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Effectiveness of Challenge-Based Learning in Undergraduate Engineering Programs from Competencies and Gender Perspectives

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Abstract: Active learning strategies are widely studied, but perspective on their effectiveness in complete undergraduate studies or about their contribution to closing the gender gap are still required. Challenge-based learning has been around for more than a decade. However, results have been collected in limited time and application environments, for example, one semester or one activity in a course. In this work, we present a quantitative study that was applied to results of the National Center for the Evaluation of Higher Education's Engineering Bachelor's Degree Standardized General Examination of 4226 students comparing those who received a traditional educational model and those who received a challenge-based learning educational model. A statistical analysis of communication and disciplinary competencies found that the traditional educational model induces a greater marginal significant result in the test. Additionally, we found that female students perform better in communication competencies while male students perform better in disciplinary competencies. Our results confirm that challenge-based learning is as effective as a traditional educational model when applied during complete undergraduate studies while developing competencies like critical thinking, long-term retention, leadership, multidisciplinary teamwork, and decision-making. Challenge based learning is a prolific learning strategy for evolving into a new way of teaching in undergraduate programs.

Keywords: educational innovation; challenge-based learning; higher education; standardized tests; engineering; gender perspective; women in STEM

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1. Introduction

Engineering education is at a pivotal juncture, confronting the evolving demands of a dynamic workforce. As noted by Froyd, Wankat, and Smith [1], significant shifts in engineering teaching over the past century have spurred a rethinking of pedagogical approaches to align with the needs of the modern world. These shifts reflect a move towards more innovative student-centered approaches.

In the current global landscape, we face multifaceted challenges. These challenges are complex, diverse, constantly changing, and often without clear boundaries [2,3]. Some of these challenges are described as part of today's VUCA (volatile, uncertain, complex, and ambiguous) world [4]. In reaction, numerous colleges are adjusting their instructive techniques and approaches to better adjust to the requests of the VUCA world. They are moving from conventional lecture-based educating strategies to more energetic, student-centered learning models emphasizing essential consideration, versatility, and real-world application of information. This move includes integrating experiential learning openings into educational programs, such as internships, agreeable instruction, and project-based learning. Moreover, education is leveraging computerized advances to form more intelligent and adaptable learning situations, empowering further and crossover learning modalities that cater to differing understudy needs. By doing so, colleges are not improving the pertinence and viability of their instructive offerings but planning for students to explore and flourish in a progressively complex and questionable worldwide scene.

In the evolving landscape of higher education, institutions are progressively adopting innovative educational techniques to improve their educational program and consider components. Among these methodologies, significant emphasis has been placed on experiential learning models that prioritize real-world problem-solving and foster independence or self-management. This move towards a more energetic and intuitively instructive system is exemplified through the appropriation of challenge-based techniques [5,6], instruction [7], and education, all driven by the principle of engaging students in autonomous work scenarios [8].

The essence of these approaches lies in their focus on empowering students to identify and tackle real-world problems [9,10], fostering a learning environment that values the process of problem identification over direct problem-solving [11,12]. This change in basic assumptions encourages the development of solutions or tangible products to apply theoretical knowledge in practical contexts [13].

Nichols and Cator [14] note that these educational models facilitate a deeper connection between students and their study subjects, promoting collaboration and a comprehensive understanding of the material. By positioning students as dynamic problem-solvers, these strategies enhance academic engagement and prepare students for the complexities of the modern workforce. The emphasis on challenge-based learning paradigms reflects a broader educational goal: to equip students with the skills and mindset necessary for innovation and adaptability in an ever-changing world. Through such educational practices, higher education institutions are not just imparting knowledge but shaping the problem-solvers and innovators of tomorrow.

Challenge-based learning (CBL) represents a progressive educational approach, initially highlighted by a pioneering study conducted by Apple in 2008. This approach was designed to rejuvenate the learning environment, making it more relevant to students. Apple's foundational study established the basis for CBL, emphasizing its potential to inspire students to take meaningful action, effect positive change (challenge learning), and make a difference [15]. Building on this foundation, Nichols and Cator further explored the concept, emphasizing its significance in engaging students in the 21st century. Their research highlights CBL's role in creating an educational environment where students are not just passive recipients of information but actively participate in a dynamic learning process connected to real-world issues [14].

The flexibility and adequacy of CBL were illustrated in advance within the field of instruction by Malmqvist, Kohn Rådberg, and Lundqvist [16]. Their case, set in a multidisciplinary environment inside designing instruction, exhibits how CBL can be successfully coordinated into higher instruction educational programs, advancing collaborative, multidisciplinary learning with a focus on finding maintainable arrangements for worldwide challenges. This adjustment highlights the method's adaptability and capacity to plan students for the complexities of tending to real-world issues. Through the focal point of CBL, instruction rises above conventional scholarly learning, wandering into the viable problem-solving and development domain. This approach is not as if it were preparing students with fundamental scholastic information but also creates essential aptitudes such as basic considering, collaboration, and imagination. By engaging with real-world challenges, students learn to explore the complexities of our worldwide society, making educated choices and taking activities that contribute to feasible and positive results.

CBL reclassifies the instructive scene, advertising a more intuitive and impactful learning involvement. It energizes students to become proactive issue solvers, prepared to handle the challenges of the cutting-edge world with certainty and competence. Through this innovative approach, CBL fosters a generation of educated learners who are deeply engaged in making a difference in the world around them.

A developmental perspective is required for universities to effectively use CBL in open, student-centered educational programs [17]; this perspective seeks to structure learning through a series of challenges, implying a diversity in the characteristics of CBL in study components. It is crucial to develop a conceptualization of CBL that allows for debate and investigation of this diversity in implementations and to understand the mechanisms that support the efficacy and success of CBL implementations.

Despite its educational potential, evidence on CBL is limited and primarily focuses on benefits for students. Ref. [17] states that the benefits that have been studied are the development of industrial networks, technical skills, application of skills in real-world environments, teamwork, problem-solving, deep understanding of knowledge, and innovation capacity, among others. Additionally, the implementation of CBL varies widely across contexts and educators. For example, Ref. [18] describes four experiences around the world that differ not only in the process but also in the local (e.g., learning objectives inside the course) and global objectives (e.g., institutional visions). However, qualitative and quantitative studies have been carried out, but they are applied over short periods of time (a course, an activity, or a semester) or using small samples. For example, Ref. [19] reports a positive and significant effect of CBL over entrepreneurial competencies when applied in a course of 14 weeks applying a pretest–posttest process. In addition, Ref. [20] compared CBL (n = 31) to problem-based learning (n = 29) and traditional lecturing (n = 31). Authors found a statistically significant difference in improving students' scientific literacy, with problem-based learning being the best strategy. Furthermore, Ref. [21] found, by interviewing 92 students, that CBL is compromised in online environments because these environments do not promote interaction between students and between students and faculty, giving less spaces for informal learning.

Evaluating the effectiveness of these innovative methods, especially in engineering education, is crucial for understanding their impact on preparing students for real-world engineering challenges. Graaff and Kolmos [22] advocate for empirical studies comparing traditional and modern teaching methods in engineering contexts. This approach is particularly relevant in the context of CBL, a methodology that focuses on solving real and complex problems, fostering active and applied learning.

CBL, as part of educational innovation in engineering, promotes not only the development of technical skills but also cross-cutting competencies such as critical thinking, creativity, and collaboration. These skills are essential for addressing contemporary challenges in engineering, which often require interdisciplinary and collaborative solutions. Additionally, CBL can be a powerful tool to increase relevance and interest in engineering studies, crucial for attracting a more diverse student population [23].

In this context, the gender perspective becomes a fundamental aspect. Traditionally, engineering fields have had low female representation. Integrating a gender perspective into CBL and educational innovation in general can help challenge gender stereotypes and promote greater inclusion and diversity in these fields [24]. This involves not only increasing women's participation in engineering but also ensuring that curricula and teaching methods address and are sensitive to the different experiences and needs of all genders [25].

Therefore, empirical studies comparing teaching methods should consider how different approaches impact diversity and inclusion. This includes examining whether innovative methods like CBL are particularly effective in supporting students of different genders and backgrounds, and how these methods can be adapted or improved to foster greater equity in engineering education [26].

In summary, evaluating the effectiveness of innovative methods in engineering education, especially in the context of CBL, must go beyond comparing technical competencies. It should include consideration of how these methods promote educational innovation, inclusion, and gender equity, fundamental aspects for preparing engineers for the challenges of the 21st century [22].

With this in mind, this work presents a study of the results, in a standardized exam at the end of their studies, of students receiving a CBL-based educational model versus students who received a traditional educational model. Results are presented in subsequent sections.

In the following sections, we present the development process of CBL, the hypothesis of this work, and the research framework to validate the effectiveness of CBL education.

2. Challenge-Based Learning Context

As university professors dedicated to the field of education, we have been witnesses and active participants in its remarkable evolution over the years. Our collective reflection on this journey, which began in the early 20th century, reveals a dynamic shift from a technical focus to a more comprehensive and holistic education.

In the initial stages, as highlighted by scholars like Jamieson and Lohmann [27], engineering education was centered on technical and practical training. The curriculum was designed to impart specific knowledge and technical competencies, preparing students for the practical aspects of engineering.

However, as the century progressed, it became evident to us that engineering education needed to encompass a broader set of skills. This understanding led to the integration of critical thinking, problem-solving, and collaborative work in multidisciplinary teams into the curriculum. This research, along with that of Crawley et al. [28], for example, has underscored the importance of these skills in the changing landscape of engineering education.

The 1990s marked a crucial era with emphasis on developing soft skills, such as communication and teamwork, in engineering programs [29]. This shift recognized the need for engineers to be competent in technical skills and interpersonal and managerial capabilities.

Entering the 21st century, we observed a trend towards more integrative and adaptable educational methodologies. Advocates, like Felder and Brent [30], have been instrumental in promoting teaching methods that balance theoretical knowledge with practical application, encouraging active student participation in their learning process. This approach resonates with the needs of modern engineering fields, where adaptability and creative problem-solving are essential.

In recent years, the incorporation of project-oriented learning (POL) and problem-based learning (PBL) into engineering curricula has marked another significant advancement. As highlighted in the work of Prince [31], these methodologies offer students experiential learning opportunities that reflect real-world challenges, thereby enhancing their readiness for professional practice.

The trajectory of engineering education, as we have studied it, reflects a gradual but profound shift from a narrow technical focus to a more inclusive approach that values both technical prowess and soft skills. This evolution, driven by the changing demands of the engineering profession, has been fundamental in shaping engineers well prepared for the complexities of the modern world.

In the last decade, we have observed an increasing emphasis on integrating digital technologies and online learning approaches. According to Nguyen et al. [32], the adoption of digital tools and virtual learning platforms has transformed how engineering students interact with content and develop practical skills. This shift towards a more flexible and accessible learning environment reflects the need to adapt to an increasingly technological workforce.

Midway through the 20th century, we witnessed a transformative phase in engineering education, propelled by rapid technological advancements and evolving job market requirements. Higher education institutions recognized the imperative to modify teaching strategies to prepare students for a world that was becoming increasingly interconnected and technologically sophisticated.

As Duderstadt [33] aptly argued, this adaptation was crucial for maintaining the relevance of engineering education in a fast-changing global context. Embracing innovative pedagogical methods became a central focus for us, educators, and our institutions, aiming to nurture the next generation of engineers.

POL, as described by Thomas [34], emerged as a key approach during this period. Faculty has applied POL to enable students to engage in projects that simulate real-life engineering scenarios, thereby bridging the gap between theory and practice. This method has proven effective in enhancing student engagement and fostering essential skills like teamwork and problem-solving.

Simultaneously, PBL gained traction as an effective educational approach. Following the insights of Mills and Treagust [35], PBL was incorporated into courses to focus on tackling complex, real-world problems, promoting a more active and applied learning experience. This method has been instrumental in developing students' analytical and critical thinking skills and collaborative abilities.

The principles of PBL, initially pioneered in medical education by Barrows [36], have been successfully adapted to the engineering context. In pedagogical practice, PBL's emphasis on active student involvement and real-world problem-solving significantly enhances the learning experience.

These innovative pedagogical approaches have received support from various prominent organizations in the United States, which has underscored the importance of such innovations in engineering education [37].

The introduction of innovative approaches like POL and PBL in engineering education, as we have observed and participated in, represents a response to the shifting technological and professional landscape. These methods have been key in improving students' practical skills and problem-solving capabilities, better equipping them for the challenges of the contemporary world.

More recently, studies like those of Smith and Kumar [38] have explored the effectiveness of project-oriented and problem-based learning in the current context, especially considering the challenges posed by the COVID-19 pandemic. These studies indicate that, despite difficulties, these methods remain effective in enhancing practical and problem-solving skills, albeit requiring adaptations for remote or hybrid learning environments.

Another active learning strategy that has appeared in the recent years is CBL. This approach is designed to engage students in understanding real-world issues through collaborative learning experiences. This approach is grounded on the conviction that students learn best when they are effectively included in tackling important challenges that have unmistakable impacts on their communities and the world at large [11,14,15].

CBL has the following key components:

- Real-world challenges: Real-world challenges are at the heart of CBL. These challenges are complex, not effectively illuminated, and require students to apply multidisciplinary information and aptitudes. The realness of these challenges persuades students by giving a clear reason for their learning.
- Collaborative learning: CBL emphasizes collaboration among students. By working in groups, learners bring differing points of view and mastery to the problem-solving handle. This collaborative environment fosters communication, arrangement, and administration aptitudes, basic for victory within the 21st-century workplace.
- Investigate and request: Students engage in research and inquiry to understand the complexities of the challenge they are addressing. This process involves critical thinking, data collection, and analysis, enabling students to make informed decisions about their proposed solutions.
- Arrangement advancement: CBL requires students to plan, create, and actualize solutions to the challenges they have distinguished. This inventive handle empowers development and permits students to apply hypothetical information in down-to-earth contexts. This intelligent hone makes a difference learner to consolidate their learning and understand the broader implications of their work.

- Technology integration: CBL often integrates technology as a tool for research, collaboration, and solution development. Technology enhances the learning experience by providing access to resources, enabling communication, and facilitating the creation of innovative solutions.

CBL has the following benefits:

- Improved engagement: By including students in real-world challenges, CBL increments engagement and inspiration. Students are more likely to contribute exertion in their learning when they see the significance and effect of their work.
- Advancing 21st-century skills: CBL cultivates core skills of thoughtfulness, resourcefulness, collaboration, and communication. These competencies are basic to victory in today's rapidly changing world.
- Deeper learning: CBL energizes deep learning as students investigate complex questions, grasp information, and apply their information in meaningful ways. This depth of learning progresses much better, stronger, and with greater understanding and maintenance of knowledge.
- Strengthening: CBL enables students by giving them a voice in their learning handle and the opportunity to form a contrast. This strengthening can lead to expanded self-efficacy and a sense of obligation towards societal issues.
- In CBL, the professor develops different roles such as facilitator of the learning process during the challenge, feedback, evaluator, and of course designer together with the training partner. Collaboration with other professors, staff of the educational partner organization, and students is high, from the stages of design to monitoring, guidance, and challenge's closing.

CBL could be an impactful instructive approach that prepares students for the complexities of the advanced world. By centering on real-world challenges, cultivating collaboration, and empowering inventive problem-solving, CBL creates fundamental aptitudes and mindsets for students to flourish in their individual, proficient, and civic lives.

In terms of evaluation, efforts have been made to evaluate the effectiveness of CBL strategies from different perspectives. For example, Refs. [39,40] detected that CBL helps the development of soft skills like leadership, collaboration, creativity, problem-solving, or communication, among others. Additionally, other works have found that CBL improves grades contrasted to traditional learning or reduces its dispersion around the mean like explained in [41,42]. In the case of the Tec21 educational model, authors in [43–45] report implementations in engineering, sciences, humanities, and education finding advantages in the integration of flexible learning paths, and support for disciplinary and transversal competency development. Additionally, authors in [17,40,46] state that the CBL strategy used by Tecnologico de Monterrey results in better student grades when compared to those obtained by students enrolled in a course with a traditional teaching–learning strategy. Even if these works identify the success of the strategy, all of them have been applied to activities or to specific topics, or to complete courses at most. The effectiveness of CBL over an entire program (i.e., when applied to all courses in the program) has not yet been explored.

In this direction, standardized end of program evaluations can be useful to measure the success of a learning strategy. The CENEVAL (National Center for the Evaluation of Higher Education) is a Mexican non-profit civil organization that seeks "to contribute to the integral improvement of education in the country, with the firm objective of raising educational levels through high quality technical evaluations" [47,48]. The CENEVAL designs and applies standardized evaluation instruments to assess skills of students looking for admission to higher education institutions or to certify the fulfillment of learning outcomes. Also, the association communicates analysis over these results to higher education institutions, so they implement continuous improvement processes.

To maintain a standardized assessment process, the CENEVAL's governing bodies (general assembly, board of directors, and general management) are constituted of representatives of educational institutions (public and private) and members of government institutions related to higher education. Also, technical councils are responsible for creating and validating assessment instruments by establishing standards, policies, and criteria for this process. They use the study plans of programs in diverse institutions around Mexico as an input to build a standard assessment tool called EGEL-PLUS (Engineering Bachelor´s Degree Standardized General Examination) [49]. This instrument is applied nationwide to undergraduate students of public and private institutions who want to evaluate the degree of knowledge and skills achieved by their students at the end of their studies. This exam's results can be used to explore the advantages and benefits of CBL beyond specific elements such as specific activities or courses.

On the other hand, the integration of gender perspectives and the promotion of diversity in engineering education has become increasingly vital. This shift addresses the historical underrepresentation of women and other marginalized groups in engineering and aims to foster a more inclusive and equitable learning environment.

Reflecting on the work of Bix [50], we are acutely aware of the historical challenges faced by women in engineering. Despite progress in increasing female participation, significant barriers to full inclusion remain. Teaching and research have strived to identify and dismantle these barriers.

The work of Beddoes and Borrego [51] has been influential in the approach to integrating gender perspectives into engineering pedagogy. Their argument for pedagogical methods that cater to diverse gender experiences has guided efforts to enhance the inclusivity and quality of engineering education.

Similarly, Rosser [52] has highlighted the importance of incorporating gender diversity in content and teaching methods. Courses have endeavored to include diverse perspectives and create an environment where all students, particularly those from traditionally underrepresented groups, can thrive.

The National Science Foundation (NSF) has played a significant role in supporting initiatives to promote diversity in engineering education. Inspired by their efforts, scholarship and mentoring programs were developed aimed at increasing the participation of women and minorities in engineering [53].

Furthermore, research by Foor, Walden, and Trytten [54] has shed light on how engineering education experiences can vary greatly based on gender and ethnic background. This insight has been pivotal in shaping inclusive teaching practices, enhancing the educational experience for all students.

Our journey as educators in engineering has been marked by a commitment to integrating gender perspectives and promoting diversity. These efforts are not only aimed at increasing representation but also at enriching the educational experience for all students, thereby contributing to a more inclusive and equitable field of engineering.

Traditional Learning and CBL Models at Tecnologico de Monterrey

The educational approach of Tecnologico de Monterrey, prior to the Tec21 model (traditional learning model), revolved around the student and was geared towards the development of professionals with leadership and innovation skills capable of applying scientific knowledge to practical problem-solving. This approach fostered informed decision-making and the execution of rational actions.

Through this educational model, the institution aimed to nurture a culture of excellence and diligence while also fostering ethical values. To achieve these objectives, active learning methods (like PBL or POL) were employed, allowing for the integration of professional practices, decision-making, problem-solving, and product development. Leveraging in-class methodologies, the institution capitalized on emerging information and communication technologies to support the learning process and facilitate a broader comprehension of reality.

This previous educational model sought to strike a balance between theory and practice, promoting rational habits and behaviors, but still based on traditional lecturing.

Within this framework, curriculum content acquired significance as it played a pivotal role in decision-making, remaining consistently updated to maintain its relevance.

This model established a 48 h weekly workload for full-time students, promoting optimal academic performance, with adjustments for those who worked and studied. This model proposed an average of six courses per semester with 3 h of direct professor–student contact per week per course. This model included course units combining classroom hours and learning activities. It emphasized common core subjects in specific areas, laying the scientific groundwork and leading to specializations in administration, health sciences, social sciences, humanities, engineering, and information technologies. It featured professional specialty areas where students gained field-specific knowledge and skills and a humanistic and civic education that encouraged critical thinking and ethical responsibility. Courses in ethical, sociopolitical perspective, humanistic, and scientific–technological areas promoted an integral approach [55].

Additionally, complementary educational components were incorporated to enrich the educational experience and prepare students to contribute to an equitable and sustainable society. The institution integrated programs and courses focused on social commitment, professional practices, and international experiences. These programs also emphasized community engagement, service activities, and professional development modalities that complemented education with enriching experiences. In addition, the institution included general education in areas such as Spanish, foreign languages, and entrepreneurship development, which prepared students for a diverse global and professional environment. The programs were designed to be completed in nine semesters, including intensive summer courses.

On the other hand, Tecnologico de Monterrey, a leading institution of higher education in Latin America, has been at the forefront of educational innovation for decades. In response to the challenges facing today's society and the need to train highly trained professionals adapted to a globalized environment, Tecnologico de Monterrey introduced the Tec21 educational model (CBL-based learning model) [56].

The Tec21 educational model is a CBL-based educational model [56] and was fully deployed in the 2019 fall semester. It represents a challenging and avant-garde educational proposal that seeks to transform the way students learn and develop in a constantly changing world. Conceived to prepare the leaders of the future, this innovative educational approach integrates elements such as comprehensive training, curricular flexibility, technology, and links with society to provide a quality and relevant academic experience in the 21st century.

In this educational model, competencies are defined as the conscious integration of knowledge, skills, attitudes, and values that enables successfully dealing with both structured and uncertain situations. Competencies integrate both the knowledge and procedures of the discipline as well as the attitudes and values that enable the training of participatory and committed professionals in society.

Fundamentals: The Tec21 educational model is based on the following:

1. Integral training: It promotes academic, emotional, social, and ethical development of students, scaffolding their growth as human beings committed to their community and the world, thus offering a memorable university experience.
2. Focus on learning: Active, meaningful, and collaborative learning is promoted by active participation of students in their own training process.
3. Curricular flexibility: A modular system is offered that allows for students to customize their academic trajectory, selecting subjects according to their interests and professional goals.
4. Technology as facilitator: Technology is integrated transversally in all stages of the educational process, fostering innovation and the acquisition of digital skills.
5. Link with the environment: It seeks to connect theoretical knowledge with reality, building a link with the productive sector and current social problems, to drive the sustainable development of the country.

The Tec21 educational model is characterized by several distinctive aspects:

1. Formative assessment: The evaluative approach focuses on continuous feedback and the development of competencies, rather than just grading, to trigger constant learning and continuous improvement.
2. Learning ecosystem: An environment of collaboration and teamwork is promoted, where faculty are facilitators of learning and students take an active role in their training.
3. Leadership, entrepreneurship, and innovation: Leadership, entrepreneurship, and creativity are stimulated in students, preparing them to face the challenges of the labor market and contribute to economic development.
4. Internationalization: Student mobility and participation in academic exchange programs are encouraged, allowing for students to enrich their educational experience in international contexts.

The Tec21 educational model represents a significant evolution in contemporary pedagogy. As one of its components, CBL encourages active student participation in real and relevant problems, thereby fostering experiential and meaningful learning.

The heart of the model is the challenge: an immersive experience that urges students to apply knowledge, skills, attitudes, and values both individually and collaboratively. Unlike conventional educational models, which focus on the accumulation of knowledge, Tec21 emphasizes solving specific challenges, thereby facilitating the development of disciplinary and transversal competencies.

This approach is based on the principle that learning is more effective when students actively engage in open learning experiences, rather than merely being spectators. Tec21's CBL offers unique opportunities to apply what is learned in real contexts, tackling problems, experimenting with solutions, and collaborating with others.

To support CBL, the Tec21 model implements learning modules tailored to the specific needs of each challenge. These modules provide essential theoretical and practical knowledge, marking a gradual shift from the traditional curriculum.

The benefits of this model are extensive and significant. They include the contextualization of learning, surpassing conventional academic standards, promoting autonomy in learning, increasing resilience and tolerance for uncertainty, and inducing motivation through connection with the real environment. Furthermore, it encourages close collaboration between students and faculty, and promotes an innovative and multidisciplinary approach.

The Tec21 educational model ensures quality education in five areas: exposure to real-world problems, reflective and integrative learning, experiencing higher-order learning, developing resilience in the face of uncertainty and failure, and stimulating both quantitative and qualitative reasoning. These elements consolidate an academic formation that prepares students not only for their professional field but also for a life of continuous learning and adaptation in an ever-changing world.

Since its implementation, the Tec21 educational model has shown encouraging results in terms of student satisfaction, retention, and links with society. Tecnologico de Monterrey graduates are projected to demonstrate an important level of adaptability, leadership, and social responsibility, thus standing out in their respective professional areas, being successful in their context, and acting as agents of transformation in society.

Looking to the future, Tecnologico de Monterrey continues to evolve the Tec21 educational model, taking advantage of technological advances and the best international educational practices. With a constant commitment to quality and innovation, the institution will continue to be a benchmark in the training of leaders who will drive the development and transformation of the country and the region.

The Tec21 educational model of Tecnologico de Monterrey is a bold commitment to educational excellence and the comprehensive training of competent professionals committed to society. With its focus on active learning, technology as a facilitator, and the link with the environment, the model is consolidated as a paradigm of higher education that adapts to the challenges of the 21st century. Through constant improvement and adaptation to the needs of the environment, Tecnologico de Monterrey will continue to leave a significant mark in the formation of the leaders of the future.

Table 1 shows a summary of the characteristics of these models.

Table 1. Summary table of the characteristics of the traditional learning and the CBL-based learning models implemented at Tecnologico de Monterrey.

Characteristic	Traditional Model	CBL Model
Number of programs in the institution	56	44
Pathways	8 (business, health, social sciences and government, communication and digital production, architecture art and design, engineering, bioengineering and chemical processes, information technology and electronics)	6 (business, health, social sciences, creative studies, built environment, engineering)
Instructional model	Mainly based on lectures and active learning strategies like POL or PBL	Challenge-based learning
Duration of courses	17.5 weeks per semester. 3 h a week per course.	5, 10, and 15 weeks per semester. 4, 12, 16, or 24 h a week per course.
Duration of programs	On average, 9 semesters	On average, 8 semesters
Role of the teacher	Teaching role (prepares, teaches, and evaluates in their courses)	Expected to develop different roles: lecturer, challenge coordinator, and evaluator.
Teaching team	Usually, only one professor by group	In most of the courses, a minimum of two professors works together
Evaluation	Oriented to course's learning objectives	Competency evaluation model

3. Hypothesis

The comparison of CBL and a traditional teaching–learning process applied to engineering undergraduate programs, from a gender perspective, is the main objective of this research. According to this, the following hypothesis served as a guide for the research approach presented in this work:

H: The effectiveness of CBL is the same as a traditional teaching–learning process when applied to courses of engineering undergraduate programs.

4. Methodology

This study applies a between-subjects analysis in an experimental research design to results of 4226 students, of 43 different engineering programs, who graduated in the spring semester of 2023 and applied the exam specific to each program in April 2023. Students were divided into two groups: 1761 students received a traditional teaching–learning process during their studies while 2965 students received a CBL model during their studies. Exposure to this learning model was carried out during all their studies in all the semesters and courses.

The CENEVAL's EGEL-PLUS (Engineering Bachelor's Degree Standardized General Examination) [49] standardized national exam was used to measure and compare the effectiveness of both learning strategies. EGEL-PLUS is a specialized exam that evaluates the proficiency level of students who are candidates for graduation (i.e., students who are in the last semester of their program) in those skills that are considered essential at the end of their studies. So, this evaluation is related to the achievement of programs' learning outcomes.

EGEL-PLUS has the objective of determining students' performance and mastery level at the end of the program and is divided into two sections. The first section is language and communication, which is transversal and common to all programs and evaluates reading comprehension and indirect writing. It has 60 questions. The second section evaluates disciplinary skills, and it is specific to each program. It has between 140 and 160 questions.

For each section, a performance level is assigned based on the percentage of correct answers and is declared under a scale that ranges from 700 to 1300 points. Three performance levels are defined: (1) not yet satisfactory (700–999 points), (2) satisfactory (1000–1149 points), and (3) outstanding (1150–1300 points). These two last levels represent a passing grade for the exam.

Having taken the exam is a requirement to obtain a degree for each student enrolled in a program that has an EGEL-PLUS exam available at the CENEVAL. This applies to students under both teaching strategies. In this case, the results of students in the following EGEL-PLUS exams were incorporated in this study: agricultural engineering, chemical engineering, chemistry, civil engineering, computer engineering, electrical engineering, electrical mechanical engineering, food engineering, industrial engineering, informatics, mechanical engineering, mechatronics, and software engineering. Results of students enrolled in the following programs were not included in this study because these programs do not have an EGEL-PLUS exam in the CENEVAL's catalogue: physics engineering, innovation and development engineering, sustainable development engineering, and data science and mathematics engineering. These results are delivered by the CENEVAL directly to Tecnologico de Monterrey approximately one month after their application and are integrated into the students' academic records.

In the experimental design, the independent variable was whether students received a CBL or a traditional learning strategy throughout the development of their undergraduate studies and the dependent variable was their scores in each section of the EGEL-PLUS exam.

As analytical strategy, we evaluated if there was any initial difference between the two samples over their exam scores by means of a statistical exploratory analysis. Afterwards, to analyze the validity of this work's hypothesis, a two-sided *t*-test for independent samples was applied separately to the results of the communication section and the disciplinary section. No outliers were removed in this process.

On the other hand, a statistical exploratory analysis was applied to both samples but subdivided into groups according to gender and program (type of EGEL-PLUS exam) to deepen the causes of the differences between both learning strategies.

5. Results

In this study, we evaluate hypothesis under the environment of a traditional model and a CBL model (Tec21 educational model) both deployed at Tecnologico de Monterrey. We measured students results under the National Center for the Evaluation of Higher Education's (CENEVAL) Engineering Bachelor's Degree Standardized General Examination (EGEL-PLUS). In this section, we describe the variables used to compare CBL and the traditional teaching–learning process applied to engineering undergraduate programs.

5.1. Communication Section

In this section, we present the students' results for the communication section of the exam, without program distinction, and classify them in terms of students who received a traditional teaching–learning model during their studies (control group) and those who received a CBL teaching–learning model during their studies (focus group). For the control group (N = 1761), mean value = 1138.88, std. deviation = 67.38, and std. error mean = 1.61. For the focus group that applied CBL (N = 2465), mean value = 1130.79, std. deviation = 67.24, and std. error mean = 1.35. Table 2 shows a summary of these values and Figure 1 shows the raincloud plots for the samples.

Table 3 shows a cross-table for students' performance level for the communication section by learning model.

Table 2. Exploratory analysis for samples over the communication section sector in the EGEL-PLUS exam.

Learning Model	N	Min.	1st Qu.	Median	Mean	3rd Qu.	Max	Std. Deviation	Std. Error Mean
Traditional	1761	873	1096	1146	1138.88	1187	1281	67.38	1.61
CBL	2465	817	1086	1137	1130.79	1178	1284	67.24	1.35

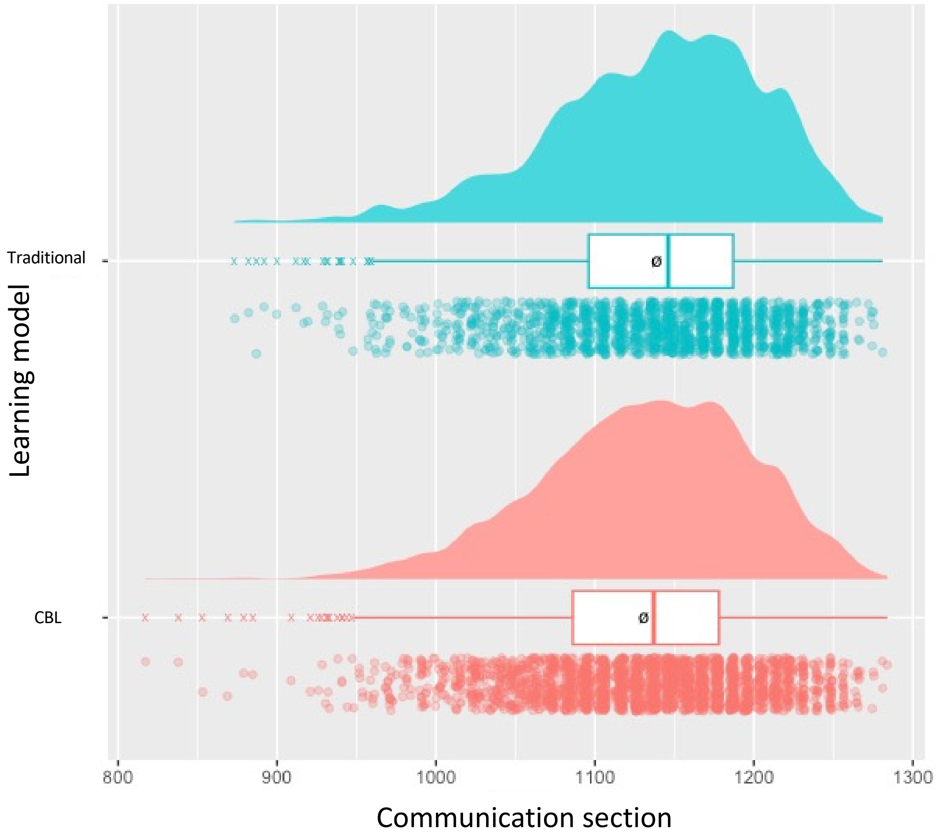

Figure 1. Raincloud plots for samples over the communication section score in the EGEL-PLUS exam.

Table 3. Cross-table for students' performance level for the communication section, in EGEL-PLUS exam, by learning model. Count (row percentage) is shown.

Learning Model	Not Yet Satisfactory	Satisfactory (a)	Outstanding (b)	Passing Grade (a) + (b)	Total
Traditional	58 (3.29%)	872 (49.52%)	831 (47.19%)	1703 (96.71%)	1761 (41.67%)
CBL	89 (3.61%)	1355 (54.97%)	1021 (41.42%)	2376 (96.39%)	2465 (58.33%)
Total	147 (3.48%)	2227 (52.70%)	1852 (43.82%)	4079 (96.52%)	4226 (100.00%)

A Lavene's test [57] was applied to check homogeneity of variance to the data. Table 4 shows these results. Given the results and the size of samples, we can apply a *t*-test [58] to know if there is a difference of mean between the samples. This test has values $p = 0.0079$, inf. = 3.97, and sup. = 12.2, with the control group having better results over the focus group. Table 5 shows these results.

Table 4. Levene's test for homogeneity of variance results for samples over the communication section in the EGEL-PLUS exam.

df	F	Sig.
4224	0.077	0.78

Table 5. *t*-test for samples over the communication section in the EGEL-PLUS exam.

t	df	*p*-Value	Inf.	Sup.
−3.85	4220	0.000119	3.97	12.2

5.2. Disciplinary Section

In this section, we present the students' results for the disciplinary section of the exam, without program distinction, and classify them in terms of students who received a traditional teaching–learning model during their studies (control group) and those who received a CBL teaching–learning model during their studies (focus group). For the control group (N = 1761), mean value = 1054.77, std. deviation = 50.54, and std. error mean = 1.20. For the focus group that applied CBL (N = 2465), mean value = 1048.18, std. deviation = 48.79, and std. error mean = 0.98. Table 6 shows a summary of these values and Figure 2 shows the raincloud plots for the samples.

Table 6. Exploratory analysis for samples over the disciplinary section score in the EGEL-PLUS exam.

Learning Model	N	Min.	1st Qu.	Median	Mean	3rd Qu.	Max	Std. Deviation	Std. Error Mean
Traditional	1761	911	1019	1054	1054.77	1091	1204	50.54	1.20
CBL	2465	874	1014	1046	1048.18	1083	1195	48.79	0.98

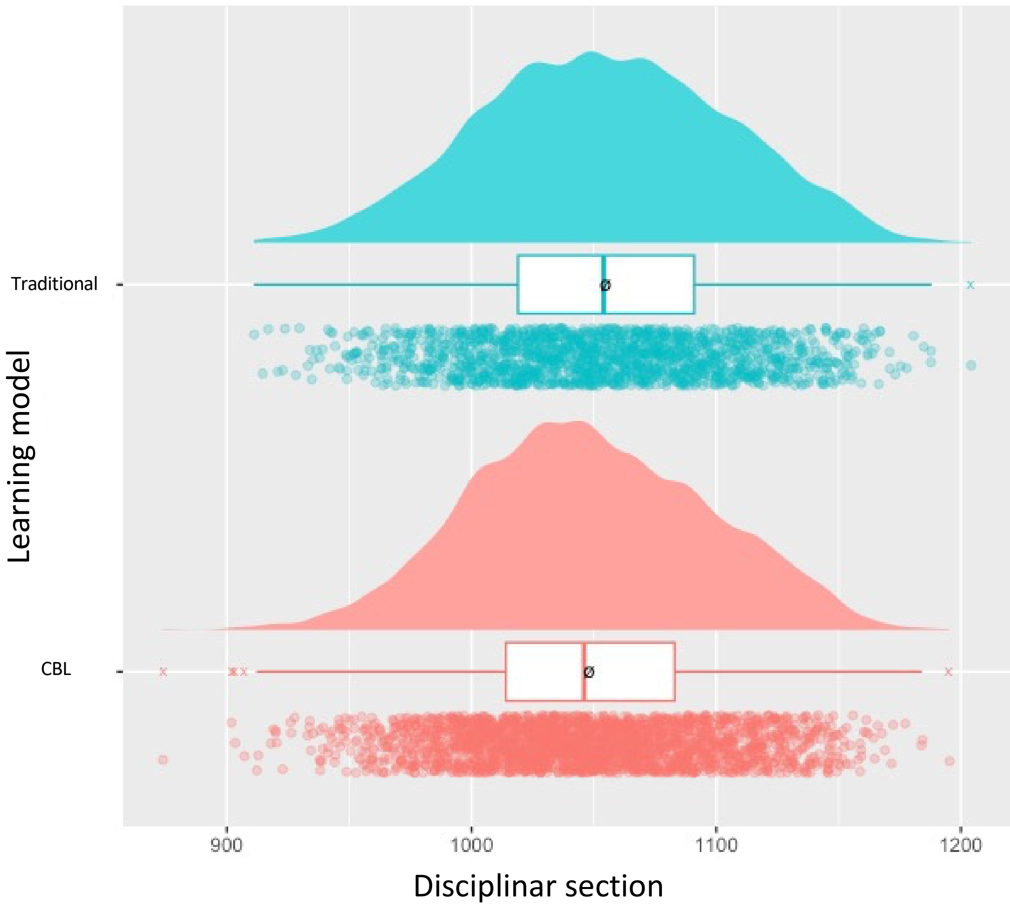

Figure 2. Raincloud plots for samples over the disciplinary section score in the EGEL-PLUS exam.

Table 7 shows a cross-table for students' performance level for the communication section by learning model.

Table 7. Cross-table for students' performance level for the disciplinary section, in EGEL-PLUS exam, by learning model. Count (row percentage) is shown.

Learning Model	Not Yet Satisfactory	Satisfactory (a)	Outstanding (b)	Passing Grade (a) + (b)	Total
Traditional	249 (14.14%)	1463 (83.08%)	49 (2.78%)	1512 (85.86%)	1761 (41.67%)
CBL	390 (15.82%)	2042 (82.84%)	33 (1.34%)	2075 (84.18%)	2465 (58.33%)
Total	639 (15.12%)	3505 (82.94%)	82 (1.94%)	3587 (84.88%)	4226 (100.00%)

A Lavene's test [57] was applied to check homogeneity of variance to the data. Table 8 shows these results. Given them, we can apply a *t*-test [58] to know if there is a difference of mean between the samples having $p = 2.07 \times 10^{-5}$, inf = 3.56, and sup = 9.62, with the control group being better than the focus group. Table 9 shows these results.

Table 8. Levene's test for homogeneity of variance results for samples over the disciplinary section in the EGEL-PLUS exam.

df	F	Sig.
4224	3.62	0.057

Table 9. *t*-test for samples over the disciplinary section in the EGEL-PLUS exam.

t	df	*p*-Value	Inf.	Sup.
−4.26	4220	2.07×10^{-5}	3.56	9.62

5.3. Students' Gender

To extend this, further analysis over students' demographics can be developed. In this sense, Figure 3 and Table 10 present an initial view over an important variable, student's gender, over results in the disciplinary section of the exam.

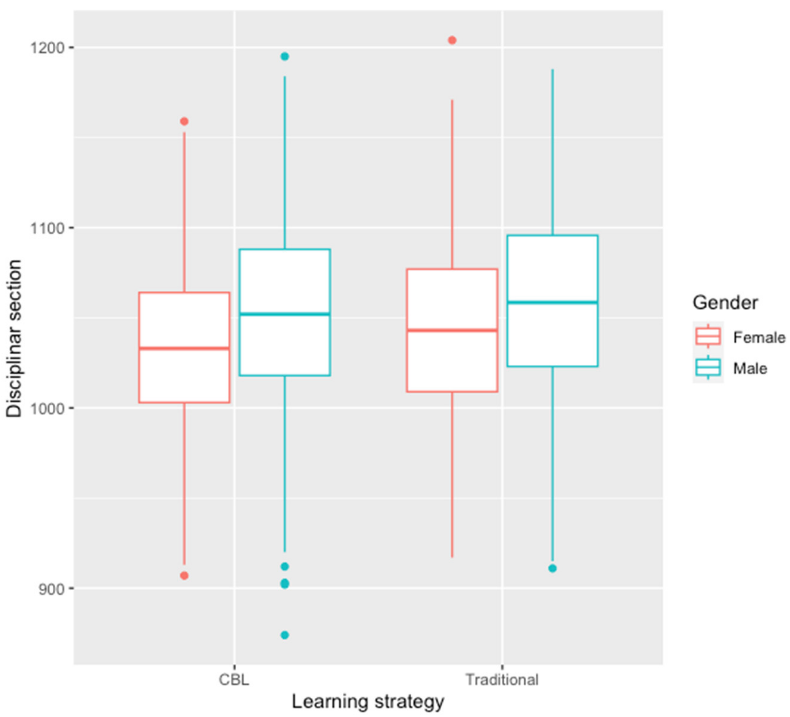

Figure 3. Boxplot for samples (disciplinary score of EGEL-PLUS) of female and male students under CBL and traditional learning strategies.

Table 10. Exploratory statistics variables for samples (disciplinary score of EGEL-PLUS) of female and male students under CBL and traditional learning strategies.

Learning Model	Gender	N	Min.	1st Qu.	Median	Mean	3rd Qu.	Max	Std. Deviation	Std. Error Mean
Traditional	Female	487	917	1009	1043	1043.61	1077	1204	49.09	2.22
	Male	1274	911	1023	1058.50	1059.03	1095.75	1188	50.45	1.41
CBL	Female	674	907	1003	1033	1034.80	1064	1159	45.84	1.77
	Male	1791	874	1018	1052	1053.21	1088	1195	48.93	1.16

However, in the results of the communication section of the exam, this situation is not the same. Figure 4 and Table 11 show that, in this case, female students present higher scores.

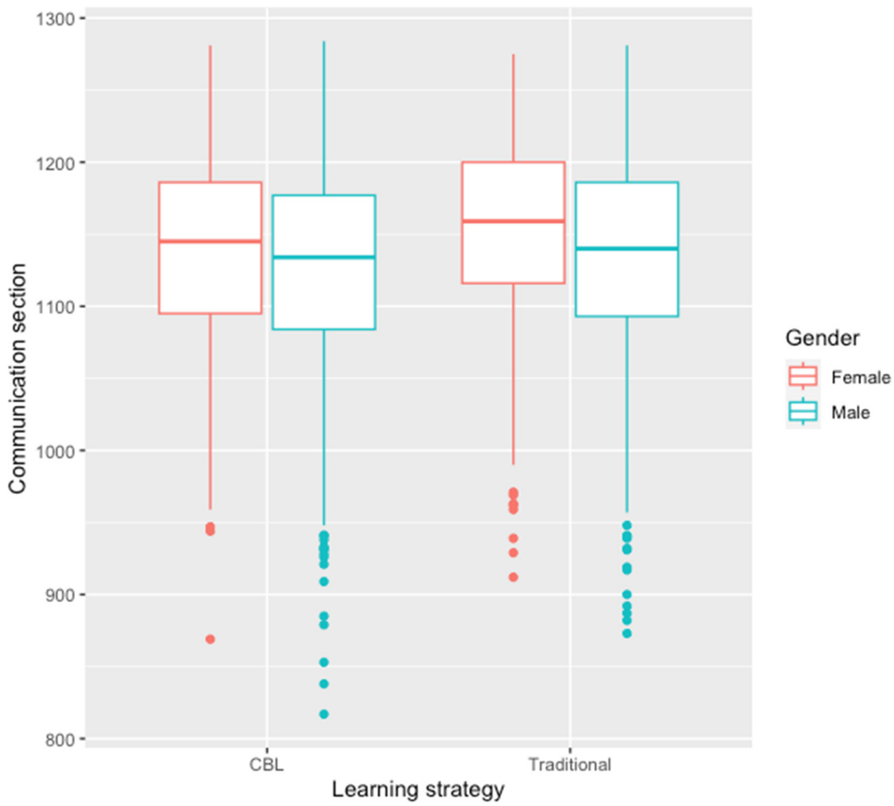

Figure 4. Boxplot for samples (communication score of EGEL-PLUS) of female and male students under CBL and traditional learning strategies.

Table 11. Exploratory statistics variables for samples (communication score of EGEL-PLUS) of female and male students under CBL and traditional learning strategies.

Learning Model	Gender	N	Min.	1st Qu.	Median	Mean	3rd Qu.	Max	Std. Deviation	Std. Error Mean
Traditional	Female	487	912	1116	1159	1152	1200	1275	63.96	2.90
	Male	1274	873	1093	1140	1134	1186	1281	67.96	1.90
CBL	Female	674	869	1095	1145	1139	1186	1281	62.89	2.42
	Male	1791	817	1084	1134	1128	1177	1284	68.55	1.62

Given that EGEL-PLUS has a specific exam for each discipline, we can segment the sample to analyze the same information. In this study, 13 exams were analyzed: agricultural engineering, chemical engineering, chemistry, civil engineering, computer engineering, electrical engineering, electrical mechanical engineering, food engineering, industrial engineering, informatics, mechanical engineering, mechatronics, and software engineering.

Tables 12 and 13 show sample size by gender for each EGEL-PLUS exam. In total, 27.47% of the students are female. However, the gender distribution is different for each engineering discipline. While certain programs have a predominantly female presence (food engineering 83.33%), there are disciplines where women are underrepresented (electrical mechanical engineering 9.76% and mechanical engineering 15.04%). Additionally, Table 12 presents the communication section score's mean, while Table 13 presents the disciplinary section score's mean, both in detail by EGEL-PLUS exam discipline and gender. These results are discussed in the following section.

Table 12. Sample sizes and communication section score's mean by EGEL-PLUS exam type and by gender.

	Sample Size			Communication Section's Mean			
Exam	**Female**	**Male**	**Total**	**Female**	**Male**	**Delta**	**Sample**
Agricultural engineering	12 (30.77%)	27 (69.23%)	39 (0.92%)	1139.42	1123.48	15.94	1128.39
Chemical engineering	152 (48.10%)	164 (51.90%)	316 (7.48%)	1134.58	1125.67	8.91	1129.95
Chemistry	33 (57.89%)	24 (42.11%)	57 (1.35%)	1170.24	1161.50	8.74	1166.56
Civil engineering	70 (20.23%)	276 (79.77%)	346 (8.19%)	1140.33	1109.51	30.81	1115.75
Computer engineering	21 (22.83%)	71 (77.17%)	92 (2.18%)	1165.19	1155.42	9.77	1157.65
Electrical engineering	33 (26.83%)	90 (73.17%)	123 (2.91%)	1182.91	1155.43	27.48	1162.81
Electrical mechanical engineering	8 (9.76%)	74 (90.24%)	82 (1.94%)	1154.50	1130.39	24.11	1132.74
Food engineering	70 (83.33%)	14 (16.67%)	84 (1.99%)	1108.73	1105.36	3.37	1108.17
Industrial engineering	395 (35.81%)	708 (64.19%)	1103 (26.10%)	1136.12	1110.86	25.26	1119.91
Informatics	43 (32.82%)	88 (67.18%)	131 (3.10%)	1152.19	1140.24	11.95	1144.16
Mechanical engineering	57 (15.04%)	322 (84.96%)	379 (8.97%)	1148.95	1121.65	27.30	1125.76
Mechatronics	155 (17.24%)	744 (82.76%)	899 (21.27%)	1163.47	1145.82	17.65	1148.86
Software engineering	112 (19.48%)	463 (80.52%)	575 (13.61%)	1162.11	1142.68	19.44	1146.47
Sample	1161 (27.47%)	3065 (72.53%)	4226 (100.00%)	1144.89	1130.10	14.79	1134.16

Table 13. Sample sizes and disciplinary section score's mean by EGEL-PLUS exam type and by gender.

	Sample Size			Disciplinary Section's Mean			
Exam	**Female**	**Male**	**Total**	**Female**	**Male**	**Delta**	**Sample**
Agricultural engineering	12 (30.77%)	27 (69.23%)	39 (0.92%)	1018.67	1032.19	−13.52	1028.03
Chemical engineering	152 (48.10%)	164 (51.90%)	316 (7.48%)	1028.28	1029.92	−1.644	1029.13
Chemistry	33 (57.89%)	24 (42.11%)	57 (1.35%)	1008.03	1020.00	−11.97	1013.07
Civil engineering	70 (20.23%)	276 (79.77%)	346 (8.19%)	1043.29	1058.31	−15.03	1055.27
Computer engineering	21 (22.83%)	71 (77.17%)	92 (2.18%)	1041.29	1078.42	−37.14	1069.95
Electrical engineering	33 (26.83%)	90 (73.17%)	123 (2.91%)	1017.55	1054.76	−37.21	1044.77
Electrical mechanical engineering	8 (9.76%)	74 (90.24%)	82 (1.94%)	1050.75	1070.15	−19.40	1068.26
Food engineering	70 (83.33%)	14 (16.67%)	84 (1.99%)	1059.59	1066.07	−6.49	1060.67
Industrial engineering	395 (35.81%)	708 (64.19%)	1103 (26.10%)	1030.34	1035.72	−5.38	1033.79
Informatics	43 (32.82%)	88 (67.18%)	131 (3.10%)	1046.30	1071.60	−25.30	1063.30
Mechanical engineering	57 (15.04%)	322 (84.96%)	379 (8.97%)	1034.56	1043.47	−8.91	1042.13
Mechatronics	155 (17.24%)	744 (82.76%)	899 (21.27%)	1042.14	1062.64	−20.50	1059.10
Software engineering	112 (19.48%)	463 (80.52%)	575 (13.61%)	1074.78	1085.02	−10.25	1083.03
Sample	1161 (27.47%)	3065 (72.53%)	4226 (100.00%)	1038.49	1055.63	−17.14	1050.925

6. Discussion

As results have shown, students who received a traditional educational model during their undergraduate programs have a statistically significant greater mean versus students who received a CBL-based model. This happens in the disciplinary (inf = 3.56, sup = 9.62, $p = 2.07 \times 10^{-5}$) and in the communication (inf = 3.97, sup = 12.2, $p = 0.000119$) sections of the EGEL-PLUS exam. It is worth saying that this difference is on a scale of 700–1300 points. This means that these differences represent only between 0.59% and 1.60% of the scale for the disciplinary section and only between 0.66% and 2.03% for the communication section.

As we can see, this difference is very small, and it could be due to other factors besides the educational model received by the students. One example of these factors is the evaluation instruments that are used in each educational model. Ref. [59] reports that students' work in CBL is evaluated mainly by evidence such as written reports, oral presentations, prototypes, and final products, all of them seeking to measure the performance of the students in their program's learning outcomes. The Tec21 model (CBL model used by Tecnologico de Monterrey in this study) implements this strategy. This contrasts with the traditional model in which students receive written exams as the main source of their performance assessment. In this sense and given that EGEL-PLUS is a written exam, it is understandable that students in the traditional model have better abilities to face this test.

On the other hand, Ref. [60] found a change in the role of faculty from a traditional role (that includes course creation and design of course plans) to three roles needed to implement CBL. These roles are academic professor (as knowledge acquisition support), coach (as skills acquisition support), and project manager (as facilitator of interactions with internal and external course actors). This new association requires a faculty team to deploy CBL. In turn, this requires that faculty gives up the total control they had in experiences with traditional models and that they must communicate with other peers to ensure that students achieve the objectives of their courses. This, together with the practical and application approach proposed by CBL as opposed to the theoretical and in-depth approach proposed by traditional models, causes faculty to fear that students will not acquire the necessary knowledge of the discipline by using CBL. Results in this study show that students in both educational models have similar results in a standardized disciplinary knowledge test showing that this fear that faculty has does not come true.

Additionally, it is reported that students in CBL develop other skills and elements beyond pure knowledge. For example, Ref. [59] says that students grow interdisciplinary and transversal competencies. Also, through these transversal competencies, Ref. [45] states that students can find meaning in their education by solving social or sustainability challenges, for example. Ref. [61] states that CBL develops critical thinking, self-directed learning, and long-term retention as a pedological method. Ref. [62] adds leadership, insight into the professional world, oral and written communication skills, and frustration tolerance to this set of elements. Ref. [63] states that multidisciplinary teamwork, decision-making, and ethics are also developed by this learning strategy.

Concerning the effectiveness of these educational models, students' results in this analysis surpass other historical reports. For example, Ref. [48] found a mean of 979.53 in the disciplinary section. Also, Ref. [64] notes 46.20%, Ref. [65] records 19.8%, while Ref. [66] counts 61.96% of students achieving a passing grade.

Furthermore, the CENEVAL recognizes both students and academic institutions with excellent results on the EGEL-PLUS exam. Students who obtain outstanding results in all the exam sections receive the "CENEVAL Award for Excellence in EGEL Performance" and it is typically given to 1% of the students who sit the exam across the country. On the other hand, academic institutions are recognized by belonging to the "Padrón EGEL" (EGEL List) for High-Performance Academic Programs if they meet one of the following criteria [67]:

- Level 1 Plus. At least 80% of the students obtain satisfactory or outstanding and at least 50% obtain outstanding.
- Level 1. At least 80% of the students obtain satisfactory or outstanding and less than 50% obtain outstanding.
- Level 2. At least 60% (but less than 80%) of the students obtain satisfactory or outstanding.

Given these criteria as reference, the EGEL-PLUS results for both the traditional and the CBL models are admirable. As observed in Tables 3 and 7, in the "Passing grade (a) + (b)" column, more than 80% of the students obtained either satisfactory or outstanding results.

With this analysis, considering the small difference between the results for both educational models and the fact that both meet the high-performance standard of this external assessment instrument, we can confirm our research hypothesis.

Regarding the gender perspective, it is important to say first that this gender analysis must be extended and deepened to know the specific factors generating these results, and how to diminish the gap found in these samples. First, a complete statistical analysis should be performed over data. Also, other demographics could be used to explore students' characteristics, but it is important also to analyze outside-student factors like the design of undergraduate programs.

On the other hand, it is well known that the gender gap in STEM areas is a multifaceted global challenge and several efforts have been implemented to attract, retain, and develop more women in STEM fields.

Tables 12 and 13 show the female and male representation of the sample population. Overall, the sample has 27.47% female and 72.53% male. The disciplines with less female representation are mechanical engineering, mechatronics, software engineering, and civil engineering. On the other hand, the programs with more female representation are food engineering and chemistry. According to this sample, the discipline that has a more gender-balanced representation is chemical engineering, with 48.10% female and 51.90% male. Coincidently, chemical engineering was the exam with the smaller delta in the disciplinary section. For future analysis, it would be interesting to study if there is a correlation between gender balance and academic results.

Another interesting observation from the gender perspective are the results of the disciplinary and the communication sections. In both educational models, men scored higher in the disciplinary section while women scored higher in the communication section. Identifying these patterns might help educators to analyze the situation and design different strategies and approaches toward a more inclusive education.

Finally, the instrument for analyzing student performance from a traditional model to a CBL model was a nationally standardized test applied in Mexico. As an interesting reflection, originally, standardized tests such as the SAT were considered an element that promoted gender inequality because of the results obtained at the beginning. Male students obtained a high score with a significant difference versus female students. However, the history of this instrument describes how its objectivity allowed for minorities to gain admission to universities. As part of the validation process of the standardized exams, studies were conducted on the predictability of students' success in the first year of their academic program, in contrast to the results of the standardized exams. Among the conclusions, it was observed that it does not predict performance, since although male students had better results in the standardized exam, in the first year of their professional career, women had better performance. Therefore, adjustments were made to the standardized exams, changes that helped to reduce the gender gap through their improvement and better represent the capabilities of students regardless of their gender [68].

With a standardized test design considering these gender perspectives, it is possible to explore other standpoints or elements that influence the achievement and fulfillment of the competencies that are sought to be developed. Under this paradigm, the standardized test applied as an end-of-studies instrument in engineering academic programs is used for the analysis and comparison of educational models as well as the comparison between the genders of the students [69].

7. Conclusions

In this study, we presented a statistical analysis on students' results from the National Center for the Evaluation of Higher Education's Engineering Bachelor's Degree Standardized General Examination. A total of 4226 undergraduate students in engineering programs of Tecnologico de Monterrey participated in this study. Scores for the communication and the disciplinary sections were compared, contrasting results for those who received a traditional learning model and those who received a CBL model.

It was found that the traditional learning model has a greater significant effectiveness over a CBL model in both sections of the exam. However, this difference is between 3 and 12 points under a scale of 600 points. Given this and that this result can be caused by factors other than the learning model, we found this difference small enough to say that both strategies have the same effectiveness supporting the hypothesis of this work. Even though the CENEVAL exam is an instrument whose purpose is to determine whether students who are candidates for graduation have the knowledge and skills that are considered indispensable at the end of their academic training, with a focus on the evaluation of competencies, the reviewing whether the exam is aligned to this type of competency-based assessment or to a traditional learning model is a recommendation for future research.

It is important to state that these results were obtained by implementing strategies in a specific knowledge area (engineering). A similar analysis must be performed in other fields to surpass the limitation of generalization. In addition to the above, we must consider that CBL prepares students to apply their knowledge in real and challenging situations by developing interdisciplinary and transversal competencies like critical thinking, self-directed learning, frustration tolerance, decision-making, and ethics, among others. This is crucial for success in the professional world. In the implementation of CBL, students in teams develop their analysis and proposals, justify their results from different perspectives, and communicate them to their different audiences: professors and educational partners. This type of learning allows for collaborative work between different disciplines in its implementation. For the purposes of the CENEVAL exam, the transversal competence evaluated is that of communication, which allows for this skill's development.

Future work on student demographics must be applied to know if there are other differences caused by educational or cultural background, for example. This analysis would be helpful to create and design programs to dissolve differences between population sectors like the gender gap. This work used the Engineering Bachelor's Degree Standardized General Examination as an external evaluation instrument. This exam is the same for each engineering program for all Mexican academic institutions, which means that it is not completely aligned to the study plan. It would be interesting to analyze how aligned the study plan of each of the educational models is to the standardized exam and see if it is a relevant factor on the overall analysis. As future work, it would be interesting to analyze students' performance from a gender perspective with other types of assessment instruments.

Also, a study on grading systems in both learning strategies and their effect on student results and learning gains would be interesting as future work in order to know if the alignment of assessment and learning objectives presents new approaches or paradigms.

Finally, work on the construction of standardized exams is needed to assure that questions maintain consistency during the evaluation process among different demographic subgroups like gender or nationality.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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