Bridging Theory and Practice: Exploring Real-World Problem Solving for Construction Engineering Seniors

Prof. Carmen Paz Munoz, Universidad Andres Bello, Chile

Carmen Paz has a degree in Civil Construction from the Universidad Técnica Federico Santa María and a master's degree in Real Estate Development from the Universidad de Chile. She has over 22 years of experience in the areas of concrete construction, the cement industry, ready-mixed concrete, construction process consultancy, and concrete deterioration and durability. In addition, she has more than 16 years of experience in university and field-based teaching. She is the Director of the Construction Engineering program at the Universidad Andrés Bello in Santiago, Chile, and a permanent contributing columnist for the Negocio & Construcción magazine. Her areas of interest include improving academic management in the Construction Engineering degree program and seeking new ways to enhance the experience of students and teaching professionals at the university. She also focuses her efforts on recruiting and retaining students to the program and ensuring they can learn key concepts in the most meaningful manner possible.

Dr. Monica Quezada-Espinoza, Universidad Andres Bello, Chile

Monica Quezada-Espinoza is a professor and researcher at the School of Engineering at the Universidad Andres Bello in Santiago, Chile, where currently collaborates with the Educational and Academic Innovation Unit, UNIDA (for its acronym in Spanish), as an instructor in active learning methodologies. Her research interest topics involve university education in STEM areas, faculty and continuing professional development, research-based methodologies, community engagement projects, evaluation tools and technology, and gender issues in STEM education. https://orcid.org/0000- 0002-0383-0179

Bridging Theory and Practice: Case Studies for Construction Engineering Seniors

Abstract
Many researchers advocate integrating real-world problem analysis into science-related subjects using case study approaches. These approaches engage students with practical issues, fostering sophisticated thinking, promoting reflection, integrating, applying prior knowledge, and developing self-management learning skills. In our university's Construction Engineering program, introducing case studies addressing real-world problems in thesis projects in the first semester of 2017 significantly improved the graduation rate, rising from 10% in 2016 to 25.9% by 2022. These enhancements across various performance metrics demonstrate the efficacy of this methodology. This research employs a non-experimental mixed-methods approach, utilizing surveys and interviews as primary data collection tools. Its objective is to assess the influence of the case study methodology on the education of Construction Engineering students. It investigates the perspectives of current students, alumni, and instructors, proposing enhancements to the comprehensive curriculum. The study involves three participant groups—students, alumni, and instructors—associated with the course responsible for final degree projects. Projects entail collaborative analysis of real cases within groups of three students. The study includes learning outcomes and evaluations assessed using course-specific rubrics to support interview findings. Graduates are expected to share insights on methodology practicality and its influence on their careers. Current students addressing real-world issues in their projects evaluate prior knowledge integration. Instructors identify process challenges and weaknesses. This collaborative effort aims to validate and enhance the case study methodology in the degree program, thereby contributing to the assessment of the program's declared learning outcomes.
Keywords: *Case study methodology, Collaborative work, Construction Engineering, Mixed-methods approach, Real-world problem analysis, senior students*

Introduction

This research article examines real-life construction case studies as a teaching method in an integrative course where creating a portfolio is a graduation requirement. This course represents one of the final academic stages for students in the Construction Engineering program at a large private Chilean university. The portfolio is developed collaboratively and encompasses various phases, which will be detailed later. After several years leading this program, the primary researcher of this paper observed that the timely graduation rate was below expectations. Before 2018, when the new curriculum was implemented - graduation was via a thesis; indicators showed a graduation delay of two years from leaving the program and a timely graduation rate of 3.4%. This situation occurred when the requirement for graduation was the completion of an individual thesis, in which students had to research a topic related to construction, materials, or new technologies. In 2018, a proposal was made to improve these indicators, and a change in the curriculum was suggested. The new approach involves a collaborative effort to analyze real-life cases and create portfolios that integrate various skills and knowledge of the students. This experience also helps them deal with the challenges related to the analyzed case and group dynamics, preparing them for similar situations they may encounter in their future work in the construction industry.
Several authors have analyzed the benefits of adopting case study methodologies in different disciplines in the context of the formative process. By their definition, these methodologies enhance the student's leading role. These authors agree that solving real problems becomes a

means to acquire or integrate practical knowledge and promotes the development of critical skills and meaningful learning [1-3].

Araya [4] states that small group work benefits students' integral development. Teamwork allows them to develop fundamental skills and attitudes for professional practice, enabling them to argue their proposals and solutions in a collaborative environment. Similarly, Bedregal et al. [5] conclude that students recognize the contributions of each team member, constructive criticism, and equitable participation as relevant aspects of teamwork. In precursor research, Davis and Yadav [6] determined that students place significant value on achieving "collaborative teamwork" competence. This valuation highlights the importance students attribute to acquiring skills that allow them to respond professionally in multidisciplinary and complex work scenarios. This valuation has been studied not only in engineering but is highlighted as a characteristic that transcends the academic realm, preparing students in other areas (e.g., nursing) for challenges in the labor world [6]. On their part, Davidson and Major [7] suggest that small group learning promotes student protagonism in their formative process; interaction among them improves motivation and develops critical and creative thinking abilities. Furthermore, regarding students' academic performance in courses that confront real problems, [4] establishes that practical activities yield better academic performance and an improved perception of learning achievements. This relates to students' support in problem development, with quality feedback, which does not necessarily occur in a traditional class [8-9].

In terms of the teacher's role, it has been shown that the influence of the teacher, acting as a facilitator, must be considered fundamental if case studies are expected to generate effective change in students [10-11]. According to Magalef and Canabal [12], there are more effective ways to develop competencies than simply transferring knowledge from teachers to students. Instead, they suggest learning occurs when the case study methodology and effective feedback facilitate adequate interaction between teachers and students. The study also highlights that the role of academics is to guide the process in a structured manner, helping to consolidate the knowledge acquired in previous courses. This is particularly important in the context of an integrative subject, which can be effectively applied in the Final Construction Engineering Portfolio Course.

In this approach, the teacher acts not only as an information transmitter but as a mediator, facilitating active knowledge construction through collaborative interaction between teachers and students [11,13]. Considering the study by Okere and Giroux [14] in the specific work field of construction engineering, it establishes that the case study methodology can positively impact the training of future engineers, as it exposes them to situations required by the industry. Additionally, students will develop problem-solving skills, teamwork, and critical thinking necessary to adapt to changing projects and contexts, complementing their technical-disciplinary training [1, 2, 14].

Under the framework of Chile's General Law of Urbanism and Construction (Ministry of Housing and Urbanism, 2023) [15], it is established that competent professionals are those who possess legal authorization to practice their disciplines and assume total responsibility in their actions or omissions within their specific competence area. For active participation in construction projects, these professionals must demonstrate the validity of their professional license, supported by a recognized professional title, and be duly registered in the construction permit corresponding to each project. Under this regulation, competent professionals include architects, civil engineers, and construction engineers. Within their area

of competence, each performs tasks and works dictated by the Chilean legal framework. In this scenario, it is crucial to recognize that graduates in construction engineering play various roles in projects, acquiring applied skills and technical knowledge a determining factor in their professional success. Therefore, it is imperative that academic training provides the necessary tools to face the industry's challenges, ensuring successful and effective job placement.

At the university where this study was conducted, students in Construction Engineering (CE) have been graduating through the Final Construction Engineering Portfolio Course since 2018. The course emphasizes collaborative teamwork among three members who analyze various proposals and simulate the project's materialization. It mainly focuses on the economic and technical considerations of real projects the State of Chile tendered.
The course is structured over 16 weeks, each week dedicated to solving various topics that form part of the project analysis. Additionally, the teams submit two reports - one intermediate and one final - and work in parallel on installation projects and proposals for execution and analysis of the involved construction processes. The course is designed based on a case study methodology. Having outlined the structure and methodology of the course, we now turn to our study's specific areas of interest and research objectives.

Interests and motivations

This research transcends local boundaries and aims to contribute to the global discourse in Construction Engineering education. Our investigation is grounded in three critical areas, each holding significant implications not only for our local context but also for the broader international community:

- Students' perceptions of curriculum relevance and learning experience: One of the primary interests of this study is to delve into how students perceive the relevance of the curriculum to their future professional endeavors in construction engineering. We are interested in exploring their views on the applicability of the knowledge and skills they acquire and how these align with the demands and realities of the construction industry. Furthermore, the study aims to gauge students' overall learning experience, focusing on the course content's engagement, challenges, and practicality. Understanding students' perceptions is crucial as it directly influences their motivation, learning outcomes, and overall satisfaction with the course.
- Graduates' evaluation of the course's contribution to job placement: Another key area of interest is to evaluate the course's effectiveness from the graduates' perspective. This includes assessing how well the course has prepared them for their careers and its impact on their job placement. The study seeks to understand the graduates' views on the course's role in equipping them with the necessary skills and knowledge for the construction sector and how these have translated into real-world applications and employability. This evaluation will provide insights into the long-term benefits of the course and its alignment with professional requirements.
- Teachers' perspectives on implementation and effectiveness: Finally, the study aims to gather insights from teachers regarding the course's implementation and effectiveness. Teachers' perspectives are invaluable in evaluating the course structure, teaching methodologies, and the overall delivery of the curriculum. Their views on what works well and what could be improved are essential for continual course refinement. Additionally, understanding their experiences and challenges in teaching the course will provide a comprehensive view of the educational process and its efficacy.

The overarching motivation of this study is to contribute to the global advancement of Construction Engineering education. By exploring these key areas, our research aims to provide valuable insights that resonate beyond our local context, offering recommendations and strategies that apply to a broader international audience. The goal is to foster a collaborative and informed approach to engineering education that prepares future professionals for the challenges and opportunities of a globalized construction industry.

Research Questions

RQ1: What are students, graduates, and teachers' perceptions about the contribution of the integrative course's learning outcomes applied through real-life case analysis in construction?
RQ2: How do students value the graduation course in terms of integrating previous knowledge and the utility of real-life case analysis?
RQ3: How do graduates perceive the influence of the course on their initial job placement?
RQ4: What are the teachers' perceptions of the strengths, weaknesses, and opportunities for course improvement?

Objective

This study aims to analyze and evaluate the contributions of the "Final Construction Engineering Portfolio Course" to training construction engineers. This involves assessing its impact on the development of essential skills and the practical application of knowledge in addressing real-world challenges. The goal is to offer targeted recommendations for enhancing the course's effectiveness and relevance within the contemporary educational landscape.

The following sections will detail the adopted methodology and the results obtained from the implemented instruments. Subsequently, a critical analysis will be conducted based on existing literature to formulate concrete recommendations to enhance the effectiveness of the course and its relevance in the contemporary educational context. In addition, a comparative integration and analysis of the results obtained from the three studied samples will be carried out. To conclude, the study's conclusions will be presented, highlighting the limitations encountered and the possible directions for future research in this field.

Methodology

In this study, we adopted a mixed-methods approach, combining quantitative and qualitative methods. Integrating various types of data and methodological approaches enhances the understanding and validity of the findings.

Participants

The study encompasses three key groups:

- Students group (SG): Students from the "Final Construction Engineering Portfolio Course" during the second semester of 2023 (18 participants: 17 males, one female).
- Alumni Group (AG): 32 participants in the Construction Engineering program alumni took the course between 2018 and the first semester of 2023. Out of the 32 participants, 22 were male and ten were female. The largest group of participants were the 2022 graduates, accounting for 34% of the total participants.

- Instructors Group (IG): consists of six members, four males and two females, each with specific roles and expertise in technical and administrative aspects of the course.

Context

Our university's Construction Engineering (CE) program spans ten semesters and currently has 190 students, with a 10% female participation. An essential curriculum component is the "Final Construction Engineering Portfolio Course" integrative course offered in the tenth semester. Per the university decree regulating the program, the title portfolio course contributes to the two disciplinary areas of realization composed of the learning outcomes (LO), see Figure 1.

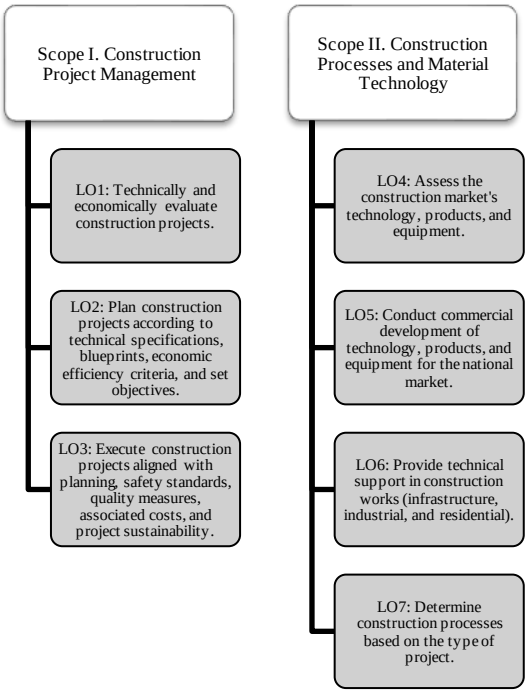

Figure 1. Learning outcomes and curriculum structure.

This course stands out for its collaborative approach. Students are grouped into triads based on their past academic performance to ensure a well-rounded mix of skills. In a nontraditional format, the course blends theory with practice, focusing on teamwork, analyzing real construction case studies, and presenting weekly topics such as proposal analysis, construction execution, cost analysis, and project management.

The course's practical sessions involve:

- studying the construction processes that are relevant to the projects,
- exploring the possibility of implementing new technologies and
- analyzing technical and administrative data from real projects tendered publicly.

The program guides students through various tasks, including reviewing technical documents, assessing financial strategies, and optimizing processes. This will help them prepare for real-world challenges in construction engineering. Additionally, the course includes a Community Engagement activity that enhances the practical application of academic theory.

Materials and methods: Surveys

We employed two structured surveys, each featuring questions based on the Likert scale ranging from 1. Strongly disagree to 5. Strongly agree, in addition to open-ended questions. The surveys are described as follows:

A. Survey for active students in the CE program: Students were incorporated into the study through purposive non-probability sampling. The survey aims to analyze the perception of the contribution towards achieving the learning outcomes (LO) that the proposed methodology for developing the title portfolio course has in the training of Construction Engineering students. Additionally, to assess the perception of the integration of previous courses into their educational process. The survey consists of the following sections:

- Perception of the fulfillment of learning outcomes (e.g., The title portfolio workshop course allowed me to evaluate construction projects technically and economically.) Likert
- Perception of knowledge integration by training areas (e.g., The following areas were helpful to me in the development of the title portfolio course project: Construction Management Area (Unit price analysis, Work scheduling, Construction legislation, Works administration, Human resources, etc.) Likert
- Perception of the courses and tools that contributed most and least to the title portfolio course. Open-ended
- Opinions on their individual and group experience developing the title portfolio course. Open-ended

This survey was completed by all students enrolled in the course, corresponding to 18 enrolled students.

B. Survey for alumni of the CE program: Alumni were incorporated into the study through non-random convenience sampling (self-selection). The survey aims to analyze the perception of the contribution to professional development through the learning outcomes of the proposed methodology for developing the title portfolio course. Additionally, to evaluate the perception of the influence of the course on job placement in their first work experience within the construction industry. The survey consists of the following sections:

- Perception of the fulfillment of learning outcomes. Likert
- Perception of the influence of the title portfolio on the first work experience (e.g., Please detail both positive and negative aspects of your experience in the title portfolio course and how it influenced your job placement, considering your first job in construction.). Open-ended

Materials and methods: Focus group

We conducted a focus group with six instructors from the Final Construction Engineering Portfolio Course, taught from August to December 2023. This group was selected through purposive non-probability sampling. The primary goal of the focus group was to gather feedback and perspectives from the instructors regarding the course, especially concerning the final integrative project. Our objective was to identify potential improvement areas and strengthen the students' educational experience using a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. The collaborative discussion lasted two hours, with 15 minutes allocated to address each of the SWOT factors, where instructors first wrote down their ideas and then verbalized and discussed them with their peers (see Appendix 1). The session concluded with a general discussion on the students' perceptions of achieving learning

objectives and their collaborative dynamics. Furthermore, instructors were requested to express their level of agreement regarding attaining the learning outcomes through an online form.

Data analysis

In the analysis phase, we triangulated the data collected from the surveys and the focus group. This triangulation thoroughly compared the quantitative and qualitative findings to achieve a more comprehensive and validated understanding of the studied phenomenon. We looked for areas of agreement and disagreement among students, alumni, and instructors. This approach allowed for a richer and more nuanced interpretation of the data, facilitating the identification of convergences and divergences among the different groups and types of information collected.
For qualitative data analysis, we utilized NVivo software. This process included a detailed review of the open-ended survey responses and the focus group discussions. We engaged in reflective content analysis with emergent categorization to identify significant themes and patterns. This ensured that our interpretation was firmly grounded in the perspectives and experiences expressed by the participants.

Results

The results are divided into three groups: students, alumni, and faculty participants. Afterward, a thorough analysis of all these outcomes is conducted to merge the key findings discovered.

A. Students results

Firstly, the survey conducted among the students, explained in the previous sections of the report, forms the most comprehensive part of the study. It examined various dimensions, including knowledge areas, learning outcomes, the contribution of different fields to the final project, acquired tools and skills, and individual and collective academic experiences. The results are presented systematically in tables and figures to summarize the findings effectively. In certain instances, it is noted that additional and more specific information is available in the appendices.

Training areas. Students were asked to indicate their level of agreement with the following statement: The following areas were useful in developing the course project for the degree portfolio. They were provided with the following list, including examples for each area.

- General Education and English Area (courses such as English, Oral and Written Communication, Social Responsibility, etc.)
- Construction Management Area (courses such as Unit Price Analysis, Construction Scheduling, Construction Legislation, Project Management and Human Resources, etc.)
- Construction Processes, Materials, and Structures Area (courses such as Concrete Technology, Building Processes, Sustainable Construction and Habitability, Wood and Steel Construction, etc.)
- Facilities, Equipment, and Professional Training Electives Area (courses such as Surveying, Sanitary Installations, Road Infrastructure, Electives, etc.)

Based on the responses, Figure 2 graphically represents the level of agreement with this item (by area).

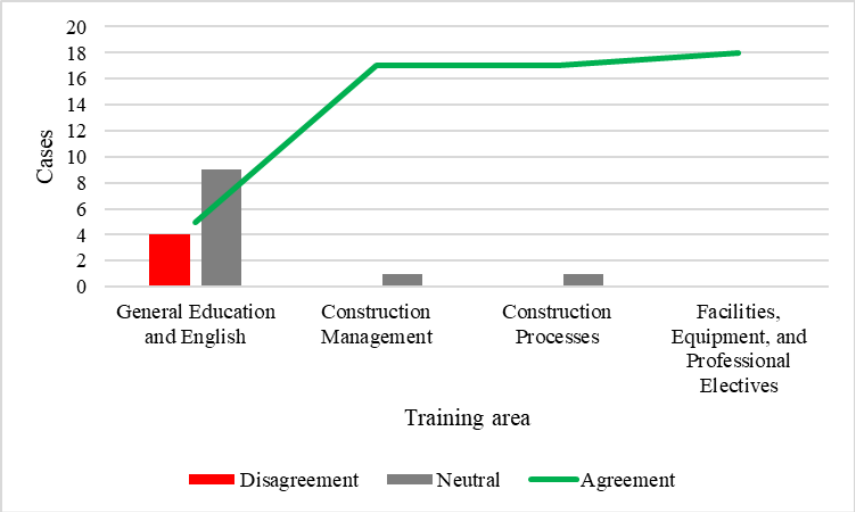

Figure 2. Agreement perceptions regarding training areas.

Regarding the General Education area, 4 students disagreed, and 9 were neither in agreement nor disagreement.

Perception of most and least contributory courses and tools in the Final Construction Engineering Portfolio Course

Students were given a list of conceptual and technical tools as part of the capstone course design. The students were asked to choose the top five tools they believed would be the most helpful for the project, followed by the ones they considered least useful. Table 1 below provides a summary of the students' selections. Detailed tables of all responses can be found in Appendix 2.

Table 1. Courses and tools with the highest and lowest contributions to the portfolio course.

#	Most helpful (Frequency)	Least useful (Frequency)
1	Construction Scheduling and Deadline Analysis. (9)	Risk prevention considerations. (14)
2	Quantity Surveying and Budgeting. (9)	Ability to perform construction checklists and supervision. (12)
3	Technical Specification Analysis, Administrative Basis, and Blueprint Reading. (9)	Installation coordination. (10)
4	S-Curve Analysis, Physical and Financial Progress. (8)	Capability to execute construction process protocols. (10)
5	Regulatory Analysis, Zoning Plans, and OGUC (General Urban Construction Ordinance). (8)	Proposal of technical solutions and material selection. (7)

Personal and collaborative academic experience of students in completing the final project.

Responses to these two questions were categorized, and the main findings are presented below.

For the personal experience, the following question was asked: "Provide your opinion on your academic and personal experience in completing the final project based on the analysis of real construction cases." The categories that emerged are presented in Table 2 below.

Table 2. Categorization of student responses on academic personal experiences in completing the final project based on real construction case analysis.

Academic, personal experience (SG)	
Categories emerged (frequency)	*Description (an example of response)*
Activity Design Recommendations (5)	Suggestions on improving the course structure and tools, focusing on better use of essential programs, and more considerate deadline setting concerning other assignments. - *"I would recommend reinforcing the use of the Project program since it's what we are least familiar with, and it's quite important."*
Integration of Knowledge (6)	Reflections on how the project enables the synthesis and application of knowledge gained throughout the degree, encompassing various topics from materials and management to technical aspects like physics-based building calculations. -*" This provided a good opportunity for feedback on the subjects studied throughout the degree, such as the use of technologies (Project), which was one of the most significant challenges."*
Personal Experience (6):	Individual perceptions of the project vary from enriching and rewarding to challenging and frustrating, with a focus on the impact of assessment methods on motivation. - *"Personally, it has been quite an enriching experience and, at the same time, very frustrating."*
Practical Application and Realism (4)	Opinions emphasize the project's practicality and its realistic depiction of project execution, offering a more hands-on experience than theoretical studies like a thesis. - *"I believe it is more useful than a thesis because it's an intensely applied process."*
Preparation for Professional Life (9)	Insights into how the project prepares students for real-world engineering challenges, enhancing future career skills by providing experiences that mirror professional scenarios and decision-making. - *"I was able to delve into a project that I hadn't evaluated before, which helped me improve my skills as a future engineer."*
Skills Development (3)	Descriptions of personal development in critical thinking and decision-making, highlighting the enhancement of collaborative skills and the ability to analyze problems from multiple angles for comprehensive solutions. - "*My experience has been very pleasant as it demands analysis and critical thinking about various situations that arise within the course's development."*

Academic group experience according to the student's group for an open-ended question: "Provide your opinion on your academic group experience in completing the final project based on the analysis of real construction cases." The categories that emerged are presented in Table 3 below.

Table 3. Categorizing student responses to academic group experiences in completing the final project based on real construction case analysis.

Academic group experience (SG)	
Categories emerged (frequency)	*Description (an example of response)*
Challenges & Limitations (7)	This category reflects on the group's diverse viewpoints and potential shortcomings, impacting the overall performance and outcomes, such as more straightforward work approaches or significant skill deficiencies among peers. - *"Each member had different thoughts on how to carry out each presentation, where some wanted to do simpler work, that is, without going beyond, which was later reflected in the grade."*
Collaborative Learning (7)	It focuses on the mutual learning experience and the respect for diverse ideas within the group, highlighting the benefits of working together and learning from one another throughout a project. - *"We achieve it by doing a project during a semester with our peers; we learn from each other and complement each other."*
Practical Application (4)	This category underscores the relevance of the course in covering essential aspects of the degree and analyzing real-world construction project experiences, emphasizing the practical utility of the curriculum. - *"The course is very enriching because it covers all the fundamental subjects of the degree."*
Skills Development (7)	It captures the growth in key competencies like leadership and communication and improved group work effectiveness, showcasing personal and professional development through the course. - *"It allowed me to develop leadership and communication skills."*
Teamwork Experience (13)	This category emphasizes teamwork aspects, including developing a cooperative spirit to achieve common goals and responsible and respectful interactions among group members. - *"As a group, it helped us to complement each other with a focus on achievement; there was development of teamwork, which increased as we progressed in the project."*

B. Alumni results

The methodology section describes the process of a survey administered to alumni. The survey explored two main dimensions. The first dimension assessed learning outcomes, while the second dimension investigated the positive and negative aspects of their experience in the capstone portfolio course. The survey also investigated the impact of this course on their job placement, with a particular emphasis on their first professional position in the construction industry. The findings corresponding to the first dimension are presented at the end of this section.

Regarding the second dimension, the survey collected 67 testimonials, of which 39 were positive, representing 58.2%. Table 4 displays a detailed graphical representation of the emerging categories and the associated positive and negative comments.

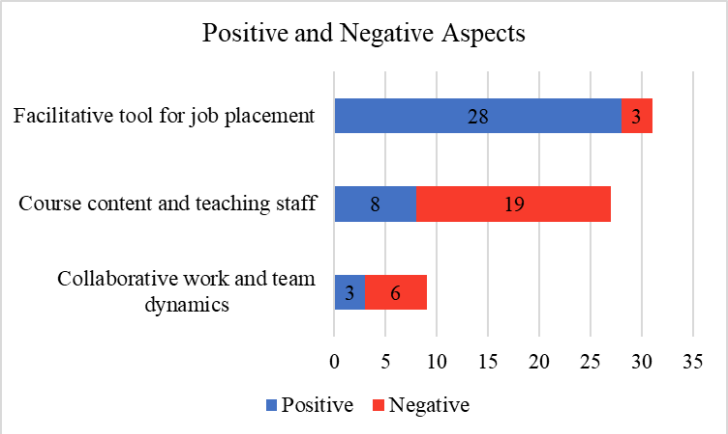

Figure 3. Graphical representation of the emerging categories and the associated positive and negative comments.

Table 4 below outlines emerging categories from analyzing the question posed to CE program alumni, along with one positive and negative example for each category.

Table 4. Emerging categories from analyzing the question posed to CE program alumni.

Negative and positive experiences (AG)	
Categories emerged (frequency)	*Description (an example of response)*
Collaborative Work and Team Dynamics (31) *Positive: 28* *Negative: 3*	This category encompasses the effectiveness of collaborative work and interaction among students within the academic framework of the course. It considers aspects such as teamwork, knowledge exchange, cooperation in projects, and the impact of these dynamics on learning and academic performance. (+) *"Managing people and teamwork, dealing with peers who are not always in our comfort zone, is the main lesson of the portfolio course."* (-) *"Personally, my experience with teamwork was challenging. I believe there should be follow-up with each group member to ensure shared responsibility and commitment."*
Course Content and Teaching Staff (27) *Positive: 8* *Negative: 19*	This category focuses on the evaluation of the course content, including the relevance and updating of teaching materials, the employed teaching-learning strategies, the assessment methodology, the competence and pedagogical effectiveness of the teaching staff, and the alignment of the contents with the curricular and professional demands of the construction engineering field. (+) *"Some positive aspects include a thorough internalization of what encompasses a construction project, from administrative foundations to execution, integrating and applying everything learned in previous courses, as well as excellent support from the teachers in the project development."* (-) *"There is a need for deeper exploration in several technical subjects."*
Facilitative Tool for Job Placement (9) *Positive: 3* *Negative: 6*	In this category, course factors that contribute to graduates' job placement are identified and analyzed. It includes the students' perceptions of how the course has facilitated or limited their success in transitioning to the professional sphere and the relevance of the skills and knowledge acquired in their initial experiences in the construction sector. The course's effectiveness as a link between university education and the job market is considered. (+) *"One of the main aspects that the portfolio benefited me in real life was determining the technical study of a project, that is, quantifying, planning, calculating performance and APU, calculating installations, etc. All these factors helped me to develop in my first job after graduation."* (-) *"I would like for future generations to have reinforcement in the programming area for a better understanding of the subject and its application in the field."*

C. Instructors results

The SWOT analysis focused on four categories emerging from the faculty team's comments. These are:

(1) Inter-student: This encompasses reflections on collaborative work and students' attitudes in facing the study of the project.

(2) Faculty and curricular elements: These consider aspects of the curriculum, course content, and the relationship between faculty and students in terms of feedback and guidance in the study of the project.

(3) Administrative issues: Elements detected related to the enrollment in the course, coordination of submissions, course structure, and clarity in instructions, and finally, (4) Community engagement and employability: This includes working with external communities and companies regarding students' job placement.

Figure 4 presents a summary of the findings grouped into the four categories mentioned above; the strengths identified by the faculty total 21, highlighting the promotion of teamwork, integration, feedback, and the relationship between faculty and students. On the other hand, 19 identified weaknesses in the project. These weaknesses mostly pertain to the diagnostic and verification processes to ensure that all students start from the same prior knowledge level.

Additionally, it is recommended that visits to similar projects be included in the study to provide a more comprehensive understanding of the subject matter. Regarding the 18 identified threats, the faculty mentions the lack of motivation and adaptation of students, various technological advancements, and skills in synthesis and critical analysis as the most relevant. At the same time, the opportunities for improvement can be summarized by implementing diagnostic evaluations and strengthening elements of community engagement, totaling 20 observations.

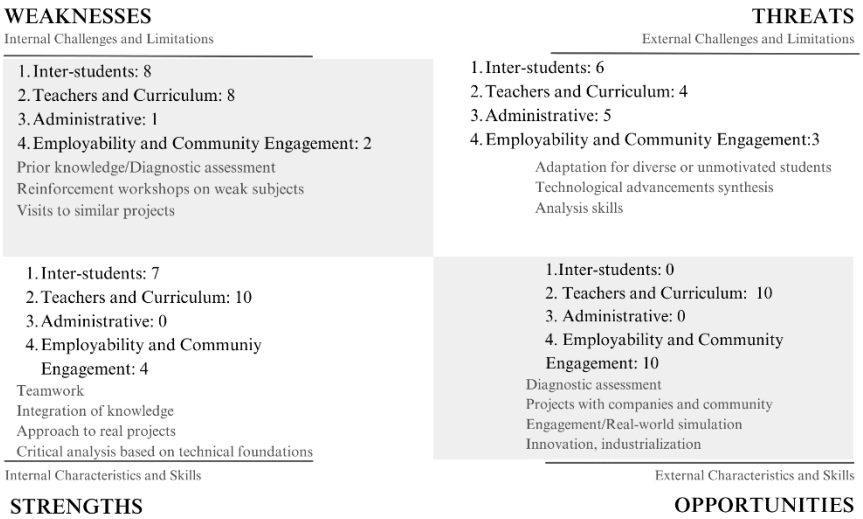

Figure 4. Detailed results of the SWOT analysis conducted with faculty members.

D. Integration of results from the three participant groups

Regarding learning outcomes, Figure 5 displays a graph depicting the cumulative level of agreement among the three participant groups concerning the achievement of the learning outcomes stated in Fig. 1. To create this graph, responses of '5. Strongly Agree' and '4. Agree' were combined into a single category representing general agreement.

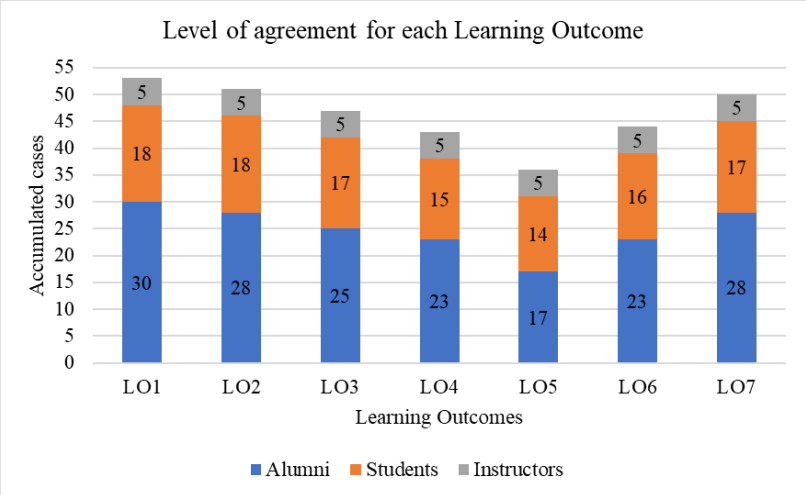

Figure 5. Cumulative level of agreement among the three participant groups regarding the achievement of learning outcomes.

As shown in Fig. 5, according to the participants (SG, AG, IG), the three weakest learning outcomes are LO4, LO5, and LO6. Conversely, the most strengthened learning outcomes are LO1, LO2, and LO7, with LO3 appearing to have a moderate level.

Upon analyzing the results from the three participant groups (students, alumni, and faculty), several common themes and areas of interest emerge from the different perspectives. These themes are crucial for proposing improvements to the course and related practices. A synthesis of the key findings and their integration is presented below.

i. Collaboration and Teamwork

Students: Highlighted the importance of collaborative learning and teamwork, reflecting both challenges and benefits in group experiences.
Alumni: Specifically mentioned collaboration and team dynamics as significant elements of their experience.
Instructors: Pointed out the promotion of teamwork as a strength of the course.

ii. Course Content and Instructor Role:

Alumni: Evaluated the course content and the effectiveness of the teaching staff, with both positive and negative comments.
Instructors: Considered aspects of the curriculum, course content, and the relationship between faculty and students.

iii. Preparation for Professional Life and Practical Application

Students: Emphasized how the project prepares students for real-world engineering challenges and enhances skills for their professional careers.
Alumni: Identified the course as a facilitative tool for job placement.

iv. Administrative Elements and Course Structure

Students: Identified areas for improvement in the creation of materials (e.g., rubrics) and the deadline submissions throughout the semester.
Instructors: Identified administrative aspects as weaknesses, suggesting the need for course structure and clarity improvements.

v. Community Engagement and Employability:

Faculty: Underlined the importance of connecting with external communities and companies concerning students' job placement.

Integration of findings to propose improvements to the portfolio course based on the analysis of real construction cases:

- Develop strategies to strengthen teamwork, addressing both the positive aspects (collaboration, mutual learning) and the challenges (diversity of opinions, member commitment).
- Review and update the course content and teaching methodologies to align them with current professional and academic needs.
- Enhance the connection between theoretical content and practical application, emphasizing preparation for real professional situations.
- Improve administrative elements and course structure to ensure a more coherent and clear learning experience.
- Encourage community participation and interaction with the professional sector to improve student employability.
- Integrating findings from different perspectives provides a solid foundation for formulating specific recommendations that address the needs and experiences of all participant groups, thereby improving the effectiveness and relevance of the course in the contemporary educational landscape.

Integrating insights from students, alumni, and instructors, alongside a critical assessment of learning outcomes, offers a comprehensive view of the Final Construction Engineering Portfolio Course. This synthesis underscores the course's strengths in promoting teamwork and professional readiness while highlighting areas for growth, particularly in learning outcomes LO4, LO5, and LO6. Balancing theoretical knowledge with practical application, refining administrative and structural elements, and addressing specific learning gaps are imperative. This reflective approach identifies areas for enhancement and validates the course's role in preparing students for real-world engineering challenges, enriching their educational experience.

Discussion

The discussion of this study focuses on interpreting the key findings, revealing that the capstone project course, based on the analysis of real construction cases, acts as a key integrator at the end of the academic program. This course strengthens fundamental aspects of training construction engineers, such as collaborative work, case analysis in real-world contexts with their respective challenges, the integration of technical and conceptual tools throughout the program, and the significance of the teacher's role in this process.

Teamwork and student interaction emerge as fundamental elements for the success of the course. This is corroborated in the literature, where the importance of cooperation and teamwork skills in any academic discipline, transferred to learning in small groups, is highlighted [16]. This aspect, mentioned by Davidson and Major [7], is confirmed in our study, as 46% of the comments from alumni are related to this point. Likewise, in the student group, this category records the highest number of mentions among the five detected, accounting for 34% of the total. On the other hand, administrative factors do not have a significant impact on the achievement of student competencies.

Regarding the perception of integration of prior knowledge, both students and alumni agree in highlighting the positive aspects of the course. Students, in particular, value the relevance of the contents of previous disciplinary subjects when preparing their portfolios, reflecting the pertinence between the learned theory and its practical application. In this context, Rico et al. [17] assert that exposing students to implementing projects contextualized in real-life situations and group work promotes integrating previous theoretical and practical knowledge. However, a less favorable perception is identified regarding the contribution of general education and English subjects to the development of their final projects. This finding indicates a possible improvement in integrating these subjects with the students' specific projects, aiming to strengthen the practical application of knowledge acquired in non-disciplinary subjects, thus enhancing their overall integral training.

Regarding preparation for the first work experience, graduates positively perceive the course. It allows them to face real work situations, supporting the conclusions of Okere and Giroux [14], who argue that exposure to industry-relevant practical cases is essential for a comprehensive education. Concurrently, the course validates the acquired technical skills and facilitates the development of key competencies to effectively adapt to changes in projects and various contexts, common aspects in the industrial environment. Moreover, there is a parallel with the findings of Gravitt (2017) [1], whose research supports the notion that this approach in academic training is beneficial for successful job placement.

According to the studies conducted by Peretz et al. [18] and Allen and Razvi [10], educators play a crucial role in promoting active learning among students. They highlight the significance of teachers as facilitators in creating an environment that fosters critical thinking, deeper learning, and active participation. This approach highlights the shift from traditional didactic teaching methods to a more interactive and student-centered approach, where the teacher's role evolves to become a guide, mentor, and source of inspiration for students to explore, inquire, and apply their learning dynamically. Our study found that alumni consider course content and teaching staff crucial to their learning experience. They also appreciate receiving feedback from their peers and identifying areas of the discipline that require further exploration. In line with research by Magalef and Canabal [12], we found that teachers should not impose knowledge on students, as it does not facilitate skill development. Instead, our study highlights the importance of educators' role as facilitators of active learning, creating an engaging and participatory educational environment. This interaction between students and teachers is a decisive factor in the teaching and learning process.

Conclusion

The present study aimed to analyze and evaluate the contributions of the “Final Construction Engineering Portfolio Course” to training construction engineers. This involved assessing its impact on the development of essential skills and the practical application of knowledge in addressing real-world challenges. Through a mixed-methods approach, surveys and focus groups were conducted involving three key interest groups: current construction engineering students enrolled in the mentioned course, alumni of the program, and active teachers. Based on the methodology above, the following conclusions were reached:

- Instructors, students, and alumni recognize the quality and experience of the teaching staff as key course strengths.
- Opportunities exist to improve the course's linkage with the industrial and labor environment and implement diagnostics to balance student differences.
- There is a need to enhance interaction and communication between students and instructors, underscoring the importance of effective feedback.
- Learning outcomes show high compliance in LO1, LO2, and LO7, but lower performance in LO4, LO5, and LO6, suggesting a need to adjust the course structure.
- Reviewing the learning outcomes is recommended to align them with professional expectations and job market integration.
- Despite positive results, it is necessary to strengthen the connection between projects and the local reality and improve feedback channels and diagnostic tools for teamwork.

Future work and Limitations

For future research, it is recommended to include employers who have collaborated with graduates during their first formal work experience. This would provide a rich perspective on the graduates' preparedness for the real-world work environment and significantly contribute to adjusting the declared learning outcomes. Furthermore, the implementation and measurement of methodologies that incorporate diagnostic and leveling elements are suggested, enabling a more accurate and quantitative evaluation of the effectiveness of these tools in the educational process.

Regarding the limitations, it is crucial to highlight that the results of this study are not generalizable due to its specific focus on the responses of instructors and students from the second semester of 2023 in our program. However, despite this limitation, the findings provide relevant and valuable information for other contexts facing similar challenges. The responses from the alumni, offering a broader perspective, are particularly valuable, though they may not fully reflect the improvements implemented in each period of the course. This consideration underscores the need for future research to specifically address the evolution and adaptability of the integrative course over time, thus offering a more holistic and updated understanding of its impact and efficacy.

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Appendix 1

Focus Group Protocol

Objective: To gather feedback and insights from faculty on the capstone project course to identify improvement areas and strengthen the student learning experience, based on a SWOT analysis.

Agenda:

Introduction (15 minutes)

- Welcome and appreciation for participation.
- Request for signing the informed consent.
- Initiation of session recording.
- Explanation of session objectives.
- Overview of the SWOT analysis process.

SWOT Analysis (60 minutes)

- Strengths (15 minutes):
  - Faculty share their views on the strengths of the capstone project course.
  - Encouragement for faculty to highlight positive aspects of the course.
- Opportunities (15 minutes):
  - Discussion on potential areas for improvement and growth in the course.
  - Encouragement to identify areas where future opportunities can be leveraged.
- Weaknesses (15 minutes):
  - Faculty share their concerns or current challenges in the course.
  - Encouragement for honesty about areas perceived as weaknesses.
- Threats (15 minutes):
  - Exploration of potential threats that could impact the course.
  - Identification of challenges that might arise in the future.

Discuss learning outcomes (30 minutes)

- Faculty reflect on the learning outcomes (LOs).
- Discussion about student collaboration and group dynamics.

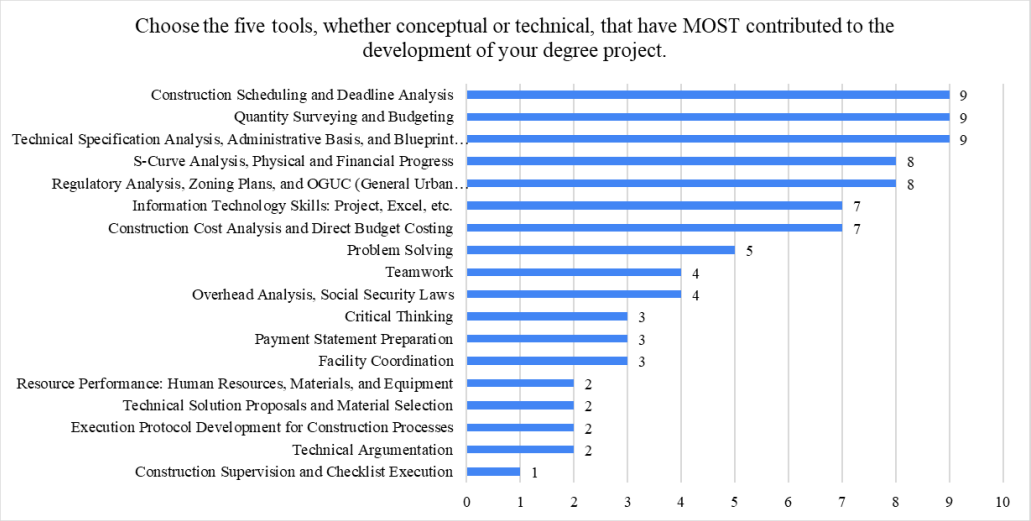
Conclusions and next steps (15 minutes)

- Summarize key points identified during the session.
- Discussion of potential actions to enhance the course.

Closure (5 minutes)

- Thanks to the faculty for their valuable contribution.
- Informing faculty about the next steps, such as information compilation and decision-making based on the findings.

Appendix 2


Choose the five tools, whether conceptual or technical, that have MOST contributed to the development of your degree project.
Construction Scheduling and Deadline Analysis 9
Quantity Surveying and Budgeting 9
Technical Specification Analysis, Administrative Basis, and Blueprint… 9
S-Curve Analysis, Physical and Financial Progress 8
Regulatory Analysis, Zoning Plans, and OGUC (General Urban… 8
Information Technology Skills: Project, Excel, etc. 7
Construction Cost Analysis and Direct Budget Costing 7
Problem Solving 5
Teamwork 4
Overhead Analysis, Social Security Laws 4
Critical Thinking 3
Payment Statement Preparation 3
Facility Coordination 3
Resource Performance: Human Resources, Materials, and Equipment 2
Technical Solution Proposals and Material Selection 2
Execution Protocol Development for Construction Processes 2
Technical Argumentation 2
Construction Supervision and Checklist Execution 1
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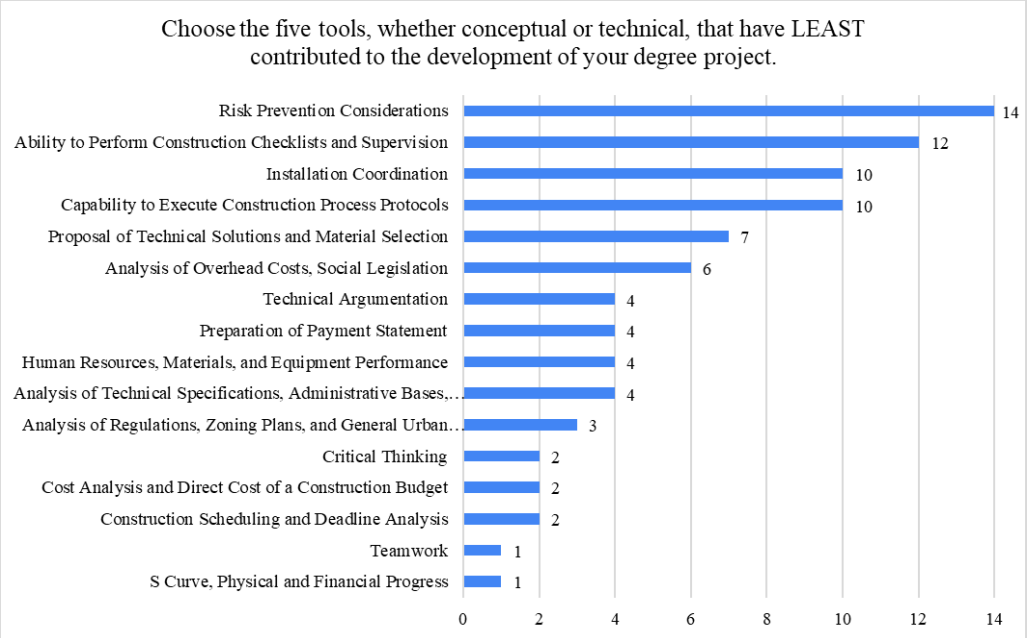
Choose the five tools, whether conceptual or technical, that have LEAST contributed to the development of your degree project.
Risk Prevention Considerations 14
Ability to Perform Construction Checklists and Supervision 12
Installation Coordination 10
Capability to Execute Construction Process Protocols 10
Proposal of Technical Solutions and Material Selection 7
Analysis of Overhead Costs, Social Legislation 6
Technical Argumentation 4
Preparation of Payment Statement 4
Human Resources, Materials, and Equipment Performance 4
Analysis of Technical Specifications, Administrative Bases,… 4
Analysis of Regulations, Zoning Plans, and General Urban… 3
Critical Thinking 2
Cost Analysis and Direct Cost of a Construction Budget 2
Construction Scheduling and Deadline Analysis 2
Teamwork 1
S Curve, Physical and Financial Progress 1
0 2 4 6 8 10 12 14