Innovative active learning in engineering: A course model combining flipped classroom, real-time evaluation, and real-world projects

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ABSTRACT

This paper presents an innovative teaching experience implemented in an engineering program, designed to enhance student engagement and learning outcomes through the integration of active learning techniques. The course Introduction to Engineering Project (IEP I) employs a flipped classroom model combined with real-time evaluation and project-based learning (PBL), centered around a real-world project related to university infrastructure. Students were tasked with addressing practical challenges, such as improving structural design, allowing them to apply theoretical knowledge to tangible problems. The flipped classroom approach enabled students to engage with course materials prior to class, while in-class sessions focused on collaborative problem-solving, peer feedback, and real-time assessment. This methodology improves understanding of engineering principles and develops critical soft skills, such as teamwork, communication, and project management. Initial findings suggest notable enhancements in students' academic performance, engagement, and overall satisfaction, along with a more meaningful integration between theoretical instruction and its practical application. This educational initiative underscores the value of merging active learning strategies with authentic, real-world projects to create a transformative effect on engineering education. The article explores the structure of the course, the obstacles encountered during its implementation, and the insights gained throughout the process, providing a model that can be adapted by educators aiming to improve their instructional methods and more effectively prepare students for the demands of engineering professions.

Keywords: *Active learning, Integration, Real-world projects, Flipped classroom, Engineering education, Project-based learning.*

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Highlights of this paper

- The paper describes an active learning approach that combines a flipped classroom, project-based learning, and real-time assessment in an engineering course.
- Students engaged with real-world infrastructure challenges, fostering both technical knowledge and critical soft skills.
- Results indicate improved academic performance, engagement, and satisfaction, offering a replicable model for engineering education.

1. INTRODUCTION

In recent decades, higher education has undergone significant transformations, driven primarily by technological advancements. These changes have redefined the ways in which knowledge is transmitted, acquired, and applied, resulting in a more dynamic, accessible, and interactive learning environment. One of the most remarkable shifts is the democratization of knowledge. However, digital transformation does not come without challenges. While the widespread availability of information facilitates student access to educational content, it simultaneously increases the need for learners to critically evaluate the relevance and reliability of that information. Consequently, critical thinking and analytical skills have become increasingly essential and must be more intentionally developed in today's students (Goldberg & Somerville, 2014).

In response to these transformations and the need for higher education institutions (HEIs) to adapt, the field of engineering education has been undergoing a process of modernization. Notable developments in this context include the revised accreditation criteria for engineering programs in the United States (ABET, 2019) as defined by ABET, as well as the CDIO (CDIO, 2021) framework of best practices for engineering schools. In both cases, there are explicit recommendations for the adoption of active learning methodologies and the promotion of student engagement in real-world projects, with the goal of providing meaningful opportunities for the application of theoretical knowledge.

This paper reports on the experiences of the course Introduction to Engineering Project I, offered to third-semester students of the engineering program at the Military Institute of Engineering (IME), one of the most prestigious engineering schools in Brazil. The course integrates various active learning techniques, real-time feedback assessments, and the development of real-world projects. Finally, the course's maturity level in active learning is assessed using the E^2ALM^2 framework (Arruda & Silva, 2021), and the corresponding results are discussed.

2. THEORETICAL BACKGROUND

The aim of engineering education is to transmit the knowledge necessary for students to become successful engineers, encompassing technical expertise, social awareness, and an inclination for innovation (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014). Modern engineers are involved in all phases of the life cycle of products, processes, and systems that range from the simple to the incredibly complex, but they all have one characteristic in common: they meet a need of a member (or members) of society. Good engineers observe and listen carefully to determine the needs of the members of society for whom the benefit is intended (Crawley et al., 2014).

The main task of higher education in engineering is to transform new students into modern engineers, capable of participating in, and even leading, work on the conception, design, and implementation of new products and processes (Crawley et al., 2014). During the last years, there has been a shift in engineering education towards a competency-based pedagogy. Competency-based learning (CBL) is an educational approach that focuses on students' achievements and allows them to face more advanced tasks once they have mastered the required foundational content and skills (Henri, Johnson, & Nepal, 2017). A global engineer today needs to have competencies in five categories: technical, professional, personal, interpersonal, and cross-cultural (Hundley, 2015).

One of the most relevant movements to improve engineering education, with new actions and the search for advances in the field, is the CDIO initiative (CDIO, 2021). It is based on a few key ideas, the first two being a restatement of the underlying need for reform of engineering education and a set of objectives for engineering education.

The central point of the CDIO approach is a vision for engineering education that includes using the engineering life cycle process as the context for engineering education. A specific pedagogical foundation supports the realization of this vision (Crawley et al., 2014).

The CDIO approach has three general objectives. Educate students who can:

- Master a deeper practical knowledge of technical fundamentals.
- Lead the creation and operation of new products, processes and systems.
- Understand the importance and strategic impact of research and technological development in society.

Currently, the CDIO community has more than 120 engineering schools around the world. In Brazil, the Instituto Militar de Engenharia (IME) became an official member of the CDIO community in 2019.

To fully achieve the objectives proposed by the CDIO framework particularly those related to leading the development of innovative systems and understanding the strategic impact of technology it is essential to integrate active learning methodologies into engineering education. These pedagogical approaches foster student-centered learning environments in which the acquisition of technical knowledge is interwoven with practical application, collaborative work, and critical reflection. In a context increasingly shaped by the widespread adoption of artificial intelligence across the engineering lifecycle, from design to system operation, it is imperative that future engineers engage with these tools actively, exploring their capabilities and limitations, interpreting their outputs, and integrating them with sound technical judgment (Hoidn & Kärkkäinen, 2014). This reality reinforces the need for engineering graduates to go beyond functional proficiency and develop a deep understanding of the underlying principles and societal implications of such technologies (Kolmos, 2021; Royal Academy of Engineering, 2023; UNESCO, 2021).

Within this context, active learning plays a critical role in fostering the development of critical thinking: a key competence in the age of AI. Although AI systems can accelerate analysis and automate complex tasks, they cannot replace human judgment in questioning assumptions, evaluating risks, considering diverse perspectives, and making ethically informed decisions. By engaging students in activities that require decision-making, argumentation, and reflection on the technological and social impacts of their solutions, active learning equips engineers not only to use emerging technologies effectively but also to lead their responsible and strategic application, precisely in line with the CDIO vision for engineering education.

2.1. Active Learning Techniques

With the aim of fostering the development of the competencies required of modern engineers, the literature widely recognizes active learning techniques as effective and appropriate instructional strategies (Felder, Woods, Stice, & Rugarcia, 2000; Hartikainen, Rintala, Pylväs, & Nokelainen, 2019; Hernández-de-Menéndez, Vallejo Guevara, Tudón Martínez, Hernández Alcántara, & Morales-Menendez, 2019; Howell, 2021; Kerrigan & Kwaik, 2024; Prince, 2004; Rugarcia, Felder, Woods, & Stice, 2000; Streveler & Menekse, 2017). The central premise of active learning lies in transforming students from passive recipients of information into active and critical participants in the construction of knowledge. Well-executed implementations of active learning have been shown to enhance student engagement and motivation (Edström & Kolmos, 2014; Kolmos, 2017). When learners perceive the practical relevance of the content being taught and are given opportunities to work on projects that capture their interest, they tend to become more involved in the learning process and more intrinsically motivated (Hernández-de-Menéndez et al., 2019). This leads to deeper and more lasting learning, while also contributing to lower dropout rates and improved academic performance (Hartikainen et al., 2019).

Among the main active learning techniques, Project-Based Learning (PBL) and the Flipped Classroom were used in this study and are detailed below.

2.1.1. Project-Based Learning (PBL)

The use of project-based learning (PBL) in engineering higher education focuses on the practical application of theoretical knowledge, promoting deeper and more meaningful learning experiences for students (Lantada et al., 2013). Through PBL, students are challenged to solve real-world problems or develop projects that require the direct application of knowledge acquired in the classroom (Kolmos, 2017). This approach not only reinforces theoretical understanding but also provides valuable hands-on experience (Marinho et al., 2022).

In addition, PBL fosters the development of essential skills such as teamwork, communication, time management, and problem-solving (Alves et al., 2018; Hoidn & Kärkkäinen, 2014; Leão, Alves, Soares, & Silva, 2022). By working on collaborative projects, students learn, in an integrated way, how to share responsibilities, articulate ideas clearly, and address challenges collectively (Hartikainen et al., 2019; Hernández-de-Menéndez et al., 2019; Maingi, Mulwa, Maithya, & Migosi, 2017).

2.1.2. Flipped Classroom

In this approach, students access instructional content outside the classroom, typically at home. This allows classroom time to be dedicated to more dynamic and interactive activities, such as discussions, problem-solving, group work, and hands-on projects (Clark & Besterfield-Sacre, 2017; Mori, 2017; Pardo & Ga, 2019). The role of the instructor shifts from being a transmitter of information to that of a facilitator and mentor, supporting students in the practical and collaborative application of knowledge (Alves et al., 2018; Felder & Silverman, 1988).

For classroom sessions to be effective, it is essential that students have previously acquired the theoretical knowledge related to that session. Therefore, it is common to include assessments at the beginning of class to encourage students' prior preparation (McLaughlin et al., 2014).

2.2. Evaluation of Active Learning Implementations

While active learning has been widely recognized as an effective approach to enhance student learning and is increasingly adopted in educational settings particularly for its pivotal role in transforming engineering education there remains a lack of structured methods to assess and qualify how educators apply these strategies. Maturity models offer a means to address this gap. They provide a framework for evaluating institutional practices, guiding decision-making, and fostering continuous improvement (Maier, Moultrie, & Clarkson, 2012). In addition, maturity models serve as tools to assess organizational components and help identify suitable actions that drive progress toward advanced maturity stages and improved outcomes (Kohlegger, Maier, & Thalmann, 2009).

This study employed the Engineering Education Active Learning Maturity Model - E^2ALM^2 (Arruda & Silva, 2021) as its primary framework for evaluating the implementation quality of active learning practices in engineering education. The model was selected due to its comprehensive and multidimensional structure, which facilitates a detailed diagnosis of factors that influence the adoption and effectiveness of active learning at the course level.

E^2ALM^2 is organized into five key dimensions, each representing a fundamental area of influence on active learning environments: (i) Content Quality, referring to course artifacts, assessment practices, and learning facilitation; (ii) Organizational Environment, which includes institutional culture, educational policies, feedback mechanisms, and instructional design processes; (iii) Organizational Infrastructure, encompassing the adequacy of physical spaces and technological support; (iv) Lecturer, addressing the educator's knowledge, skills, and attitudes toward active learning; and (v) Interactions, focusing on the quality of engagement between students and between students and instructors.

These five dimensions are operationalized through 14 Key Success Factors (KSFs), which are further broken down into 41 constructs and 90 measurable variables. Each variable includes a defined measurement approach – typically based on Likert-type scales (Likert, 1932) or binary responses and an associated degree of uncertainty, which reflects the reliability and potential bias of the information source. To ensure comprehensive data collection, three instruments were used: a lecturer questionnaire (LQ) and a student questionnaire (SQ). The combined use of multiple instruments allowed for triangulation of data and greater robustness in the analysis.

This model was not applied with the intention of producing a linear maturity score but rather as a diagnostic tool to identify patterns of strength and weakness across the five dimensions. All instruments and indicators were derived directly from the original model, ensuring methodological consistency with its conceptual foundation. The model's flexibility and scalability also allowed its application in different course contexts within the institution.

Regardless of the specific maturity level in active learning implementation, perceptions of students and lecturers can be quite misaligned due to natural differences in points of view. In this context, the aim of the Lecturer Self-Awareness Index – LSAI (Arruda & Silva, 2022) is to depict these possible discrepancies and provide feedback for the decision-making process regarding how lecturers and students perceive the benefits and characteristics of a given active learning implementation.

One significant advantage of the LSAI is its ability to bridge the gap between lecturer and student perceptions, fostering a more aligned and collaborative learning environment. By quantifying discrepancies in key areas such as course activities, student assessment, and classroom infrastructure, the index provides lecturers with actionable insights to refine their teaching strategies. This alignment is crucial for enhancing student engagement and satisfaction, as it ensures that instructional methods and resources meet learners' expectations and needs. Moreover, the LSAI's focus on self-awareness empowers educators to reflect critically on their practices, aligning their self-perception with external feedback to drive continuous improvement.

Another key benefit of the LSAI lies in its role as a diagnostic tool for institutional development. By identifying misalignments in specific Key Success Factors (KSFs), the index helps institutions prioritize targeted interventions, such as upgrading classroom technologies or improving communication protocols. This data-driven approach not only enhances the effectiveness of active learning implementations but also supports evidence-based decision-making at both the individual and organizational levels. Ultimately, the LSAI contributes to a culture of transparency and accountability, where lecturers and institutions can collaboratively address gaps and elevate the overall quality of engineering education.

Finally, the evaluation process can contribute to optimizing instructors' performance. By analyzing the results of their teaching practices, educators can identify strengths and areas for improvement, fostering a more dynamic and effective learning environment. In this way, the assessment process not only benefits students but also enhances the overall quality of education.

3. CASE DESCRIPTION AND ANALYSIS

The course Introduction to Engineering Project 1 (IEP 1) is offered in the third semester of the engineering program at IME. At this stage, students are still engaged in foundational coursework, as the selection of an engineering specialization in this institution takes place in the fifth semester. The course was designed to align with selected CDIO standards (CDIO, 2021) such as:

- Std 4 - Introduction to Engineering: refers to a foundational course, typically offered at the beginning of the engineering program, designed to introduce students to the essential principles, mindset, and practices of the engineering profession. It provides an early contextual framework that helps learners understand what it means to engineer, laying the groundwork for future technical and professional development.
- Std 8 – Active Learning: promotes instructional strategies centered on student engagement through participatory and hands-on learning experiences. By emphasizing experiential and collaborative methods, it encourages students to take an active role in constructing their knowledge and developing skills through direct involvement in meaningful tasks.
- Std 11 - Learning Assessment: addresses the systematic evaluation of student progress in both technical and non-technical domains. It encompasses the assessment of disciplinary knowledge as well as competencies related to teamwork, communication, and the design and implementation of products, processes, systems, and services, ensuring a comprehensive understanding of learning outcomes.

Together, Standards 4, 8, and 11 form a cohesive foundation for engineering education that is both integrative and student-centered. Introducing learners to the engineering mindset early on (Std 4) creates relevance and motivation, which is further reinforced through dynamic and participatory methods (Std 8) that foster deeper engagement. Effective assessment practices (Std 11) then close the loop, ensuring that learning objectives across cognitive, technical, and interpersonal domains are being met. The alignment of these three standards contributes to a more meaningful, practice-oriented, and outcome-driven educational experience.

In this context, the course establishes a set of learning objectives designed to integrate disciplinary knowledge with practical and interpersonal skills, preparing students for real-world engineering challenges from the outset of their academic journey.

The learning objectives are as follows:

- Acquire and apply the fundamental terminology and concepts of project management based on the most recent edition of the PMBOK – Project Management Body of Knowledge (Project Management Institute, 2017), with a focus on predictive (waterfall) methodologies commonly used in engineering contexts.
- Utilize project management principles and tools to plan, execute, and control real-life engineering projects, particularly those developed during the course's final team-based competition.
- Gain proficiency in the use of project management software tools to support scheduling, task allocation, and monitoring of project progress.
- Strengthening interpersonal competencies, especially those related to collaborative teamwork, technical writing, and structured documentation.
- Develop effective communication skills by applying strategies for preparing and delivering professional technical presentations.

To achieve these outcomes, the course employs a diverse mix of active learning strategies, including team projects, peer collaboration, problem-based learning activities, and structured use of professional tools. This aligns with CDIO Standard 8, which emphasizes experiential and student-centered learning. Moreover, the course structure mirrors the intent of Standard 4 by providing early and authentic exposure to engineering practice through project-based contexts. Finally, Standard 11 is addressed through a comprehensive approach to assessment, which evaluates not only students' mastery of technical content but also their development in communication, collaboration, and project execution—key competencies for future engineering professionals.

3.1. Application of Project-Based Learning and Flipped Classroom

In the 2024 edition of the course, student learning was organized around a collaborative, real-world engineering challenge that exemplified the principles of CDIO Standards 4 and 8 by combining early exposure to authentic engineering contexts with active, project-based learning strategies. All student teams (composed of six or seven members) were tasked with a common project theme: the renovation of restrooms and locker rooms located on the university campus.

Over the course of the semester, each group worked on a specific facility, either a restroom or a locker room, and was responsible for developing a comprehensive project plan. The required deliverables included:

- A 3D digital model of the proposed renovated space, developed using appropriate modeling tools.
- A technical report containing a detailed assessment of the existing conditions, a description of the planned interventions, an estimated budget, and a proposed project schedule.
- The complete set of documentation needed for the contracting of external service providers, simulating a real procurement process.

To develop these deliverables, students engaged in direct interaction with key stakeholders, including regular users of the assigned facility, civil engineering faculty members, and IME's building maintenance personnel. These interactions were critical for gathering user requirements, validating technical solutions, and addressing domain-specific questions. This process not only enriched the authenticity of the project but also supported the development of interpersonal and professional skills aligned with CDIO Standard 11, which emphasizes the assessment of learning in communication, teamwork, and design execution. By immersing students in a realistic and socially relevant engineering context, the course fostered engagement, responsibility, and deeper learning through meaningful collaboration.

Throughout the semester, students engaged with project management content, specifically the PMBOK framework. The course placed particular emphasis on the following knowledge areas: Scope Management, Schedule Management, and Cost Management. This emphasis reflects the prioritization of these areas, although students were also introduced to the remaining knowledge areas within the PMBOK guide.

At the beginning of the semester, students received a detailed schedule outlining all class sessions. In approximately half of the weekly meetings, a specific bibliography was assigned for prior study, and a brief assessment was conducted at the beginning of class, as recommended for the implementation of the flipped classroom approach (Roehl, Reddy, & Shannon, 2013).

As assessments were conducted using digital forms, such as Google Forms integrated with Google Classroom, this allowed the instructor to access real-time, individual responses. This enabled the instructor to identify which questions had the highest error rates, analyze response patterns, and tailor in-class discussions accordingly. The teacher could also call on specific students, already knowing their answers, which made the review of concepts more focused and effective.

3.2. Integration of Active Learning Techniques

The IEP I course is distinguished by its comprehensive integration of active learning methodologies. It is not exclusively structured as a flipped classroom nor solely as a project-based learning course; rather, it synthesizes elements from both approaches, incorporating aspects of each within its sessions.

The course comprises three primary types of sessions: those beginning with diagnostic assessments, project-focused sessions, and presentation sessions. In several instances, flipped classroom strategies are implemented through assigned preparatory readings and brief assessments administered at the outset of class. These assessments are followed by a debriefing segment during which the instructor emphasizes discussion on topics that elicited the greatest difficulties among students.

The sessions adhere to a well-defined sequence of activities, including:

- Administration of the initial assessment.
- Debriefing and analysis of the assessment results.
- Execution of project-related tasks corresponding to the same content domain addressed in the assessment.

This integrated approach, combining individual assessment and collaborative project work, affords students the opportunity to cultivate complementary skill sets. The individual assessment phase demands intellectual autonomy, sustained concentration, and effective time management, requiring students to demonstrate content mastery. This stage also fosters analytical reasoning and decision-making under time constraints critical competencies for independent problem-solving.

Conversely, collaborative group work facilitates the development of socio-emotional competencies such as effective communication, teamwork, and conflict resolution. Students engage in the negotiation of ideas, delegation of responsibilities, and collective knowledge construction, thereby enhancing leadership and empathy skills. The integration of these activities results in a holistic learning experience that balances individual and collaborative development, better preparing students for academic and professional challenges.

Moreover, as the group activities address the same subject matter as the individual assessments, students are afforded the opportunity to consolidate and deepen their understanding. Subsequent team discussions enable the review of concepts, clarification of uncertainties, and exploration of alternative perspectives. This iterative process supports active learning by encouraging students to apply individually acquired knowledge in a collaborative, practical context.

Consequently, this integrated pedagogical model not only diversifies the learning experience but also strengthens knowledge retention and the development of essential academic and professional competencies.

3.3. Diverse Assessment Methods

The IEP I course adopts a diversified assessment strategy that enables students to showcase their learning progress from various angles. The evaluation system is structured to capture both individual performance and collaborative contributions throughout the course. Each student's final grade is determined by the combination of the following components:

- The average score from individual start-of-class assessments, which are designed to verify content understanding and encourage consistent preparation.
- The evaluation of project deliverables, which is adjusted based on the quality of teamwork, ensures that both the outcome and the collaborative process are taken into account.
- The assessment of the final project presentation, which considers students' ability to communicate their ideas clearly and demonstrate the integration of knowledge and skills acquired during the course.

As described in Section 3.2, the weekly sessions include both individual assessments and group activities. The group activities are dedicated to the development of project deliverables, as outlined in Section 3.1. Throughout the semester, in selected sessions, students evaluate their teammates based on teamwork-related behaviors. These peer evaluations are used to guide the distribution of points within each group.

At the end of the term, the complete project documentation is assessed to verify the quality of the deliverables produced by each group. At this stage, the grade assigned is initially collective; however, it is not uniformly distributed among all group members. Instead, individual grades are weighted according to each member's teamwork evaluation. Students who receive higher peer evaluations are awarded a greater share of the group grade, while those with lower evaluations receive fewer points. Additionally, each group presents their final project in a public session, which is also graded collectively.

This multifaceted grading system encourages students to reflect on various ways to enhance their performance and ensures that all learning objectives outlined at the beginning of Section 3 are valued and assessed.

4. RESULTS

When evaluating the IEP I course using the E^2ALM^2 framework, a diagnostic is conducted across five dimensions, as defined by the model. Table 1 and Table 2 Show dimension scores and KSF scores in each dimension, respectively. All scores are obtained using a Likert scale (Likert, 1932) from 1 to 5 points.

Table 1. Dimension scores of IEP 1 using E^2ALM^2.

Dimension	Score Dim
Quality of content	3.376
Organizational environment	3.289
Organizational infrastructure	4.354
Lecturer	4.402
Interactions	3.811

Table 2. KSF scores of IEP 1.

KSF	Dimension	Value KSF
Course activities	Quality of content	3.2461
Student assessment	Quality of content	3.7099
Learning facilitation	Quality of content	3.1556
Culture	Organizational environment	3.7000
Policy	Organizational environment	3.4000
Student feedback	Organizational environment	3.3514
Instructional design	Organizational environment	3.1389
Classrooms	Organizational infrastructure	3.8074
Technology	Organizational infrastructure	4.5926
Knowledge	Lecturer	5.0000
Skills	Lecturer	4.8333
Attitude	Lecturer	3.6667
Between students	Interactions	3.5241
With lecturers	Interactions	4.1556

Within the Quality of Content dimension, the key success factor (KSF) with the highest score was Student Assessment, which obtained a rating of 3.7099, surpassing the overall average of the dimension (3.376). This result highlights the effectiveness of the course's assessment strategy, which incorporates multiple types of evaluation and reflects a commitment to transparency and fairness. The KSF encompasses elements such as the clarity of assessment methods, the explicit communication of performance criteria, and the accessibility of evaluation guidelines for students. These aspects collectively contribute to a learning environment where students feel well-informed and supported in demonstrating their academic progress (Chen, Bastedo, & Howard, 2018).

The inclusion of varied assessment formats and hands-on activities not only enhances the perceived fairness and clarity of the evaluation process but also promotes deeper learning and student engagement (Barkley, 2010; Borrego et al., 2019). By integrating individual and group assignments, project-based tasks, presentations, and real-world problem-solving exercises, the course allows students to apply theoretical knowledge in practical contexts and to develop a broader range of skills (Guimarães & Lima, 2021). This diversity in assessment supports different learning styles and encourages the development of competencies such as critical thinking, collaboration, and effective communication, key attributes for professional success in engineering. Moreover, practical activities provide meaningful opportunities for students to receive feedback, reflect on their performance, and take ownership of their learning journey.

In the Interactions dimension, the best-rated KSF was With Lecturers (4.1556). This result reflects the strong presence and active engagement of faculty members during class sessions. The course design emphasizes guided and supervised activities, which foster meaningful dialogue between students and instructors. These interactions support not only content mastery but also the development of trust and rapport, enhancing the overall learning experience (Kerrigan & Kwaik, 2024).

In addition to fostering strong connections between students and faculty, the course places significant emphasis on different kinds of interactions, which are essential for cultivating interpersonal and project management skills. Group-based activities and collaborative assignments encourage students to communicate effectively, negotiate roles, resolve conflicts, and manage time and resources, experiences that closely mirror real-world engineering practice. Regular interaction with instructors further enriches this dynamic by providing mentorship, guidance, and structured feedback, helping students to navigate team challenges and reflect on their contributions. These collaborative environments not only enhance academic outcomes but also prepare students to lead and thrive in multidisciplinary, team-oriented professional settings.

The Lecturer dimension stood out as the highest-rated among all five dimensions. Within this category, the KSF Knowledge received a perfect score of 5.000, followed closely by Skills (4.8333) and Attitude (3.6667). These results demonstrate the instructional team's high level of expertise and didactic ability. The faculty's ongoing engagement with active learning methodologies, along with their openness to experimentation and continuous improvement, is clearly recognized and valued by the students.

The Organizational Infrastructure dimension also received a notably high average score (4.354), reflecting favorable perceptions of the physical and technological conditions of the learning environment. In particular, the KSF Technology was rated 4.5926, indicating excellent evaluations related to the availability, reliability, and usability of digital tools and technological resources. This high level of satisfaction suggests that students benefit from a well-equipped campus that supports both in-person and technology-enhanced learning.

In the Organizational Environment dimension, the KSF Culture achieved the highest score, with a value of 3.7000, indicating its prominent role in the evaluated context. This result suggests that the institution fosters a supportive and well-structured academic culture, characterized by clear expectations and a shared commitment to educational quality among students, faculty, and administration.

Table 3 presents the results of the Learning Self-Awareness Index (LSAI) for the IEP 1 course, highlighting the level of agreement between student and instructor perceptions across key factors. Among these, the Technology factor exhibited the highest alignment, with an index score of 4.3704, indicating strong consensus regarding its role in supporting the learning environment. This result underscores the effective integration of technological tools as an enabling component of the course experience.

Table 3. LSAI results of IEP 1.

KSF	Self-awareness index
Course activities	4.2917
Student assessment	3.8000
Learning facilitation	4.1778
Classrooms	3.9222
Technology	4.3704
With lecturers	4.1556

Another notable finding was the KSF Course Activities, which achieved an index of 4.2917, reflecting a high degree of shared understanding between students and instructors. This factor encompasses several critical pedagogical constructs, including the use of real-world problems, application of active experimentation, and diversity of instructional resources. Additionally, it evaluates the alignment with learning outcomes, appropriate level of intellectual challenge, clarity in activity design, optimal task length, and clear communication of activity objectives. These outcomes suggest that course activities were thoughtfully structured, fostering mutual recognition of their educational value and effectiveness.

Further reinforcing the positive dynamics of the course, the Learning Facilitation (4.1778) and Interaction with Lecturers (4.1556) factors also demonstrated strong agreement, pointing to a collaborative and supportive academic environment. The KSF Classroom (3.9222) and Student Assessment (3.8000) factors further contribute to this overall picture, confirming a generally consistent and constructive perception of course-related elements.

Collectively, these findings reflect a well-structured course in which pedagogical, technological, and interpersonal components work synergistically to create a cohesive and impactful learning experience, as recognized by both students and instructors.

5. CONCLUSION

The experience described in this study, related to the Introduction to Engineering Project 1 course (offered at the Military Institute of Engineering – Brazil), demonstrates how the integration of active learning methods such as flipped classroom and project-based learning (PBL) can contribute to the evolution of engineering education. By connecting theoretical content to real challenges involving campus infrastructure, students were encouraged to apply their knowledge in a practical and collaborative way, fostering more meaningful learning. The use of real-time assessments and peer feedback also contributed to the development of interpersonal and management skills, which are essential in engineering training.

The IEP 1 course was evaluated using the Engineering Education Active Learning Maturity Model (E^2ALM^2), and the Lecturer Self-Awareness Index (LSAI) was also calculated. Preliminary results indicate significant improvements in academic performance, student motivation, and perceived relevance of the course for future professional practice. In addition to enhancing the understanding of technical concepts, the adopted approach strengthened key competencies such as communication, teamwork, and problem-solving. These skills are increasingly valued in the labor market and highlight the potential of student-centered methodologies to drive the modernization of higher education in engineering.

Finally, this initiative offers a replicable model for institutions and educators seeking to innovate in their teaching practices. The lessons learned throughout the implementation of the course – as well as the challenges encountered – serve as a foundation for future adaptations and the dissemination of more effective teaching strategies. By bringing academic content closer to real-world demands, this approach contributes not only to the students' technical education but also to their preparation as well-rounded professionals, aware of their role in society.

Future studies could further explore the impact of course design on student engagement and academic performance by adopting two complementary approaches. First, a comparative analysis between courses that incorporate real-world projects and those that utilize simulated or hypothetical scenarios could provide valuable insights into how the authenticity of project contexts influences student motivation and involvement. Second, investigating the correlation between students' reported levels of engagement and their academic performance metrics may help to identify patterns that can inform more effective pedagogical strategies. Together, these lines of inquiry could contribute to a deeper understanding of the mechanisms through which experiential learning environments support both cognitive and affective dimensions of student development in engineering education.

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