validation and user understanding. (2) The integrative activity allowed participants to understand the relevance of social intelligence in project management, highlighting that skills such as empathy, communication, and leadership are as important as technical knowledge for achieving success. (3) The activity also allowed participants to understand the importance of teamwork and collaboration in achieving common goals.

The results of applying participatory methods using a trigger question are reflected in Table 3. This activity maintained the constant attention and participation of the group and each student. In addition, they were able to replicate the methodology by understanding the process and the importance of clarifying ideas and prioritizing.

TABLE III. RESULTS OF PARTICIPATORY METHOD APPLIED

Group	*Trigger question results: Characteristics of an ideal job*
February-March, 2025	• A job that allows for a healthy balance between personal and professional life. • With opportunities for growth, with opportunities for postgraduate studies or specializations. • With a competitive salary. • With a good and healthy work environment.
August-September, 2025	• Recognition for the value I bring to the job. • Work´s flexibility. • Positive and proactive work environment. • Salary increase that covers inflation.

These are some thoughts from students on what it's like to be part of a multidisciplinary team:

“During this project, I had the opportunity to use the concepts I learned in class and collaborate with different teams and people. It allowed me to collaborate with people from different engineering fields, which, although they had certain similarities with my degree, I was able to observe the difference between the skills and personalities that different degrees have. I was able to observe how each person had a different approach to the different activities carried out, and even though we had different approaches, we all reached the same conclusions.”

“The most important thing was to make sure we were all on the same page. This is even more important in a multidisciplinary team, as it can be difficult for all members to understand the technicalities of a particular area. The meetings have allowed us to include the different perspectives present, as well as to determine who should oversee developing which activity, considering the skills of everyone.”

In general, students share that working collaboratively with other engineering or business programs allows them to observe the different skills they develop from their discipline and how these skills complement each other when solving or designing systems, processes, or equipment. As the approaches of the disciplines vary, some focus more on results while others focus on the design process itself. This experience also helped them gain self-awareness of their personal and disciplinary strengths. In addition, the students observed that trust and consideration of stakeholder perspectives are conditions for success; therefore, the communication strategy prioritizes stakeholders, decisions, and ethics. In terms of the soft skills to be developed, students generally show improvement in their communication processes, understanding the difference in the ways and processes of communicating depending on who they are addressing. Related to the teaching of participatory decision-making techniques using topics of interest to students, it provides an engaging description of the characteristics of an ideal job for today's graduating generations. Characteristics that emerge are such as flexibility at work, hybrid jobs, opportunities for growth, and positive environments.

Finally, the teaching teams evaluated both communication and agile project management skills with outstanding results, with more than 95% of the skills achieved in both groups, using the rubrics previously defined and communicated. The evidence used for the evaluation included: a video of less than 5 minutes in which they shared their experience using their skills to reach agreements, as well as those of others; the use of inclusive language; and how they ensured team collaboration.

V. CONCLUSIONS

Today's increasingly complex world, with its global challenges, cannot be solved or improved from a single perspective or discipline. Using the challenge-based learning method with a multidisciplinary approach allows students to observe the contributions and perspectives of each discipline and their own personal skills and knowledge as they are brought together to solve a complex problem. The challenges defined jointly with the educational partner allow for the integration of disciplines not only from engineering but also from other fields such as business and music production. The possibility of solving problems for a company or impacting on the well-being of society and ensuring that these solutions are innovative and have a greater impact, leads to conversations and an understanding of different perspectives, generating constructive dialogue, which is not easy but possible, with a common goal and methods that lead to collaboration and decision-making. That is why it is important to raise awareness among STEM students about the development of these soft skills, as well as to understand and recognize what each discipline and person contributes from their individual and team strengths. Our complex reality requires engineers with a global perspective, who are sensitive, creative, and innovative, able to use technology and artificial intelligence for the common and personal good, who can transform the world, knowing that they are not alone and that progress can be significant when collaborating with this multidisciplinary approach.

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