

Assessing the Impact of Project-Based Learning on Sustainable Knowledge Construction

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Abstract

Project-based learning (PBL) has become a transformative pedagogy in sustainable education, providing learning experiences in which students blend theoretical knowledge and experience. As educational institutions increasingly work with PBL, it needs to be assessed to ensure sustainable outcomes for teaching and learning. This study employs a convergent parallel mixed-method approach to explore participants' perceptions and experiences of how PBL influences learners to ensure sustainable knowledge construction in higher education. It also explores critical thinking, communication, and collaboration skills, examining student engagement and motivation levels in PBL activities and identifying factors that influence PBL effectiveness in sustainable education contexts. Data were collected from students through surveys and semi-structured interviews. The quantitative results showed that students improved their collaboration, self-directed learning, communication, technical, and knowledge-integration skills. Qualitative data indicated that PBL encourages students to apply theoretical concepts to real-world problems, thereby helping them achieve lifelong learning. Research findings suggest that project-based learning significantly enhances student engagement, problem-solving abilities, and critical thinking skills.

Keywords

Project-Based Learning, Sustainable Learning, Critical Thinking Skills, Quality Education, Knowledge Construction, Higher Education

Introduction

Project-based learning (PBL) is an active, learner-centered teaching and learning method in which students engage in a problem-solving process over an extended period to develop a better understanding of the subject and skills such as critical thinking, communication, collaboration, and self-directed learning. It inspires students' creativity in learning and can make learning procedures more interesting and engaging (Al-Kamzari & Alias, 2025). Within the field of sustainable education, Project-based learning is increasingly recognized for fostering stages

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specifically aimed at developing the skills required to address socio-environmental problems (Bramwell-Lalor et al., 2020). It enables knowledge acquisition through discovery and promotes real-world application of knowledge. Using the principles of the theories, a project is developed to solve different problems related to them within a specified time frame (Zhang & Ma, 2023). Earlier educational methodologies were more focused on gaining theoretical understanding, without implementation or practical engagement. Project-based learning provides an experience-based, student-centered approach that stimulates critical thinking, collaboration, and the application of what has been learned in the real world (Roy, 2025). PBL can be closely associated with Education for Sustainable Development (ESD) because ESD emphasizes learner-initiated investigation across disciplines and the practical application of knowledge (Khandakar et al., 2020).

In recent years, there has been increasing attention on the study of how PBL can promote sustainable knowledge building over time, the ability to create, store, and use knowledge over time to address dynamic problems. Nonetheless, solid evidence about the impact of PBL in higher education, and more specifically the development of sustainability-focused skills, is rare. Such dynamics are essential for educators and policymakers to consider when designing curricula that foster academic achievement and, more broadly, prepare individuals for lifelong learning and social participation. This study fills the gap of project-based learning by examining PBL effectiveness in the higher education context in terms of sustainable knowledge construction. It studies the development of critical thinking, communication, collaboration, and problem-solving abilities, as well as issues of student engagement and motivation. Combining quantitative survey and qualitative interview methods, the study yields an integrated scenario of how PBL influences learner outcomes and recommends strategies for using PBL to promote sustainable education.

Methodology

This study followed a convergent parallel mixed-method design, in which quantitative and qualitative data were collected concurrently to gain a comprehensive understanding (Creswell & Plano Clark, 2018) of students’ perceptions of Project-Based Learning (PBL) and its role in fostering sustainable knowledge construction. In this study, we conducted semi-structured interviews with 10 participants to understand their perceptions about PBL. Additionally, this study employed a quantitative, correlational design and collected data from 187 engineering students to assess the extent to which perceived skill improvements predicted students’ preferences for project-based learning. Data were analyzed through multiple regression to test the explanatory power of the independent variables.

Table 1. Items Reliability

Construct’s Name	Cronbach's Alpha	N of Items
Preference to PBL	0.756	5
Collaborative Learning and PBL	0.701	4
Self-Directed Learning and PBL	0.719	3
Technical Skills and PBL	0.712	4
Ability to Connect Real World Problem and PBL	0.628	3

Data were collected using a structured questionnaire consisting of two main sections. The first section measured students' preference for project-based learning (PBL), which served as the dependent variable (MeanPr). The second section focused on perceived improvements in specific skills, which acted as independent variables. All items were rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The reliability of the instrument was verified using Cronbach's alpha (see Table 1), which confirmed that the coefficient value of Cronbach's alpha, ranging from 0.62 to 0.75, is quite acceptable (Sekaran & Bougie, 2016; Taber, 2018).

Results and Discussion

Qualitative Phase

The semi-structured interviews conducted with 10 participants helped explain the effectiveness of PBL and thus triangulated the results from the quantitative data. All participants described PBL as "a bridge between theory and practice," with one noting that, "I finally understood the concepts because I could apply them to a real project." The major themes that emerged included skill development, supported by comments such as, "Working in teams improved my communication and leadership abilities more than traditional classes." Greater motivation and engagement were also strongly emphasized. As one student noted, "I looked forward to coming to class because the projects seemed meaningful," another added, "PBL made me confident I could solve real-world problems."

However, participants disclosed some challenges here. Time management was the major challenge, as one participant said, "Sometimes it was hard to manage time because projects required a lot of coordination." Another added, "Not everyone contributed equally, and it affected the team's progress." Others added that clearer guidance would have helped: "Clearer guidelines at the beginning would have helped us stay on track." Generally, the interviews validated that, though PBL enhances sustainable knowledge construction, collaboration, and critical thinking, it requires strong support for successful implementation through effective facilitation and structured scaffolding.

Quantitative Phase

Descriptive Statistics

Descriptive statistics indicated a generally positive perception of students toward Project-Based Learning across the areas measured. The Preference for PBL component ($M = 4.09$, $SD = 0.50$) had the highest mean score, indicating that learners favored PBL as a good method for teaching and learning. Technical Skills and PBL is also rated highly ($M = 4.05$, $SD = 0.46$) by the respondents signifying that activities under PBL could improve their technical skills; Self-Directed Learning and PBL has a mean rating of 3.99 & $SD = 0.48$ which means this process helps learners to learn independently; Ability to Connect Real World Problems and PBL is positively rated at $M = 3.95$, $SD = 0.48$ indicating that PBL can help make connections with real situations. The lowest-rated dimensions, Collaborative Learning and PBL ($M = 3.90$, $SD = 0.32$), indicated favorable views.

Table 2. Descriptive Analysis of Components

Construct's Name	Mean Rating	Standard Deviation
Preference to PBL	4.09	0.50
Collaborative Learning and PBL	3.90	0.32
Self-Directed Learning and PBL	3.99	0.48
Technical Skills and PBL	4.05	0.46
Ability to connect Real World Problem and PBL	3.95	0.48

Overall, the descriptive analysis leads to the conclusion that Project-Based Learning effectively helps students improve their collaboration and communication skills, technical skills, and self-directed learning, and ensures sustainable learning.

Regression Analysis

A multiple regression analysis was conducted to examine whether students' perceived improvements in collaborative skills (CS), self-directed learning (SDL), technical skills (TS), and ability to connect real-world problems (ACRP) predicted their preference for project-based learning (PBL). The overall regression model was statistically significant, $F(4, 182) = 22.73$, $p < .001$, and explained approximately 33% of the variance in students' preference for PBL ($R^2 = .333$, Adjusted $R^2 = .318$). Table 3 presents the unstandardized coefficients (B), standardized coefficients (β), t-values, and significance levels for each predictor.

Table 3. Multiple Regression Coefficient

Predictor	B	SE B	β	t	p
Constant	.948	.331	—	2.86	.005
Collaborative Skills (CS)	.329	.087	.277	3.77	<.001
Self-Directed Learning (SDL)	.082	.082	.083	1.01	.316
Technical Skills (TS)	.230	.081	.214	2.84	.005
Ability to Connect Real-World Problems (ACRP)	.148	.082	.151	1.81	.072

Note. Dependent variable = preference for PBL.

The results indicated that perceived improvement in collaborative skills ($\beta = .277$, $p < .001$) and technical skills ($\beta = .214$, $p = .005$) were significant positive predictors of students' preference for PBL. Collaborative skills emerged as the strongest predictor in the model. In contrast, self-directed learning ($\beta = .083$, $p = .316$) was not a significant predictor. The ability to connect real-world problems showed a positive but only marginal effect ($\beta = .151$, $p = .072$).

Among the predictors, collaborative skills and the ability to connect real-world problems emerged as the strongest positive predictors of students' preference for PBL. This suggests that students who perceive PBL as enhancing teamwork and real-life problem-solving prefer this learning approach. A study by Hmelo-Silver (2004) emphasized that PBL fosters meaningful learning primarily through active collaboration, shared problem-solving, and engagement in authentic learning experiences.

The overall result indicated that students were more likely to prefer PBL when they perceived that it enhanced their collaborative and technical skills, whereas gains in self-directed learning and real-world problem connection had less influence.

Conclusion

This study asserts that project-based learning effectively constructs sustainable knowledge. Results indicated that students expressed positive perceptions of PBL, particularly regarding its role in enhancing their technical and teamwork abilities. Regression results showed that enhanced collaboration and technical abilities increased students' likelihood of favoring PBL. However, self-learning and real-world problem solving were weaker determinants. Both qualitative and quantitative data indicate that PBL leads to the development of essential skills and supports long-term academic progress when issues such as time management and equal participation are properly addressed.

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