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ORIGINAL ARTICLE

Perception of Construction Engineering Students concerning Professional Competencies at a Chilean Private University

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Abstract:
This study examines the development of professional competencies in 21 construction engineering students enrolled at a private university in Chile. Recognizing the growing demand for highly skilled professionals in the construction industry, the research aims to evaluate the students' self-perceived competencies using a 21-item Likert-scale questionnaire. The study focuses on identifying key strengths and areas for improvement in their preparation for the labor market. Results indicate a favorable perception of their abilities, particularly in technical problem-solving, teamwork, and effective communication—competencies considered critical for professional success in the field. The findings underscore the effectiveness of the current curriculum in fostering these competencies while highlighting the need for ongoing enhancement in practical training and leadership development. The main conclusion is that the students demonstrate a solid foundation of professional skills, positioning them well for career challenges, but there is room to strengthen specific areas to align fully with industry demands.

Introduction

The 21st century has brought unprecedented challenges and opportunities for engineering education, driven by rapid technological advancements, globalization, and evolving societal needs. In this context, universities play a pivotal role in shaping professionals capable of addressing complex problems and contributing to sustainable development. The construction engineering field, in particular, requires a blend of technical expertise, innovative thinking, and collaborative skills to tackle issues such as urbanization, climate change, and resource management. To meet these demands, academic programs must integrate cutting-edge knowledge with practical, hands-on training, fostering not only technical, but also transversal competencies such as teamwork, communication, and leadership (de Campos et al., 2020; Caten et al., 2019; Vera, 2023a). These competencies are crucial for bridging the gap between academic preparation and industry expectations, ensuring graduates are ready to thrive in dynamic, multidisciplinary environments.

Despite significant progress in modernizing curricula, questions remain about how effectively engineering education equips students with the professional competencies required for the labor market. Higher Education Institutions (HEIs) must continuously assess and refine their educational strategies to align with industry needs and global standards. This is particularly relevant in Chile, where private universities are gaining prominence in producing skilled construction engineers. By evaluating students' self-perceptions of their competencies, researchers can identify strengths and areas for improvement in current programs, guiding future reforms. This study focuses on understanding these dynamics, using empirical data from construction engineering students to offer insights into educational outcomes and propose actionable recommendations.

Research Questions

1. How do construction engineering students perceive their professional competencies?
2. What specific competencies are most developed among students in this field?
3. Are there significant gaps between perceived competencies and industry demands?
4. How can academic programs be improved to better prepare students for professional challenges?

Engineering education

Fostering problem-solving capabilities and driving innovation (Bakthavatchaalam, 2024) have traditionally formed the cornerstone of engineering education, equipping graduates with the technical skills needed to address complex challenges and develop practical solutions. However, in the evolving context of the 21st century, the scope of engineering education has broadened significantly. Beyond achieving technical proficiency, there is a growing need for engineers to develop a diverse set of competencies. These include critical thinking, effective communication, collaboration within multidisciplinary teams, and the adaptability required to navigate dynamic global industries.

Additionally, engineers must now integrate ethical decision-making and sustainability considerations into their solutions, aligning technological advancements with societal and environmental needs. This shift reflects the growing recognition that innovation must not occur in isolation but address global challenges such as climate change, resource scarcity, and social equity. By embedding ethics and sustainability into engineering education, future professionals are better prepared to develop solutions that are not only effective but also responsible and inclusive. Modern engineering graduates must be equipped with the ability to evaluate the broader impacts of their work, balancing economic, environmental, and societal priorities. This holistic approach ensures they are not only innovators but also well-rounded professionals capable of leading progress in an ever-changing world while fostering a sustainable future for all.

The field of engineering education is constantly evolving as new technologies and methodologies emerge (Veza et al., 2023). This evolution reflects the growing complexity of global challenges and underscores the importance of preparing engineers who can lead interdisciplinary initiatives, contribute to sustainable development, and thrive in dynamic professional environments. Engineers today are expected to address issues that transcend traditional technical boundaries, such as climate change, resource scarcity, and ethical implications of emerging technologies. To meet these demands, engineering education must emphasize not only technical expertise but also critical thinking, creativity, and effective communication skills. Furthermore, engineers must be equipped to collaborate across disciplines, working alongside professionals from diverse fields to develop innovative and sustainable solutions. By fostering adaptability and leadership, academic programs can prepare engineers to navigate the complexities of an interconnected world and play a key role in solving pressing global issues while advancing technological and societal progress.

The significance of engineering education and its curriculum in equipping learners with the skills needed to navigate the complexities of the 21st century and contribute to a sustainable future cannot be overstated (Lamere et al., 2021; Vera, 2023b). A well-structured curriculum extends beyond imparting technical knowledge; it fosters critical thinking, ethical responsibility, and creativity, enabling students to design and manufacture products and processes that emphasize energy efficiency, resource conservation, and social responsibility. Integrating sustainability principles into educational frameworks ensures that students are not only technically competent but also capable of addressing pressing environmental challenges. This holistic approach prepares graduates to innovate solutions that align with global sustainability goals, contributing meaningfully to society and industry. Engineering programs, therefore, serve as catalysts for fostering a new generation of professionals dedicated to driving sustainable development and technological progress worldwide.

More importantly, such a curriculum shapes students into agents of transformative change, equipping them with the ability to critically assess and mitigate the long-term social, economic, and environmental impacts of their professional practices (Kolmos, 2021). This holistic approach develops engineers who excel not only in technical expertise but also in ethical responsibility, sustainability awareness, and global citizenship.

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By fostering interdisciplinary collaboration, problem-solving skills, and critical thinking, engineering education empowers graduates to address real-world challenges effectively. These future professionals are prepared to lead initiatives that drive sustainable development, balancing technological progress with environmental stewardship and societal well-being. Aligning curriculum design with sustainability imperatives ensures the development of resilient, forward-thinking leaders capable of contributing meaningfully to societal progress without compromising the needs of future generations.

Professional Competencies in Engineering

The success of contemporary engineering graduates in their professional roles increasingly hinges on a comprehensive skill set that extends beyond technical expertise (Lowe et al., 2024; Vera, 2023). Professional competencies encompass transferable skills essential for holistic performance at the point of attaining professional registration. These competencies include abilities such as effective communication, teamwork, ethical reasoning, and project management, which are crucial in addressing real-world challenges (Berdanier, 2021; Colman & Willmott, 2016; Vera, 2023a). While there is some variation in how professional competencies are interpreted, they consistently emphasize skills that enable engineers to navigate complex, multidisciplinary environments and adapt to rapidly evolving industry needs. Thus, fostering these skills within engineering education is not just beneficial but essential for preparing graduates to thrive in a competitive global landscape.

Accredited engineering programs globally have incorporated professional competencies into their learning outcomes, reflecting the guidelines set by bodies such as the Washington Accord in 1989. These competencies are now integral to accreditation processes, ensuring that graduates meet minimum international standards for employability and professional practice. However, embedding these skills into curricula requires innovative pedagogical approaches, including problem-based learning, collaborative projects, and experiential education. While progress has been made, gaps remain in aligning academic training with industry demands, especially in fostering leadership and entrepreneurial thinking among engineering students.

Despite the increased emphasis on professional skills within engineering curricula, many employers report that graduates often fall short of expectations in key areas. Research by Byrne et al. (2020) highlights persistent dissatisfaction with graduates' readiness to effectively apply professional skills in the workplace. This gap underscores the need for stronger collaboration between academia and industry to co-design educational experiences that reflect real-world requirements. Practical initiatives such as internships, mentorship programs, and industry-driven projects can act as effective bridges to enhance skill development and workplace readiness. By fostering these partnerships, students gain exposure to real challenges and opportunities to apply their technical and professional competencies. Addressing these gaps is critical for developing a workforce that not only excels in technical proficiency but also demonstrates adaptability, creativity, and leadership—key attributes for success in today's dynamic and competitive engineering profession.

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Critical Thinking: A Cornerstone for Technical Competencies in Engineering Education

Critical thinking is an essential competence in engineering education because it empowers students to analyze, evaluate, and systematically solve complex problems. In a field where precision, innovation, and practicality are crucial, critical thinking equips students and professionals with the tools to approach challenges using a structured and evidence-based mindset. This skill enables them to identify root causes of problems, assess available data, explore multiple viable solutions, and make informed decisions that optimize outcomes.

Additionally, critical thinking fosters creativity and adaptability, empowering engineers to navigate the uncertainty and demands of rapidly evolving technologies. This skill enables them to question assumptions, analyze problems from multiple perspectives, and recognize the limitations of existing methods or solutions (Vera & Tejada, 2020). By balancing technical, economic, and ethical considerations, critical thinking ensures engineers make informed and responsible decisions in complex situations. It also encourages a mindset of continuous learning and improvement, essential for addressing challenges in a dynamic, technology-driven world. Engineers equipped with strong critical thinking skills are better prepared to develop innovative, effective, and sustainable solutions that address pressing real-world problems. Moreover, these skills help them anticipate future trends, collaborate effectively in interdisciplinary teams, and lead technological advancements that align with societal needs, ultimately shaping a better, more resilient future for all.

As Adair and Jaeger (2016) highlight, the quality of students' and engineers' thinking, as well as their methods of problem-solving, directly impacts the quality of what they produce. Strong critical thinking skills allow individuals to systematically analyze problems, evaluate alternatives, and implement effective solutions with precision. Beyond improving technical performance, critical thinking fosters creativity by encouraging innovative approaches and novel ideas. Additionally, it promotes adaptability, enabling engineers to navigate challenges in rapidly changing technological and societal landscapes. Ethical decision-making is another critical outcome, ensuring that solutions are not only effective but also responsible and sustainable. These traits—creativity, adaptability, and ethical awareness—are essential for success and leadership in the dynamic, complex, and ever-evolving field of engineering.

According to Waks et al. (2011), the majority of graduates from engineering schools engage in engineering design, which is a central and essential activity in their professional practice. In fact, engineering design involves the creation of new products, processes, or systems to address specific needs or solve complex problems. This process requires the application of engineering-focused thinking, which combines technical knowledge, creativity, and critical analysis to develop innovative and practical solutions. Graduates must integrate multidisciplinary skills, including mathematics, science, and technology, to ensure their designs are functional, efficient, and sustainable. Furthermore, engineering design emphasizes collaboration, as it often involves teamwork and communication with clients, stakeholders, and other professionals. By engaging in design activities, engineers contribute significantly to technological advancements and the development of solutions that meet societal and industrial needs.

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In this context, engineering challenges often involve ambiguity, incomplete data, and multiple possible solutions, requiring students to assess information critically and make informed decisions. By developing critical thinking skills, engineers can approach problems logically, break them into manageable components, and identify patterns or relationships that lead to effective solutions. This competence is particularly valuable in today's fast-paced technological landscape, where engineers must adapt to emerging tools, evolving processes, and interdisciplinary demands. Beyond technical expertise, critical thinking fosters an innovative mindset, enabling graduates to approach problems with creativity and resilience (Adair & Jaeger, 2016; Vera, 2023a). Without this skill, students risk relying on rote learning or predefined methods, limiting their capacity to adapt to real-world complexities. Encouraging critical thinking equips future engineers to question assumptions, explore diverse solutions, and address global challenges with a focus on sustainability and ethical considerations.

Moreover, critical thinking fosters ethical and responsible decision-making—key qualities for modern engineers (Álvarez-Salazar, et., 2024; Lysak, 2022). Engineers often face decisions with significant societal, environmental, and economic implications. Integrating critical thinking into engineering education ensures that students develop a holistic perspective, considering the broader impact of their solutions while balancing risks, benefits, and sustainability. This approach enables future engineers to design systems, technologies, and processes that are not only efficient but also socially responsible and environmentally conscious. As industries demand professionals who can think critically, solve problems creatively, and lead effectively, embedding this competence in engineering curricula equips graduates with the adaptability and leadership needed to drive innovation, meet evolving professional standards, and tackle the complex challenges of the 21st century with confidence and responsibility.

Overview of the Washington Accord

The Washington Accord, established in 1989, is an international agreement that fosters mutual recognition of engineering education programs among its signatory nations. Under the umbrella of the International Engineering Alliance (IEA), the Accord ensures that accredited programs meet a set of internationally benchmarked graduate attributes and educational standards. Its primary aim is to facilitate global mobility for engineering graduates by enabling the recognition of qualifications across borders, thereby supporting international professional practice (International Engineering Alliance, 2014). Initially signed by six countries—Australia, Canada, Ireland, New Zealand, the United Kingdom, and the United States—the Accord has since grown to include 15 signatories, representing over 7,000 accredited programs globally. The agreement emphasizes outcome-based education, where the quality of graduates is measured by their demonstrated competencies rather than merely course content or instructional methods. This shift to outcome-based accreditation has significantly influenced the evolution of engineering education worldwide (Box 1).

Box 1: *Summary of the Six Most Relevant Characteristics of The Washington Accord*

- *Mutual Recognition:* Facilitates the recognition of accredited undergraduate engineering degree programs among signatory countries, ensuring global credibility.
- *Unified Global Standard:* Establishes consistent quality standards for engineering education across participating nations.
- *Outcomes-Based Education (OBE):* Emphasizes the development of graduates' knowledge, skills, and professional competencies to meet modern engineering demands.
- *Quality Assurance:* Implements rigorous processes to maintain compliance with academic and professional standards.
- *International Mobility:* Enhances opportunities for engineering graduates to practice professionally across signatory regions.
- *Graduate Preparedness:* Ensures graduates possess key competencies such as problem-solving, ethical responsibility, teamwork, and innovative design capabilities to excel in professional practice.

Source: Own elaboration.

As a result, it is regarded as the gold standard for engineering education, promoting consistency in graduate preparation for complex, multidisciplinary challenges. By aligning educational practices with shared graduate attributes, the Accord strengthens the foundation for mutual trust and recognition between countries. Accredited programs under the Accord prepare graduates to address societal and environmental needs, uphold ethical standards, and embrace lifelong learning in response to technological advancements. Furthermore, the Accord has inspired other educational agreements, such as the Sydney and Dublin Accords, which cater to engineering technologists and technicians. Its influence extends beyond signatory nations, offering guidance to aspiring members and fostering collaboration in engineering education. By emphasizing quality and international benchmarking, the Washington Accord ensures the development of engineers equipped to contribute effectively to global innovation and sustainable development.

The Washington Accord is an international agreement that recognizes the substantial equivalence of engineering degree programs accredited by its signatory countries. Each signatory is represented by its respective accrediting body, which ensures that the accredited programs meet rigorous academic and professional standards for engineering education. This mutual recognition facilitates mobility for engineering graduates, enabling them to pursue professional opportunities across member countries.

The table below lists the signatory countries alongside their corresponding accrediting institutions. These institutions play a critical role in maintaining the quality of engineering education and fostering a globally competent workforce. By aligning accreditation standards internationally, the Washington Accord supports collaboration, innovation, and the exchange of engineering talent across borders. This agreement is particularly valuable in an increasingly interconnected world where engineering solutions address global challenges.

Table 1: Signatory Countries and Their Accrediting Institutions Under the Washington Accord

Country	Accrediting Institution
Australia	Engineers Australia (EA)
Bangladesh	The Institution of Engineers Bangladesh (IEB)
Canada	Engineers Canada (EC)
China	China Association for Science and Technology (CAST)
Chinese Taipei	Institute of Engineering Education Taiwan (IEET)
Costa Rica	Colegio Federado de Ingenieros y de Arquitectos de Costa Rica (CFIA)
Hong Kong China	The Hong Kong Institution of Engineers (HKIE)
India	National Board of Accreditation (NBA)
Indonesia	Indonesian Accreditation Board for Engineering Education (IABEE)
Ireland	Engineers Ireland (EI)
Japan	Japan Accreditation Board for Engineering Education (JABEE)
Korea	Accreditation Board for Engineering Education of Korea (ABEEK)
Malaysia	Board of Engineers Malaysia (BEM)
Mexico	Consejo de Acreditación de la Enseñanza de la Ingeniería (CACEI)
New Zealand	Engineering New Zealand (EngNZ)
Pakistan	Pakistan Engineering Council (PEC)
Peru	Instituto de Calidad y Acreditación de Programas de Computación, Ingeniería y Tecnología (ICACIT)
Philippines	Philippine Technological Council (PTC)
Russia	Association for Engineering Education of Russia (AEER)
Singapore	Institution of Engineers Singapore (IES)
South Africa	Engineering Council South Africa (ECSA)
Sri Lanka	Institution of Engineers Sri Lanka (IESL)
Turkey	Association for Evaluation and Accreditation of Engineering Programs (MÜDEK)
United Kingdom	Engineering Council United Kingdom (ECUK)
United States	Accreditation Board for Engineering and Technology (ABET)

Note: Based on the latest available data from the International Engineering Alliance (2024).

It is important to highlight that the Washington Accord emphasizes the necessity for engineering graduates to develop the ability to navigate complexity and uncertainty in professional practice. Real-world engineering projects are inherently unique, requiring graduates to tackle challenges with a combination of creativity and analytical thinking. A key component of their professional skill set is the ability to solve complex engineering problems, seamlessly integrating technical expertise with innovative approaches. This ensures they can adapt to dynamic environments, address unprecedented challenges, and contribute effectively to advancing modern engineering solutions.

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Chile's Status within the Washington Accord

Chile, represented by the Agencia Acreditadora Colegio de Ingenieros de Chile S.A. (ACREDITA CI), currently holds Provisional Signatory status within the Washington Accord. This status, approved in 2018, signifies that Chile has established appropriate systems and processes for accrediting engineering degree programs but has not yet achieved full recognition. As a Provisional Signatory, Chile's accreditation framework and quality assurance mechanisms are recognized as being on the right path toward alignment with the Washington Accord's rigorous standards. However, this status implies that Chile is still in the process of demonstrating substantial equivalence with the educational standards upheld by full signatories.

To progress to full signatory status, Chile must continue refining its accreditation processes, ensuring they consistently meet the Accord's requirements. This involves rigorous evaluation, peer reviews, and periodic assessments to verify that engineering programs produce graduates equipped with outcomes-based education, aligning with global engineering education standards. Achieving full status would enhance the international recognition of Chilean engineering graduates, facilitating professional mobility and fostering trust in the quality of engineering education in the country.

Engineering Education in Chile: A Critical Perspective

Engineering education in Chile has undergone significant reforms over the past decades to align with global trends and address the growing demand for skilled professionals. One of the central features of these reforms has been the incorporation of generic competencies, such as teamwork, communication, critical thinking, and ethical reasoning, into undergraduate curricula. However, these competencies are often introduced as standalone courses or workshops, disconnected from the technical and disciplinary-specific learning outcomes of engineering programs. This siloed approach results in fragmented learning experiences where students struggle to see the relevance of generic skills in their professional practice (Vera, 2023b; Vera, 2024). Consequently, while graduates may formally meet academic requirements, their ability to integrate and apply these competencies within complex, real-world engineering scenarios often falls short of industry expectations.

Traditionally, curriculum development in HEIs has often been characterized by a siloed approach, where individual departments or faculties operate independently with minimal collaboration (Kirwan et al., 2022; Vera & García-Martínez, 2022). This fragmented structure can lead to a range of inefficiencies, particularly when it comes to the design and implementation of learning resources. A lack of coordination across departments frequently results in the unnecessary duplication of course content and curricula, causing significant waste of time, effort, and institutional resources. Moreover, this disconnected approach contributes to inconsistencies in learning and teaching methods, learning outcomes, and the overall student experience, as each silo may interpret standards and objectives differently.

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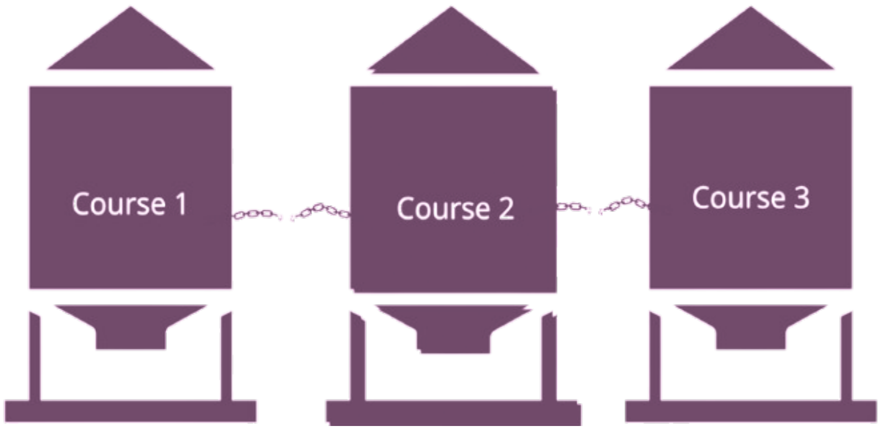
Inefficiencies in higher education curricula often arise due to poorly designed or outdated learning resources, which fail to meet the evolving needs of students and industries. For instance, textbooks and materials that lack alignment with current technological advancements or professional practices leave students underprepared for real-world challenges. Similarly, learning platforms or digital tools may be introduced without proper training for faculty, leading to inconsistent or ineffective implementation. In some cases, generic resources are reused across courses without tailoring them to specific learning outcomes, diminishing their relevance and impact. Additionally, there are instances where traditional lectures dominate the curriculum while active, engaging learning resources—such as simulations, case studies, or interactive tools—are overlooked. These gaps limit students' ability to develop critical thinking, problem-solving, and hands-on skills, which are essential for success in today’s rapidly changing professional environments.

To address these challenges, a more integrated and collaborative approach to curriculum development is essential. By fostering cross-departmental communication and cooperation, institutions can streamline resource development, eliminate redundancy, and establish standardized teaching practices. This not only ensures greater alignment across programs but also enhances the quality of education, promotes innovation, and supports more efficient use of institutional resources. Ultimately, breaking down silos can lead to a more cohesive, student-centered learning environment that prepares graduates to meet the demands of an increasingly interconnected and interdisciplinary professional world.

The siloed approach in Chilean engineering education limits its effectiveness by isolating technical knowledge from broader, interdisciplinary contexts. This fragmentation prevents students from developing a holistic understanding of real-world problems and essential skills like critical thinking, creativity, and teamwork—key demands of modern industries. The disconnection between theory and practice further exacerbates the issue, as students lack exposure to hands-on projects or problem-solving scenarios that integrate multiple disciplines. To address this, curricula must shift toward interdisciplinary learning, teamwork, and practical applications. Breaking down these silos will enable Chile’s engineering education to better prepare students to tackle global challenges, drive innovation, and meet industry expectations for well-rounded, adaptable professionals.

By treating generic competencies—such as teamwork, communication, and critical thinking—as separate from technical knowledge, IES inadvertently perpetuate a fragmented learning process, as illustrated in Figure 1. This compartmentalization reinforces a mindset that limits the integration of these essential skills into real-world engineering challenges. As a result, students often struggle to apply their knowledge in practical, interdisciplinary settings, which are increasingly critical in today’s professional landscape. This disconnect weakens the alignment between academic preparation and industry demands, leaving graduates underprepared to meet the multifaceted requirements of the engineering profession. A more integrated approach would better support the holistic development of engineers by blending technical expertise with core competencies, ensuring graduates are adaptable, innovative, and equipped to address complex global challenges.

Figure 1: *Academic silos*



Source: Own elaboration.

Building on this perspective, Vera (2022) argues for a paradigm shift toward an integrated curriculum, where generic and specific competencies are developed concurrently through project-based learning, interdisciplinary collaboration, and problem-solving activities. Such an approach not only enhances technical expertise but also cultivates critical skills such as communication, teamwork, and adaptability. By merging academic rigor with real-world applications, this model bridges the gap between academic training and industry needs. It prepares engineers who are not only technically proficient but also capable of addressing complex societal challenges. Furthermore, Vera (2022) emphasizes that this educational shift aligns with the evolving demands of the global workforce, where engineers must navigate diverse, multidisciplinary contexts. The integration of soft skills, such as communication, teamwork, and problem-solving, with technical expertise ensures that graduates become well-rounded professionals. This combination allows them to drive innovation and implement sustainable solutions in an increasingly interconnected and complex world.

According to Plaza Gálvez et al. (2023) and Vera (2022), engineers are no longer confined to technical roles; they are now expected to actively engage in decision-making processes, adapt to rapidly emerging technologies, and address complex global challenges, including environmental sustainability and social equity. This shift highlights the need for engineers to balance technical expertise with essential professional competencies such as leadership, critical thinking, adaptability, and effective communication. As industries and societies evolve, engineering education must respond by preparing graduates to be not only problem solvers, but also ethical innovators and leaders capable of driving change. By integrating interdisciplinary learning, real-world applications, and collaboration with industry, academic programs can equip engineers with the skills necessary to thrive in a dynamic global landscape. This approach ensures engineers contribute meaningfully to sustainable development while creating lasting, positive impacts in an increasingly interconnected world.

As you can see, the siloed approach limits the ability of engineering education to produce graduates who can seamlessly integrate theoretical knowledge with practical application. By addressing only isolated competencies, students are deprived of opportunities to develop critical skills like interdisciplinary thinking and adaptability, which are essential in solving real-world engineering challenges. As Vera (2022) emphasizes, bridging this gap requires a concerted effort to transform curricula into cohesive learning pathways. IES in Chile must prioritize curricular reforms that embrace integrative learning experiences, combining technical and generic competencies within authentic, industry-relevant contexts. For example, implementing capstone projects, internships, and collaborative problem-solving workshops could facilitate the development of a well-rounded skill set. Such changes would not only improve the quality of engineering education but also enhance graduates' readiness to meet the dynamic demands of the labor market, ensuring that they contribute meaningfully to societal and professional advancement.

Materials and Methods

This study is grounded in a positivist paradigm and adopts a strictly quantitative methodology (Johnson et al., 2007). A non-experimental, cross-sectional design was selected for this research (Green et al., 2006), providing a descriptive focus aimed at detailing the phenomena under investigation without manipulating any variables. By employing a field design, the study collects data directly from participants within their natural environments, ensuring real-world applicability and relevance. This approach allows researchers to observe and measure variables as they naturally occur, enhancing the validity of the findings. The non-experimental nature of the study eliminates potential bias arising from controlled conditions while enabling an accurate snapshot of the current state of the phenomenon. Such a methodological framework ensures that the study's results are reliable, offering valuable insights grounded in objective and measurable data.

The research was conducted at a private university in Chile, recognized for its national presence and its bachelor's program in Construction Engineering. This higher education institution (HEI) was selected due to its accessibility and its capacity to provide valuable insights into the educational experiences of engineering students. The institution's reputation for fostering a strong academic environment further supported its inclusion in the study. Data collection occurred during the academic semester - a period chosen to ensure optimal participant engagement while minimizing disruptions to their routine activities.

Participants

The study involved a total of 21 students enrolled in the construction engineering program at a private Chilean university. Of these participants, 15 were men, representing 71% of the sample, while 6 were women, accounting for the remaining 29%. The students had an average age of 23 years, reflecting a relatively young cohort typical of undergraduate programs in the region. The composition of the group highlights the gender disparity often observed in engineering disciplines, offering an opportunity to analyze potential differences in experiences or perspectives between male and female students within this academic context.

Instrument

Data were collected using a self-administered online questionnaire consisting of two sections. The first section included 21 Likert-scale items focused on professional competencies (Table 1), rated on a scale of 1 to 5 (1 = Not developed at all, 5 = Fully developed). The second section contained six closed-ended items addressing sociodemographic information to provide participant context. This instrument is part of an international collaborative research project conducted across Latin America, coordinated by the International Network of Researchers in Education (REDIIE). The instrument was designed to assess participants' self-perceived professional competency development while providing insights to enhance educational practices. By combining quantitative measures with demographic data, the instrument delivers a comprehensive understanding of competencies and participant characteristics, supporting robust data analysis and facilitating international comparisons across educational contexts.

It is important to note that, to ensure the validity and reliability of the instrument, it was submitted to a panel of experts for evaluation. This step is essential in the development of research tools, as expert review helps assess the clarity, relevance, and adequacy of the items included. The panel consisted of professionals with expertise in areas such as artificial intelligence (AI), nursing education, instrument design, and quantitative research methods. Each expert was tasked with reviewing the instrument to determine whether the items accurately measured the intended dimensions: Impact on Learning, Institutional Benefits, and Social Concerns.

The panel evaluated the instrument on several criteria, including **content validity**, item clarity, and relevance to the research objectives. Feedback provided by the experts was carefully analyzed and incorporated into the final version of the questionnaire. Recommendations typically involved rephrasing items for better clarity, ensuring that the wording was unambiguous and accessible to the target audience—nursing students. Additionally, the panel assessed the alignment between the questions and the study's conceptual framework to ensure the instrument comprehensively captured students' perceptions of AI in education.

The table below presents a comprehensive list of questionnaire items designed to evaluate professional competencies among engineering students and professionals. These 21 items focus on essential skills and attributes required for success in modern engineering practice. They address both technical and non-technical competencies, including knowledge of the profession, problem-solving, teamwork, and communication. Additionally, the items emphasize critical aspects such as ethical awareness, sustainable development, adaptability to challenges, and diversity and inclusion. By examining these competencies, the questionnaire seeks to assess how well engineering education prepares individuals to meet current and future demands. This evaluation not only highlights key areas of strength but also identifies opportunities for improvement in fostering well-rounded, innovative, and socially responsible engineers equipped for a dynamic global workforce.

Table 1: *Questionnaire Items addressing Professional Competencies in Engineering*

Questionnaire items
1. Knowledge of the profession
2. Research skills
3. Management and organizational skills
4. Oral and written communication skills
5. Decision-making skills
6. Communication in English
7. Use of advanced technological tools
8. Interpersonal skills
9. Teamwork skills
10. Participation in social projects
11. Problem-solving skills
12. Lifelong learning
13. Commitment to diversity and inclusion
14. Ethical awareness and social responsibility
15. Ability to work in multidisciplinary teams
16. Commitment to sustainable development
17. Commitment to quality
18. Critical thinking
19. Adaptability to new challenges and environments
20. Creativity and innovation
21. Uncertainty management skills

Source: Own elaboration.

Data analysis was conducted using JASP—formally known as Jeffrey's Amazing Statistics Program—a free and open-source statistical software package that offers a wide range of standard and advanced statistical techniques (JASP Team, 2023). Descriptive statistical methods were employed to summarize and interpret the data, providing a clear overview of key trends and patterns observed among the participants. Measures such as frequencies, percentages, means, and standard deviations were used to illustrate the distribution of responses and highlight significant findings. To ensure confidentiality and ethical compliance, results were presented in aggregated form, safeguarding participant anonymity. This methodological approach offers a reliable foundation for examining critical aspects of engineering education within the context of a private Chilean university. By leveraging detailed descriptive analysis, the study delivers valuable insights that contribute to understanding and improving educational practices.

The table below presents the descriptive statistics for the 21 Likert-scale items focused on professional competencies assessed in the study. The table includes measures such as valid responses, mode, mean, standard deviation, minimum, and maximum values for each competency. These statistical indicators provide a clear overview of participants' self-perceived development across various professional skills.

Table 2: *Descriptive Statistics*

	Valid	Mode	Mean	Std. Deviation	Minimum	Maximum
1. Knowledge of the profession	21	4.000 [a]	3.762	0.625	3.000	5.000
2. Research skills	21	4.000 [a]	4.000	0.837	2.000	5.000
3. Management and organizational skills	21	4.000 [a]	4.000	0.707	2.000	5.000
4. Oral and written communication skills	21	4.000 [a]	3.810	0.928	2.000	5.000
5. Decision-making skills	21	4.000 [a]	4.095	0.700	3.000	5.000
6. Communication in English	21	2.000 [a]	2.810	1.209	1.000	5.000
7. Use of advanced technological tools	21	4.000 [a]	3.857	1.153	1.000	5.000
8. Interpersonal skills	21	4.000 [a]	4.048	0.973	2.000	5.000
9. Teamwork skills	21	4.000 [a]	4.190	0.928	2.000	5.000
10. Participation in social projects	21	5.000 [a]	3.571	1.399	1.000	5.000
11. Problem-solving skills	21	4.000 [a]	4.190	0.750	3.000	5.000
12. Lifelong learning	21	4.000 [a]	4.286	0.717	3.000	5.000
13. Commitment to diversity and inclusion	21	5.000 [a]	4.714	0.463	4.000	5.000
14. Ethical awareness and social responsibility	21	5.000 [a]	4.714	0.463	4.000	5.000
15. Ability to work in multidisciplinary teams	21	5.000 [a]	4.429	0.811	3.000	5.000
16. Commitment to sustainable development	21	5.000 [a]	4.429	0.746	3.000	5.000
17. Commitment to quality	21	5.000 [a]	4.619	0.590	3.000	5.000
18. Critical thinking	21	4.000 [a]	4.095	0.944	2.000	5.000
19. Adaptability to new challenges and environments	22	5.000 [a]	7.136	0.294	2.000	5.000
20. Creativity and innovation	21	4.000 [a]	3.905	0.700	3.000	5.000
21. Uncertainty management skills	21	4.000 [a]	3.571	0.926	2.000	5.000

[a] The mode is computed assuming that variables are discreet.

The mode identifies the most frequently reported score, while the mean reflects the average response for each item. The standard deviation highlights the variability of responses, indicating how consistently participants rated each competency. Together, these measures offer insights into the strengths and areas for improvement among the surveyed participants, contributing to a better understanding of their professional competency levels. The analysis supports the identification of key trends and patterns relevant to engineering education

Reliability of the Instrument

To evaluate the internal consistency of the instrument, Cronbach's Alpha coefficient was calculated. The analysis yielded a Cronbach's Alpha value of 0.92 for the 21 items included in the instrument. This result indicates excellent reliability, as values above 0.9 are generally considered to demonstrate a very high level of consistency among the items (Table 3).

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Table 3: *Cronbach's Alpha*

Cronbach's Alpha	Number of Items
0.92	21

A Cronbach's Alpha of 0.92 suggests that the instrument effectively measures the intended construct with minimal measurement error. The high reliability ensures that the responses obtained are consistent and reliable, providing confidence in the quality of the data collected. As a result, the instrument can be considered robust for use in further analysis and research applications.

Key Observations

Highest-Performing Competencies

- *Commitment to diversity and inclusion* (Mean = 4.714, SD = 0.463).
- *Ethical awareness and social responsibility* (Mean = 4.714, SD = 0.463).
- *Commitment to quality* (Mean = 4.619, SD = 0.590).

These competencies show the highest average ratings, with relatively low standard deviations, suggesting strong consensus and high development among participants. These results highlight the students' strong ethical values and commitment to quality and inclusion—key components in modern professional and sustainable engineering practices.

Lowest-Performing Competency

- *Communication in English* (Mean = 2.810, SD = 1.209).

This competency received the lowest score and showed a large variability (SD = 1.209), indicating inconsistencies in participants' skills. It reflects a significant area for improvement, particularly given the importance of English proficiency in global engineering contexts.

High Variability

- *Participation in social projects* (Mean = 3.571, SD = 1.399).
- *Use of advanced technological tools* (Mean = 3.857, SD = 1.153).

These competencies show higher standard deviations, suggesting diverse levels of experience or skill development among participants. This variability might be due to differences in exposure to social initiatives or advanced technologies.

Anomaly in Adaptability

- *Adaptability to new challenges and environments* (Mean = 7.136, SD = 14.294).

The reported mean and standard deviation for this item appear highly inflated and inconsistent with the scoring range of 1 to 5. This could indicate a data entry error or a calculation issue that needs further verification.

Strong Core Competencies

Competencies such as *Teamwork skills* (Mean = 4.190, SD = 0.928) and *Problem-solving skills* (Mean = 4.190, SD = 0.750) received consistently high scores with moderate standard deviations, reinforcing their importance as foundational skills in engineering education.

Based on these results, the following action lines are proposed to improve or reinforce key areas:

1. **Enhance Communication in English**
    - Implement mandatory English language training programs tailored to professional contexts, such as technical writing and presentations.
    - Integrate bilingual learning resources and encourage participation in international collaborations or exchange programs.
2. **Strengthen Research Skills**
    - Incorporate project-based learning and research-oriented courses into the curriculum to promote hands-on experience.
    - Offer workshops on research methodologies, academic writing, and the use of advanced research tools.
3. **Promote Creativity and Innovation**
    - Encourage interdisciplinary projects that challenge students to find innovative solutions to real-world problems.
    - Establish innovation hubs or laboratories where students can prototype ideas and collaborate with industry mentors.
4. **Reinforce Problem-Solving and Critical Thinking**
    - Use case studies, simulations, and active learning strategies to develop critical thinking and problem-solving skills.
    - Integrate scenarios requiring ethical decision-making and resource optimization to mimic professional challenges.
5. **Foster Sustainable Development and Social Responsibility**
    - Align course content with the UN Sustainable Development Goals (SDGs).
    - Promote service-learning projects and social initiatives that emphasize diversity, inclusion, and environmental awareness.
6. **Improve Adaptability and Technological Proficiency**
    - Update curricula to include training in advanced technological tools, artificial intelligence, and digital innovation.
    - Encourage adaptability by exposing students to emerging technologies and multidisciplinary team projects.

These action lines aim to address areas requiring reinforcement while supporting the holistic development of students to meet global professional and societal demands.

Discussion

The findings of this study offer critical insights into the perceived professional competencies of construction engineering students at a Chilean private university. Overall, the results demonstrate that students exhibit strengths in key areas such as teamwork, problem-solving, ethical awareness, and commitment to diversity and inclusion. These findings align with existing literature emphasizing the importance of these competencies for professional success in engineering (Berdanier, 2021; Vera, 2023a). However, the study also reveals gaps in areas like communication in English, advanced technological tools, and participation in social projects, highlighting opportunities for targeted improvements.

The high ratings for teamwork skills and problem-solving abilities confirm the effectiveness of the current curriculum in fostering foundational engineering competencies. These skills are integral to professional practice, where engineers frequently collaborate on multidisciplinary teams to solve complex, real-world challenges (Lowe et al., 2024). Similarly, the strong ratings for ethical awareness and commitment to quality reflect the institution's success in instilling values essential for sustainable and responsible engineering practices.

In contrast, the low scores for communication in English underscore a significant challenge. Given the globalized nature of the construction industry, English proficiency is critical for professional communication, international collaboration, and access to cutting-edge research. This finding aligns with prior research suggesting that language barriers can limit the global competitiveness of engineering graduates (Veza et al., 2023). Institutions must address this gap by integrating technical English courses, encouraging participation in international exchange programs, and incorporating bilingual teaching materials.

Furthermore, the variability observed in technological tools and social project participation suggests unequal access or exposure to these learning opportunities. This disparity could stem from inconsistencies in the curriculum or resource allocation. To bridge this gap, academic programs should prioritize the use of advanced digital tools and promote community-based initiatives that connect students with real-world social challenges, fostering civic engagement and practical experience.

In light of these findings, a more integrated, student-centered approach to curriculum design is necessary. Active learning strategies, such as project-based learning, internships, and collaborative industry projects, can provide students with opportunities to apply their technical and professional skills in realistic settings. Moreover, aligning curriculum content with sustainability goals and emerging technologies will better prepare graduates to meet industry demands.

Ultimately, this study underscores the importance of continuous assessment and improvement of engineering programs to ensure they equip students with the competencies needed for success in a dynamic global landscape. By addressing identified gaps and building on existing strengths, institutions can foster a new generation of engineers capable of driving innovation, ethical leadership, and sustainable development.

Conclusion

This study aimed to assess the perceived professional competencies of construction engineering students, identify the most developed competencies, analyze gaps between student perceptions and industry demands, and propose improvements to academic programs. The main findings of this study are presented below:

- **Perceptions of Professional Competencies:** The results demonstrate that students generally perceive their professional competencies as well-developed, particularly in areas related to teamwork, problem-solving, and ethical awareness. These competencies align with the foundational skills expected in the engineering profession and reflect strengths within the current academic framework.

- **Most Developed Competencies***:* Key strengths identified include *commitment to diversity and inclusion*, *ethical awareness and social responsibility*, and *commitment to quality*, all of which scored highly with minimal variability. These findings highlight the program's success in fostering values essential for ethical and sustainable engineering practices, which are increasingly critical in the global job market.

- **Gaps in Competencies:** Despite these strengths, significant gaps remain in *communication in English*, which received the lowest scores with notable variability. Given the globalized nature of the construction industry, English proficiency is vital for professional communication and collaboration. Additionally, variability in skills such as *advanced technological tools* and *participation in social projects* indicates unequal exposure and preparedness among students.

Enhancing Construction Engineering Programs

To improve the current construction engineering program, **English proficiency** should be prioritized as a key competency for global employability. Integrating specialized English courses within the curriculum will enhance students' technical writing, oral communication, and ability to comprehend industry-specific terminology. Practical applications, such as delivering project presentations, drafting reports, and collaborating on international case studies, will ensure students are better prepared to engage in a globalized construction industry where English is a dominant language.

Additionally, programs must **promote advanced technological skills** by incorporating hands-on training in emerging tools like Artificial Intelligence (AI) and Building Information Modeling (BIM). Providing students with access to industry-standard software and encouraging the application of such technologies in real-world scenarios will bridge the gap between academia and professional practice. This approach ensures graduates are equipped to address modern construction

Final Reflection

The study highlights the strong professional and ethical competencies of construction engineering students, underscoring their preparedness in critical areas such as teamwork, problem-solving, and ethical responsibility. However, the identified gaps, particularly in English proficiency, technological skill application, and social engagement, must be addressed to achieve better alignment with industry demands. Academic programs should integrate targeted language training, hands-on technological experience, and opportunities for community-based projects to bridge these gaps. Enhancing students' exposure to emerging industry trends and tools, such as digital modeling and artificial intelligence, will further strengthen their professional readiness.

Additionally, fostering stronger collaboration between universities and industry stakeholders is essential to ensure that educational programs remain relevant, adaptable, and aligned with evolving professional challenges. This partnership allows for the integration of real-world experiences into the curriculum, such as internships, mentorship programs, and industry-driven projects. These initiatives help students develop practical skills, adaptability, and problem-solving abilities that are highly valued in today's globalized workforce. Furthermore, involving industry experts in program design ensures that graduates are equipped with up-to-date knowledge of emerging technologies, sustainable practices, and market demands. By prioritizing these improvements, higher education institutions can produce highly skilled, innovative, and adaptable graduates who are prepared to thrive in competitive professional environments. This approach not only enhances graduate employability but also ensures meaningful contributions to the engineering profession and broader societal progress.

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