The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
ASEE
Paper ID #41994

Beyond the Classroom: Problem-Based Learning in Real Scenarios, Fostering Self-Efficacy and Sense of Belonging

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Abstract

This complete research presents how engaging students in practical, real-world activities within the Project-Based Learning (PBL) approach enhances their sense of belonging and self-efficacy. Situated in the practice course 'Building Processes I' of the Construction Engineering program at a private university in Chile, this study aims to address the issue of low student engagement and motivation within conventional educational settings. By shifting to a PBL paradigm, the course directly tackles these challenges by actively involving students in meaningful and applicable learning experiences. The research employed an experimental methodology, using a validated survey to assess students' sense of belonging and self-efficacy. Participants were twenty-one students enrolled in the “Building Processes I” class. The project-based activity was structured into three phases: planning, execution, and closure. Students engaged in an ongoing project, applying classroom knowledge to plan and execute construction tasks, and concluded by evaluating the project outcomes to identify lessons learned and areas for improvement. The Wilcoxon test confirms that the PBL methodology significantly improves participants' sense of belonging (interactions) and self-efficacy when engaging in projects situated in real-world scenarios. Collaborative activities that involve role assignments and active problem-solving in authentic contexts are particularly effective in enhancing these sociocognitive factors.

Keywords: Construction Engineering, Self-efficacy, Sense of belonging, Problem-based learning, Real-world scenarios

Introduction

The construction real estate sector, a pivotal contributor to Chile's Gross Domestic Product (GDP), accounts for a significant 7% of the total GDP. It encompasses about 60% of the investment and ranks sixth among national employers [1]. This industry, playing a vital role in the country's development, has seen the state making substantial investments in infrastructure projects in recent years [2]. The execution of such projects demands the involvement of experts with advanced competencies in team leadership, project management, and meticulous interpretation and adherence to advanced technical specifications. Mastery of structural regulations is crucial, given their foundational importance in any project's design and construction phases, especially in a region prone to seismic events. This specialized knowledge ensures technical viability and the safety and durability of constructions in high-seismicity contexts.

Therefore, academic preparation in university programs for these fields must be comprehensive and formative. There is ample evidence suggesting that in such careers, the educational approach yielding the best results involves problem-solving in real-world scenarios, as it promotes collaboration, critical thinking, conceptual learning, and specific skills and competencies relevant to the field [3-5].

However, it has been reported that students in these programs experience low retention and timely graduation rates [2, 6], posing a threat to the construction industry's future. Therefore, exploring the factors affecting Construction Engineering students is crucial. In this regard, sense of belonging and self-efficacy are two sociocognitive factors extensively studied for their close relationship and impact on students' academic progression indicators, such as attraction, retention, and timely graduation, among others [7-9].

This research analyzes the sociocognitive constructs of sense of belonging and self-efficacy among students taking the *Building Processes* class in the Construction Engineering program at a private Chilean university. During the semester, a Project-Based Learning activity allows students to analyze a real-world problem and plan, execute, and analyze an ongoing construction case based on actual circumstances. This aims to test the hypothesis that participation in practical activities based on Project-Based Learning significantly increases the sense of belonging and self-efficacy among Construction Engineering students. This leads to the research question:

RQ: How does participation in Project-Based Learning activities impact the sociocognitive constructs of sense of belonging and self-efficacy among Construction Engineering students at a private Chilean university during the Building Processes class, particularly in planning, execution, and analysis of real construction projects?

Literature Review

This study examines how the types of activities experienced by Construction Engineering students during their university experience influence their sense of belonging and self-efficacy. It explores practical activities that facilitate collaboration on industry problems through one of the most relevant active strategies reported in the literature, Project-Based Learning (PBL), to develop competencies, skills, and attitudes in higher education students, defining PBL as a learning strategy that uses problems to initiate the integration of new knowledge [10]. Given the low participation in conventional educational environments, we propose a paradigm shift towards more contextualized and applied experiences in real-world settings. In the literature, active learning strategies have strengthened student self-efficacy and sense of belonging [11-13]. Understanding that belonging to an educational institution is a complex and fundamental sociocognitive factor for the comprehensive development of students [11]. The sense of belonging among university students is correlated with greater academic drive, higher satisfaction in studies, improved academic performance, and a lower likelihood of educational dropout [14]. Numerous studies have corroborated that students with a strong sense of belonging are more motivated, which is reflected in their active participation and interaction in class, factors that significantly contribute to their academic success, persistence in their studies, and reduction in the likelihood of dropping out or changing academic programs [15-17]. Active and collaborative learning techniques foster reflection at individual, group, and general levels and enhance feedback exchange among peers and faculty. These strategies promote critical thinking and problem-solving skills, increasing students' motivation and confidence and strengthening their sense of belonging [8, 16].

Self-efficacy is an individual's belief in their ability to succeed in a specific area, a pillar of the Social Cognitive Career Theory (SCCT). This theory posits that career choices are influenced by confidence in our abilities (self-efficacy) and the expected outcomes (outcome expectations) within the realm of career opportunities [18]. Individuals tend to gravitate towards fields where they feel competent and avoid those where they do not perceive themselves as skilled. In challenging academic situations, an individual's perception of self-efficacy can increase if they notice progress, unlike someone who, despite success, does not see progress and feels stuck [19]. Although self-efficacy is a key sociocognitive factor for persistence in a career, studies in fields like engineering show that it can decrease over time [20]. Encouraging an appreciation of basic sciences and creating opportunities for students,

especially minorities, to reinforce their professional identity, sense of belonging, and self-efficacy are suggested to counter this trend [16, 21-23].

This study gains relevance by exploring the influence of PBL on the self-efficacy and sense of belonging of Construction Engineering students. Our work intends to demonstrate the impact of active educational practices centered on industry problems, which can boost academic performance, as evidenced in the literature, and students' personal and professional development through their sense of belonging and self-efficacy.

Methodology

This quantitative research involved 21 students enrolled in the "Building Processes Workshop I" class within the Construction Engineering program during the academic year's second semester (July-November 2023). The demographic composition of the sample includes 23 male students and one female student, aged between 19 and 22 years. Most participants were in their second year of study, with three students in their third year.

Survey

The "Sense of Belonging and Self-Efficacy Survey" examined two key sociocognitive factors: sense of belonging and self-efficacy. According to Becerra-Cid et al. [24], the survey utilized a Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"), allowing participants to indicate their level of agreement with statements concerning their sense of belonging and self-efficacy. These elements are influenced by external factors such as social and academic interactions within the school environment, including relationships with teachers and peers and the services and activities provided by the institution. Sense of belonging sheds light on how students perceive and integrate into their learning environment. At the same time, self-efficacy relates to internal aspects of students, influencing their identity, interests, and confidence in completing tasks and achieving goals. The instrument was implemented in a pre-post format, with the pre-survey conducted one month before the start of the practical application project. The post-survey was administered at the end of Stage 2 of the project.

Practical Activity Experience: Procedure

The project entailed conducting a practical activity of inspecting major construction phases in a building under construction in a municipality of the Metropolitan Region of Santiago, Chile, partially employing the Project-Based Learning methodology. Students worked in teams to carry out a practical process on a live construction site over the last five weeks of the semester. The four planned project stages were assessed using observation guidelines, covering planning, execution, and closure, focusing on aspects such as team formation, identification of challenges and opportunities, a compilation of a work item list, review and updating of checklists for conducting the inspection and applying the PDCA (Plan-Do-Check-Act) cycle to perform continuous improvement of the activity at all stages. This methodology aims to provide a detailed understanding of how participation in practical projects in real-world scenarios influences the self-efficacy and sense of belonging of Construction Engineering students. Below are the steps that outline the project stages, spanning the last five weeks of the semester (out of 17 weeks).

Stage 1. Planning

Class 1: Assignment of work Groups and Roles. Teams are formed, ensuring a diversity of skills and roles, such as group leader, using the title of manager, site supervisor, logistics coordinator, and quality and safety officer. Groups are composed of 4 students, with roles assigned to each group member. Definition of roles and responsibilities for each team member. Each student must recognize their role and understand their responsibilities within the group and the project. Explanation of project objectives and scope. The instructor in charge delivers the objectives and scope of the course according to the Building Processes Workshop I syllabus. At the end of the session, each group must introduce themselves, explain each role within the group, and justify the roles assigned to the group members.

Class 2: Site Visit and Task Review. Visits to a construction site to better understand practical tasks. The goal is to gather evidence and assess the community's needs. Observation and documentation of the construction processes for major works, including photographic evidence and tours of the facility for diagnosis and to generate the intervention project to be carried out in Class 5. Identification of specific challenges and opportunities at the intervention site. Selection of the intervention site. Definition of activities for the intervention (Class 4), determining activities to be carried out, and compiling a list of materials.

Class 3: Quantification of Materials and Task Planning. Calculate the quantity of materials required for the project. Students must estimate the listed materials to establish the necessary materials for the Class 5 intervention. Detailed task planning, including sequence, duration, and necessary resources. Develop an execution schedule, with students required to create a Gantt chart for the intervention to be carried out in Class 4.

Stage 2. Execution

Class 4: Intervention in the construction site. Implement the planned tasks discussed in Classes 1, 2, and 3. Supervise and adjust as needed during the execution of the intervention project. Completion of planned tasks considering the materials and the project's Gantt chart.

Stage 3. Closing

Class 5: Project Analysis and Continuous Improvement Cycle (PDCA). Review and analysis of the project's development compared to the initial planning. Identification of lessons learned and areas for improvement. Application of the PDCA cycle: Plan (identify areas for improvement), Do (implement changes), Check (assess the impact of the changes), and Act (adjust accordingly).

Analysis of results and ethical considerations

We employed SPSS® software and the Wilcoxon Signed-Rank Test to analyze the data. Data analysis was conducted using quantitative techniques for survey responses, which included both descriptive and comparative analyses. Informed consent was obtained from all participants before the administration of the surveys, and the confidentiality of the gathered information was maintained. Privacy was respected, and an ethical protocol consistent with research standards was adhered to throughout the study.

Results

In this study, we used SPSS® to analyze our quantitative data. We applied the Wilcoxon Signed-Rank Test to compare scores before and after the Sense of Belonging and Self-efficacy Survey (SBSS). This test is helpful for small sample sizes and compares two related samples or repeated measurements on a single sample. It helps determine if their population mean ranks differ and is an alternative to the paired t-test when the data does not meet the normality assumption. For our analysis, it was essential for participants to have both pre and post-test scores. Therefore, students with only one score were excluded from the analysis, leaving us with a final sample of 21 students.

To start an exploratory analysis of the results, we paired the pre- and post-survey outcomes for a comparative review (Figures 1-3). Following this, to analyze levels of agreement, responses indicating 4 (Agree) and 5 (Totally Agree) were amalgamated more accurately. This grouping strategy was adopted to clarify any shifts in students' sense of belonging and self-efficacy after participating in the practical activity. The results obtained from the Wilcoxon test, as processed through SPSS, are presented. The Wilcoxon test helps determine if there is a statistically significant median difference in the scores before and after the survey under the non-normal distribution of the data.

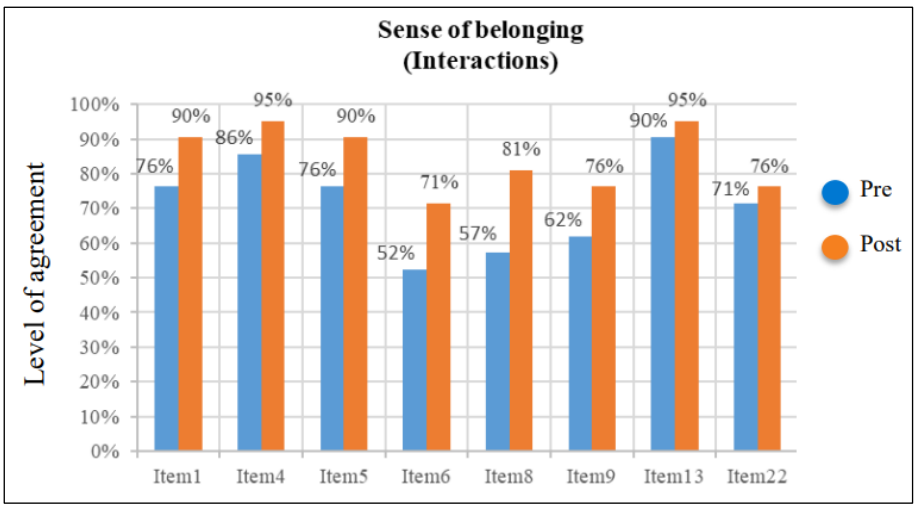

Figure 1. Levels of agreement for the items of the dimension of belongingness related to interactions.

Based on the data presented in Figure 1 regarding the levels of agreement for the belongingness dimension related to interactions, notable changes can be observed in the student's level of agreement post-intervention. Specifically, the increase from 52% to 71% for Item 6 (*If someone opposes my ideas, I can find the means and ways to persuade them to change their mind.*) suggests that the intervention may have effectively bolstered students' confidence in their persuasive communication skills, which is crucial for academic debate and collaboration. The rise from 57% to 81% for Item 8 (*I would find it easy to join study groups with other students if I wished to.*) reflects a significant enhancement in students' willingness to engage in collaborative learning through study groups, which is often associated with improved academic outcomes and a stronger sense of community. The progression from 62% to 76% for Item 9 (*When I interact with the professors at this university, I feel that they are concerned about my performance.*) indicates a more supportive

and caring interaction between students and faculty, an essential aspect of fostering a nurturing educational atmosphere that can contribute to student success.

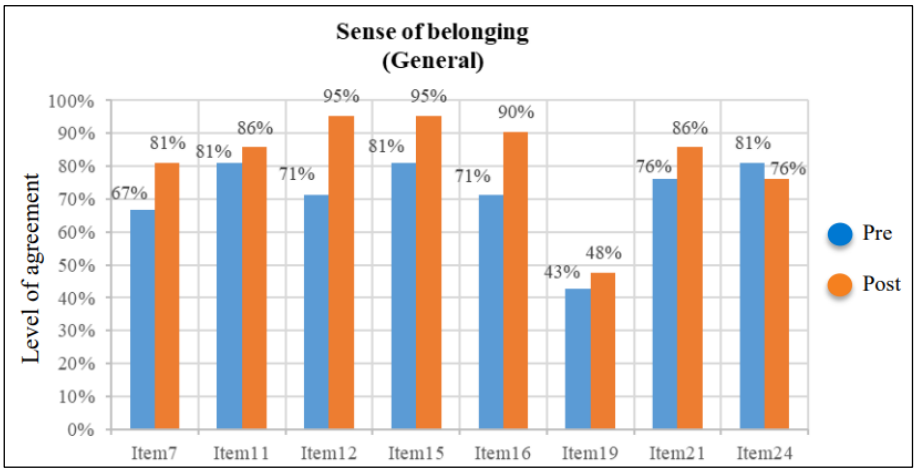

Figure 2. Levels of agreement for the general belongingness dimension.

As observed in Figure 2 regarding the general sense of belonging, the items that stand out include *Item 24: "Students at this university are friendly towards me"* (Pre: 81% - Post: 76%). The slight decrease in the percentage of students who felt their peers were friendly towards them could indicate a nuanced aspect of group dynamics. While a high level of friendliness was initially perceived, the slight drop suggests that as students become more familiar with each other, their initial impressions may adjust. For *Item 19: "Other students at this university seem interested in my opinions, ideas, and questions related to classwork*," this uptick, although modest, suggests a growing culture of academic engagement and respect for diverse viewpoints within the classroom. It reflects the positive impact of collaborative and interactive teaching methods on fostering a supportive learning environment where students feel their contributions are valued. In the latter case, both before and after the intervention, students' perceptions remained low, yet there was an increase from 43% to 48% in the level of agreement. Finally, *Item 12: "I feel confident reaching out to another student if I have a question about a specific assignment"* (Pre: 71% - Post: 95%), shows a significant increase in agreement levels before and after the practical activity. This result signifies a strong enhancement in the academic community and support among students, likely facilitated by the practical activity's emphasis on collaboration and peer learning. Such a marked increase suggests that the activity effectively addressed one of the critical goals of education: building students' confidence in their ability to engage with and learn from their peers.

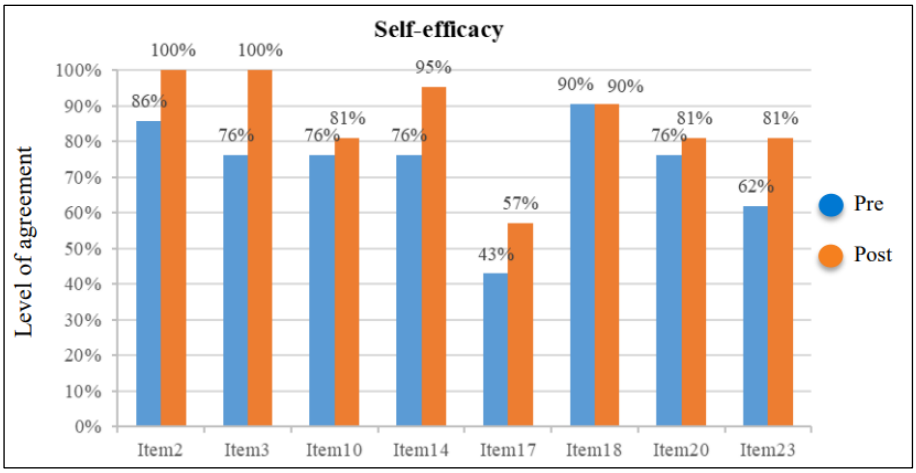

Figure 3. Levels of agreement for the self-efficacy dimension.

Within the self-efficacy dimension, *Item 17, "I prefer studying alone,"* remained low both pre- and post-intervention (43% and 57%, respectively), yet it experienced a 14-point increase over time. This shift suggests that the intervention may have empowered students to feel more competent in their study habits. However, the persistence of a relatively low percentage also indicates that a substantial proportion of students might benefit from more collaborative or guided learning opportunities. *Item 2, "I can always solve difficult problems if I try hard enough,"* and 3, *"I can usually handle whatever comes my way,"* are also notable for having seen a significant increase between the pre-and post-assessment periods (14 and 24 points, respectively). Results for these items indicate that the intervention effectively reinforced the concept of a growth mindset, where students understand that their abilities can be developed through dedication and hard work. This is a crucial component of self-efficacy, as it directly impacts students' willingness to engage with challenging material and persist in the face of difficulties. These findings suggest a noteworthy enhancement in students' confidence in their problem-solving abilities and general capacity to manage challenging situations, reflecting positively on the intervention's impact on self-efficacy.

Wilcoxon Test

If the p-value is 0.000 ($p=0.000 < \alpha=0.05$), there is evidence to reject the null hypothesis, confirming that the practical activity enhances the sense of belonging and self-efficacy among construction engineering students.

> H_0: The practical activity does not increase construction engineering students' sense of belonging and self-efficacy.
> H_1: The practical activity increases construction engineering students' sense of belonging and self-efficacy.

$$H_0: \mu_1 = \mu_2 \; vs \; H_1: \mu_1 < \mu_2$$

Based on the outcomes of the conducted test, there is statistical evidence indicating significant differences in the dimensions of sense of belonging- interactions ($p=0.007, <.05$) and self-efficacy ($p=0.003, <.05$). Consequently, this provides substantial grounds to reject the null hypothesis. It confirms that the practical activity effectively enhances the participants' sense of belonging (interactions) and self-efficacy.

Based on the reported results, it can be stated that implementing the practical activity in the "Building Processes Workshop I" course enhanced the students' sense of belonging and self-efficacy.

Discussion

The findings from this study indicate significant improvements in students' sense of belonging and self-efficacy, echoing the existing literature on the subject. These results underscore the effectiveness of active learning strategies in challenging fields such as Construction Engineering. Survey responses revealed statistically significant enhancements in belongingness and self-efficacy among the participants. This aligns with prior research highlighting the beneficial impact of practical activities on students' academic and personal development. Specifically, this research adds to the literature by focusing on Construction Engineering students, providing valuable insights into the efficacy of active learning in this educational context.

The data presented in Figures 1-2 accentuate the pivotal role of social interactions and the perception of support within the academic milieu as crucial elements in fostering a sense of belonging among students. These observations concord with the scholarly discourse, highlighting the association between a student's sense of belonging and academic engagement, perseverance, and achievement [16, 18]. Furthermore, enhancements in students' sense of belonging are anticipated to have subsequent impacts on their academic drive, ongoing engagement with the university, and potentially on their overall satisfaction with their education and retention rates. The effective integration of students represents a challenge unlikely to be met without establishing a strong sense of community and belonging within the educational institution, as discussed by Knekta et al. [25]. Various processes can augment an individual's Sense of Belonging or acceptance within a specific group, and it has been validated that increased interactions constitute one of these processes. Engineering students are more likely to continue their studies when they experience a strong sense of belonging and community engagement. Moreover, early interaction with faculty mentors and the experience of success play a significant role in fostering this persistence [11, 15, 24]. Findings contribute to the growing body of evidence supporting the positive effects of targeted educational strategies on students' self-efficacy, as Ballen et al. [8] also stated. Enhancing self-efficacy is pivotal and linked to higher motivation, increased resilience, and improved academic performance. The results also highlight the need for educational interventions to be dynamic and adaptable, addressing students' individual and collective needs to foster an environment where all learners can thrive.

Conclusion

The research objective of this paper was to examine the impact of participation in a Project-Based Learning (PBL) activity on the sociocognitive constructs of sense of belonging and self-efficacy among Construction Engineering students at a private Chilean university. This investigation focused on the students' experiences during the Building Processes course, specifically as they engaged in planning, executing, and analyzing a real construction project, to understand how these experiences influence their feelings of community and confidence in their professional capabilities. A validated survey was implemented to address this. With a non-parametric statistics test, we found that students enhanced their sense of belonging regarding interactions with peers and faculty and self-efficacy.

The findings revealed a significant improvement in students' sense of belonging and self-efficacy after participating in practical activities under Project-Based Learning (PBL). This study contributes to understanding how PBL enhances self-efficacy and sense of belonging among Construction Engineering students.
It is recommended to delve deeper into the impact of active educational practices on students' comprehensive development, particularly in specialized disciplines such as Construction Engineering. The positive link between sense of belonging, self-efficacy, and academic performance highlights the importance of exploring strategies to strengthen these aspects in engineering students.

This study's primary limitation is its small sample size, which restricts the generalizability of its findings. The unique characteristics of the participants and the study's specific context mean that while the results are insightful for the investigated phenomena, they may not be directly applicable to broader or different populations without caution. However, the importance of these findings cannot be overstated. They provide valuable insights and deepen our understanding within the study's particular context, marking an essential contribution to the field. These results highlight the need for further research with more extensive and diverse samples to confirm and expand upon these findings. This research paves the way for future studies, offering a foundation for developing broader theories and practices that could be applied across various settings despite the sample size and scope limitations.

Acknowledgments

The authors would like to acknowledge the School of Engineering at Universidad Andres Bello, Chile, for its leadership and financial support. We also thank the Educational and Academic Innovation Unit (UNIDA) for its invaluable mentoring and guidance in developing scientific articles on higher education research.

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