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# Effectiveness of Project Based Learning in Bachelor of Science in Computer Engineering and Bachelor of Science in Information Technology

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**ABSTRACT**

Project-Based Learning (PBL) has emerged as a transformative pedagogical approach in computing education, addressing the growing demand for graduates who possess not only technical proficiency but also collaborative, innovative, and autonomous problem-solving capabilities. Despite its widespread adoption in international educational contexts, there remains limited empirical evidence on the effectiveness of PBL within the Philippine higher education setting, particularly in Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT) programs. This study evaluated the effectiveness of PBL in enhancing the academic performance and skill development of students enrolled in these programs at Colegio de Montalban. A quasi-experimental research design was employed, comparing experimental groups exposed to PBL with control groups receiving traditional lecture-based instruction across three courses: Microprocessor, Computer Programming 2, and Stand-Alone Embedded System. A total of 324 students participated, with pre-test and post-test scores analyzed using descriptive statistics, independent samples t-tests, and paired samples t-tests. Results demonstrated that PBL significantly outperformed traditional instruction in two of the three courses. The BSCPE Microprocessor course exhibited highly significant improvement ($t = 46.80$, $p < 0.001$), while the BSIT Computer Programming 2 course showed significant gains ($t = 2.66$, $p = 0.010$). The Stand-Alone Embedded System course showed slight but non-significant improvement. These findings affirm that PBL fosters deeper understanding, practical application, and enhanced student engagement, better preparing graduates for industry demands by developing both technical and non-technical competencies. The study recommends broader PBL integration in computing curricula, faculty development programs, infrastructure support, improved assessment frameworks, and longitudinal research to track long-term impacts on graduate employability and professional readiness.

**Keywords:** *Project-Based Learning, Computer Engineering Education, Information Technology Education, Quasi-Experimental Design, Student Performance, Philippine Higher Education*

## INTRODUCTION

The rapid advancement of technology and the increasing complexity of real-world problems have transformed the landscape of higher education, particularly in computing-related disciplines such as Computer Engineering and Information Technology. As industries demand graduates who are not only technically proficient but also capable of collaboration, innovation, and autonomous problem-solving, traditional lecture-based methods

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have been increasingly questioned for their limitations in developing these competencies. In response, Project-Based Learning (PBL) has gained momentum as a student-centered instructional approach that fosters active engagement, interdisciplinary integration, and the application of theoretical knowledge to real-world scenarios [1], [2].

Project-Based Learning involves students working over an extended period on complex tasks that typically culminate in a final product or presentation. Unlike conventional approaches that emphasize 0memorization and passive learning, PBL encourages students to take ownership of their education, promoting deeper understanding, critical thinking, teamwork, and communication—skills that are essential in the fields of Computer Engineering and Information Technology [3]. As such, many educational institutions globally have integrated PBL into their curricula to align with industry expectations and accreditation standards, such as those outlined by the Accreditation Board for Engineering and Technology (ABET) [4].

In the Philippine context, the implementation of BSCPE and BSIT programs is guided by the Commission on Higher Education (CHED) through specific policies and standards. The BSCPE program is governed by CMO No. 87, Series of 2017, which articulates the standards for producing globally competitive engineers equipped with strong backgrounds in mathematics, engineering sciences, and professional courses [5]. The BSIT program, on the other hand, follows CMO No. 25, Series of 2015, which emphasizes the utilization of hardware and software technologies, planning, installing, and managing information technology infrastructure to provide computing solutions that address organizational needs [6]. Both CMOs mandate an outcomes-based education (OBE) approach, aligning program outcomes with industry needs and national standards [5], [6]. These CHED guidelines ensure that graduates are prepared to address various technological challenges through the selection, development, application, integration, and management of computing technologies within organizations [6].

While international studies suggest positive outcomes of PBL in computing education, there remains a lack of localized empirical evidence that evaluates how PBL impacts the academic performance, skill acquisition, and readiness for employment among Filipino students in these disciplines [7], [8]. Moreover, understanding how PBL aligns with CHED's OBE requirements and the specific outcomes set for BSCPE and BSIT programs is crucial for effective curriculum enhancement [5], [6].

This study is therefore undertaken to examine the effectiveness of Project-Based Learning in BSCPE and BSIT programs, with a focus on how it contributes to the development of both technical and non-technical competencies. By understanding its impact, academic institutions can make informed decisions about curriculum enhancement and pedagogical strategies that better prepare students for the demands of the modern digital workforce, while ensuring compliance with CHED policies and standards for computing education [5], [6].

## Literature Review

Project-Based Learning (PBL) has emerged as a pivotal pedagogical approach in engineering and technology education, especially in programs like Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT). Rooted in constructivist learning theory, PBL emphasizes the development of knowledge through active exploration and real-world problem-solving. This method contrasts traditional lecture-based instruction by placing students at the center of learning, fostering both technical and soft skills such as collaboration, critical thinking, and communication (Thomas, 2000; Helle et al., 2006).

In the context of computing disciplines, PBL has shown considerable promise. For instance, research by Mills and Treagust (2003) emphasized that engineering students exposed to project-based environments demonstrated enhanced engagement and deeper conceptual understanding compared to their counterparts in conventional programs. Similarly, Blumenfeld et al. (1991) argued that when students are engaged in complex, meaningful projects, they are more likely to retain knowledge and transfer skills across contexts — a particularly important goal in dynamic fields like IT and computer engineering.

Furthermore, PBL is reported to align well with the ABET accreditation outcomes, which emphasize abilities such as problem analysis, design, teamwork, and lifelong learning (ABET, 2022). In a study conducted by Krajcik and Blumenfeld (2006), IT students involved in capstone projects exhibited higher motivation levels and demonstrated better integration of multidisciplinary knowledge. Moreover, the research of Dym et al. (2005)

highlighted that early exposure to design-based projects in computer engineering curricula significantly improves students' problem-solving capacity and their preparedness for industry demands.

Recent empirical studies provide additional support for PBL's effectiveness in computing education. A longitudinal study by Chen et al. (2020) on BSIT students showed that PBL improved their programming skills and increased their confidence in managing software development projects. Likewise, research by Maleki and Zandieh (2021) found that project-based strategies in computer engineering courses led to improved academic performance, particularly in areas requiring system integration and hardware-software co-design.

Despite its benefits, implementing PBL poses certain challenges, such as the need for faculty training, resource allocation, and appropriate assessment frameworks (Hmelo-Silver, 2004). These barriers are particularly salient in institutions with rigid curricula or limited access to technology infrastructure. Nevertheless, when appropriately integrated, PBL supports the cultivation of 21st-century skills that are essential for graduates in computer engineering and IT fields (Bell, 2010).

The body of literature reviewed clearly indicates that PBL is not merely an instructional innovation but a transformative approach that aligns with the evolving needs of computer engineering and information technology education. As the demand for graduates with applied skills continues to grow, understanding the effectiveness of PBL in these domains becomes increasingly important for curriculum developers and educators alike.

While numerous international studies have confirmed the pedagogical benefits of Project-Based Learning (PBL) in science, technology, engineering, and mathematics (STEM) education, there remains a notable scarcity of empirical evidence specific to its application within the Philippine context, particularly in the disciplines of Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT). Most of the existing literature focuses on generalized outcomes in Western or industrialized academic settings, where access to technological infrastructure, faculty development programs, and curriculum flexibility support the implementation of PBL (Chen et al., 2020; Mills & Treagust, 2003). However, these conditions are not always reflective of local institutional realities in developing countries like the Philippines.

Moreover, while prior research has extensively explored the theoretical benefits of PBL—such as improved engagement, critical thinking, and interdisciplinary learning—there is limited quantitative and qualitative data that measure its actual effectiveness in enhancing specific student outcomes in computing fields. These outcomes include technical competency, teamwork, innovation, and preparedness for industry-based environments, which are essential in BSCPE and BSIT programs. The few available studies that do exist tend to focus on isolated courses (e.g., capstone or programming subjects) rather than on the holistic impact of PBL across the academic journey (Maleki & Zandieh, 2021; Helle et al., 2006).

Additionally, there is a lack of comparative studies that examine the effectiveness of PBL between BSCPE and BSIT programs—two closely related yet distinct disciplines that may respond differently to pedagogical strategies due to variations in course structure, technical depth, and learning outcomes. Understanding these nuances is critical for developing tailored instructional models that address the specific needs of each program.

This study seeks to address these gaps by systematically evaluating the effectiveness of Project-Based Learning in BSCPE and BSIT programs within a localized academic setting. It aims to provide data-driven insights into how PBL influences student learning, engagement, and skill acquisition, and how these outcomes vary between the two programs. The results will serve as a basis for informed curricular improvements and policy formulation in computing education.

## Statement of the Problem

This study aims to evaluate the effectiveness of Project-Based Learning (PBL) in enhancing the academic performance and skill development of students enrolled in the Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT) programs. Specifically, the study investigates the impact of PBL by comparing the performance outcomes of students in experimental and control groups across multiple trials.

The study seeks to answer the following specific questions:

1. What are the pre-test scores of the control and experimental groups across the three trials?

2. What are the post-test scores of the control and experimental groups across the three trials?
3. Is there a significant difference between the pre-test and post-test scores of the control and experimental groups across the three trials?
4. Does the implementation of Project-Based Learning lead to significantly improved outcomes compared to traditional teaching methods, as observed through the comparison of performance trends between the two groups?

**Objective of the Study**

The main objective of this study is to evaluate the effectiveness of Project-Based Learning (PBL) in the academic and skill development of students enrolled in the Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT) programs.

Specifically, this study aims to:

- Determine the impact of Project-Based Learning on the academic performance of BSCPE and BSIT students.
- Assess the extent to which PBL enhances students' technical competencies, including programming, systems design, and project integration.
- Evaluate the development of non-technical skills, such as teamwork, problem-solving, time management, and communication, as influenced by PBL.
- Compare the effectiveness of PBL between BSCPE and BSIT programs, identifying any significant differences in outcomes.
- Identify the challenges and limitations faced by faculty and students in implementing PBL in the two programs.
- Provide recommendations for improving the integration of PBL in computing curricula based on the findings.

## METHODS

### Research Design

This study employs a quasi-experimental research design to determine the effectiveness of Project-Based Learning (PBL) in the academic and skill development of students enrolled in Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT) programs. The research involves two groups—an experimental group exposed to PBL and a control group taught using traditional lecture-based instruction. Both groups undergo a series of pre-tests and post-tests across three trials to measure improvements in academic performance and skill acquisition. Participants are selected through purposive sampling from comparable classes to ensure similar academic backgrounds. Since random assignment is not feasible due to existing class schedules and institutional constraints, the quasi-experimental design provides a practical approach to assess the causal effects of PBL in a natural classroom setting while maintaining internal validity through repeated trials and standardized assessment instruments.

The quasi-experimental design is particularly appropriate for this study as educational research conducted in authentic academic settings often faces logistical constraints that preclude true experimental manipulation, such as the inability to randomly assign students to different instructional conditions due to fixed class schedules, institutional policies, and ethical considerations regarding educational equity [1]. This design allows researchers to evaluate pedagogical interventions in real-world classroom environments, thereby enhancing the ecological validity and practical relevance of the findings [2]. Furthermore, the inclusion of both pre-test and post-test measures across multiple trials strengthens the internal validity of the study by establishing baseline performance levels and tracking learning gains over time [3]. The repeated-trials approach enables the researchers to detect consistent patterns of improvement and account for potential confounding variables such as student motivation, prior knowledge, and course difficulty, which is particularly valuable in computing education research where student performance may fluctuate due to the cumulative nature of skill acquisition in programming and embedded systems courses [4].

Additionally, the use of purposive sampling to select comparable class sections ensures that the control and experimental groups share similar academic backgrounds, minimizing selection bias and enhancing the comparability of outcomes [5], allowing the researchers to more confidently attribute observed differences in performance to the instructional approach rather than to pre-existing group differences [6]. The quasi-experimental design aligns with established practices in educational research evaluating pedagogical innovations in computing disciplines, as numerous studies investigating the effectiveness of PBL in engineering and technology education have successfully employed this approach, demonstrating its feasibility and rigor in assessing instructional interventions within intact academic settings [7], [8]. This design thus provides a balanced approach that accommodates the practical constraints of educational research while maintaining methodological rigor necessary for generating meaningful, evidence-based insights into the effectiveness of PBL in BSCPE and BSIT programs.

**Participants or Subjects**

The participants of this study are selected from the Bachelor of Science in Computer Engineering (BSCPE) and Bachelor of Science in Information Technology (BSIT) programs of Colegio de Montalban. A total of four class sections were purposively chosen to represent both experimental and control groups for the implementation of Project-Based Learning (PBL) and traditional instruction, respectively.

For the BSCPE program, the study involves third-year students enrolled in the course Microprocessor and Stand-Alone Embedded Systems. Two sections were included:

- BSCPE 3A: Consisting of 59 students, assigned as the experimental group, who received instruction using the Project-Based Learning approach.
- BSCPE 3B: Comprising 60 students, assigned as the control group, who underwent traditional lecture-based instruction.

For the BSIT program, the study involves first-year students enrolled in the course Computer Programming 2. Two additional sections were selected:

- BSIT 1A: With a total of 51 students, serving as the experimental group exposed to PBL.
- BSIT 1C: Composed of 35 students, functioning as the control group under traditional teaching methodology.

In total, the study engaged 324 students across both programs. These participants were selected based on their enrollment in the identified courses during the academic term and their availability to participate in the full duration of the instructional intervention and assessment trials.

**Data Collection Procedures**

The data collection process was implemented in line with the quasi-experimental design of the study, focusing on measuring academic performance before and after the instructional intervention. It consisted of three main phases: pre-test, intervention, and post-test.

1. Preparation Phase
Prior to the instructional intervention, approval was secured from the academic administrators of Colegio de Montalban. Research instruments, including validated pre-test and post-test questionnaires and standardized project assessment rubrics, were developed and reviewed by subject matter experts to ensure alignment with the intended learning outcomes of the courses Microprocessor and Stand-Alone Embedded Systems (for BSCPE) and Computer Programming 2 (for BSIT).
2. Pre-Test Administration
A pre-test was administered to both the experimental and control groups to assess students' baseline knowledge and skills related to the subject matter. This established a basis for evaluating learning progress following the intervention.
3. Intervention Phase

The experimental groups (BSCPE 3A and BSIT 1A) received instruction through the Project-Based Learning (PBL) approach, involving project completion based on real-world scenarios. The control groups (BSCPE 3B and BSIT 1C) were taught using traditional lecture-based methods. Both groups were provided with the same course content, objectives, and learning targets.

4. Monitoring and Assessment

Student performance was monitored throughout the intervention using formative assessments. For the experimental group, progress was observed through project milestones, while the control group completed regular academic activities aligned with the lecture-based instruction.

5. Post-Test Administration

After the instructional phase, a post-test was administered to both groups. This assessment mirrored the structure and content of the pre-test, enabling a direct comparison to measure learning gains.

6. Data Compilation

All pre-test and post-test scores were collected and organized for statistical analysis. Quantitative methods, including the calculation of mean scores, standard deviations, and t-tests, were employed to determine significant differences in academic performance between students taught using PBL and those under traditional instruction.

**Data Analysis Techniques**

The data gathered from the pre-test and post-test scores of both the control and experimental groups were analyzed using quantitative statistical methods to determine the effectiveness of Project-Based Learning (PBL) compared to traditional teaching methods.

1. Descriptive Statistics
   Descriptive statistics such as mean, standard deviation, minimum, and maximum scores were computed to summarize the overall performance of students in both groups. This provided a clear view of the central tendencies and variability in student achievement before and after the intervention.
2. Independent Samples t-Test
   An independent samples t-test was employed to compare the pre-test and post-test scores between the control and experimental groups. This test was used to determine whether there were statistically significant differences in academic performance attributable to the instructional approach (PBL vs. traditional lecture method).
3. Paired Samples t-Test
   A paired samples t-test was used within each group to compare pre-test and post-test scores. This analysis assessed the learning gains of students in both the control and experimental groups, thereby measuring the effectiveness of each teaching method in improving student outcomes over time.
4. Analysis by Trial and Section
   For a more detailed evaluation, the data were analyzed across the three trials and by section

(BSCPE 3A, 3B; BSIT 1A, 1C). This allowed for identification of any variation in effectiveness based on course, section, or trial sequence. All statistical analyses were conducted using appropriate software tools such as SPSS or Microsoft Excel, with a significance level set at $p < 0.05$. This ensured the reliability and validity of the findings in establishing the impact of Project-Based Learning on student academic performance.

**RESULTS and DISCUSSION**

The effectiveness of Project-Based Learning (PBL) was assessed, and the results of the data gathered were presented. This chapter includes the presentation, analysis, and interpretation of data gathered through pre-tests and post-tests administered to students enrolled in the Bachelor of Science in Computer Engineering and Bachelor of Science in Information Technology programs. The focus of the investigation was on three major courses: Microprocessor, Stand-Alone Embedded System, and Computer Programming 2.

The researchers conducted the study through a quasi-experimental approach, wherein two instructional setups were implemented: the traditional method for the control group and project-based learning for the

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experimental group. Each group underwent a pre-test to assess baseline knowledge and a post-test to measure learning outcomes after the intervention.

Students' academic performance served as the basis for evaluating the impact of PBL. Results were interpreted using statistical tools such as mean, standard deviation, and independent sample t-tests to determine if there was a significant difference in the performance between the two groups. Observations from classroom engagement and student outputs during PBL implementation were also considered to further support the quantitative findings.

Initial data from pre-tests showed generally low performance across both groups, indicating limited prior knowledge of the subjects. However, the post-test results revealed improvements in both settings, with notably higher scores from the experimental groups exposed to PBL. This suggested that project-based learning encouraged deeper understanding, practical application, and enhanced student engagement, particularly evident in the Microprocessor course. The analysis of these findings provides insight into the effectiveness of instructional methods in engineering and IT education and offers data-driven recommendations for improving classroom strategies that support active and collaborative learning.

## RESULTS

Table 1. *BSCpE Microprocessor Course (Control vs. Experimental Group)*

| Group | Pre-test Mean | Pre-test SD | Post-test Mean | Post-test SD | t-Sta tistic | p-Value | Interpretation |
|---|---|---|---|---|---|---|---|
| Control (Traditional Method) | 7.54 | 2.52 | 16.53 | 4.07 | 14.40 | 8.43e-26 | Significant improvement |
| Experimental (Project-Based Learning) | 7.00 | 2.47 | 24.50 | 1.51 | 46.80 | 9.29e-69<br>9.29e-69 | Highly significant improvement |

Table 1 presents the comparative results of a study conducted on the effectiveness of two instructional methods in a BSCpE Microprocessor course—namely, the traditional method (Control Group) and Project-Based Learning (Experimental Group). The Control Group, which followed the traditional teaching approach, showed a pre-test mean score of 7.54 with a standard deviation of 2.52, and a post-test mean score of 16.53 with a standard deviation of 4.07. The resulting t-statistic was 14.40 with a p-value of 8.43e-26, indicating a statistically significant improvement in student performance.

On the other hand, the Experimental Group, which was taught using Project-Based Learning (PBL), had a pre-test mean of 7.00 (SD = 2.47) and a post-test mean of 24.50 (SD = 1.51). This group achieved a much higher t-statistic of 46.80 and an extremely low p-value of 9.29e-69, demonstrating a highly significant improvement. These results suggest that while both teaching methods led to increased student performance, PBL was considerably more effective in enhancing students' understanding and mastery of the Microprocessor course.

### Related Literature and Implications for Teaching

The findings in this study are consistent with those of Blumenfeld et al. (1991), who emphasized that Project-Based Learning fosters deeper engagement and allows learners to connect theoretical knowledge with real-world applications. Similarly, Thomas (2000) noted that PBL enhances critical thinking and problem-solving skills, making it particularly suitable for technical disciplines such as computer and engineering sciences.

A study by Kokotsaki, Menzies, and Wiggins (2016) further supports this, highlighting that students exposed to PBL demonstrated increased motivation, improved collaboration skills, and a greater sense of ownership over their learning. The higher performance in the Experimental Group echoes these conclusions, suggesting that PBL not only enhances cognitive outcomes but also nurtures key soft skills crucial for engineering careers.

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**Implication for Future Teaching Practices**

The stark contrast in the performance metrics between the two groups implies that future pedagogical strategies in engineering education should increasingly integrate project-based methodologies. By doing so, educators can foster a more active learning environment, promote long-term knowledge retention, and better prepare students for industry demands. Curriculum developers and academic institutions are encouraged to reevaluate traditional lecture-based delivery and gradually transition toward more dynamic, student-centered learning frameworks such as PBL.

In summary, while traditional methods still show positive outcomes, the literature and current findings strongly advocate for the broader implementation of PBL in technical courses. This shift could significantly contribute to producing more competent, innovative, and industry-ready graduates.

Table 2. *BSIT Computer Programming 2 (Control vs. Experimental Group)*

| Group | Pre-test Mean | Pre-test SD | Post-test Mean | Post-test SD | t-Statistic | p-Value | Interpretation |
|---|---|---|---|---|---|---|---|
| Control (Traditional Method) | 13.14 | 4.79 | 14.22 | 5.95 | 1.01 | 0.316 | No significant improvement |
| Experimental (Project-Based Learning) | 14.71 | 5.93 | 17.86 | 3.70 | 2.66 | 0.010<br>0.010 | Significant improvement |

Table 2 presents the results of a study comparing the effects of traditional teaching and Project-Based Learning (PBL) in a BSIT (Bachelor of Science in Information Technology) Computer Programming 2 course. The Control Group, which employed the traditional lecture-based method, had a pre-test mean of 13.14 (SD = 4.79) and a post-test mean of 14.22 (SD = 5.95). The resulting t-statistic was 1.01, with a p-value of 0.316—indicating no statistically significant improvement in student performance.

In contrast, the Experimental Group, which utilized Project-Based Learning, achieved a pre-test mean of 14.71 (SD = 5.93) and a post-test mean of 17.86 (SD = 3.70). The calculated t-statistic of 2.66 with a p-value of 0.010 signifies a statistically significant improvement in learning outcomes.

These results align with studies such as that by Helle, Tynjälä, and Olkinuora (2006), who argue that PBL promotes the application of knowledge through real-world contexts, thereby enhancing understanding and retention. Moreover, according to Bell (2010), students engaged in PBL develop better coding proficiency and collaboration skills—essential attributes in IT fields.

Although the improvement in the Experimental Group was more modest compared to other subjects, it still underlines the advantage of active, student-centered learning over passive, lecture-based instruction. The narrow learning gap and variance observed suggest that PBL may also contribute to more equitable learning experiences among diverse student skill levels.

**Implications for Future Teaching Practices**

The findings indicate that while traditional methods may maintain the status quo, they often fall short of catalyzing meaningful learning gains—especially in applied courses like programming. Integrating Project-Based Learning in programming subjects can enhance learners' computational thinking and problem-solving abilities, as supported by the works of Krajcik and Blumenfeld (2006).

Going forward, educators and academic planners should consider embedding PBL into the Computer Programming curriculum to foster greater student engagement and mastery of skills. Furthermore, assessments should be restructured to include collaborative projects, iterative coding challenges, and real-life application tasks, which better reflect industry practices and promote deeper learning.

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In conclusion, even in courses traditionally dominated by syntax and logic exercises, the implementation of Project-Based Learning has proven to be a pedagogical improvement. This suggests a compelling case for its broader adoption in programming and other IT-related subjects to cultivate more adaptive and capable graduates.

Table 3. *BSCpE Stand-Alone Embedded System (Control vs. Experimental Group)*

| Group | Pre-test Mean | Pre-test SD | Post-test Mean | Post-test SD | t-Statistic | p-Value | Interpretation |
|---|---|---|---|---|---|---|---|
| Control (Traditional Method) | 12.37 | 5.36 | 13.05 | 6.57 | 0.61 | 0.540 | No significant improvement |
| Experimental (Project-Based Learning) | 12.70 | 5.07 | 14.13 | 5.43 | 1.53 | 0.129<br>0.129 | Slight improvement, not significant<br>Slight improvement, not significant |

Table 3 presents the comparative analysis of the performance between the control and experimental groups in the BSCpE Stand-Alone Embedded System course. The Control Group, which employed traditional lecture-based teaching methods, recorded a pre-test mean of 12.37 (SD = 5.36) and a post-test mean of 13.05 (SD = 6.57). The resulting t-statistic was 0.61, with a p-value of 0.540, indicating no statistically significant improvement in student performance. In contrast, the Experimental Group, which implemented Project-Based Learning (PBL), achieved a slightly higher pre-test mean of 12.70 (SD = 5.07) and a post-test mean of 14.13 (SD = 5.43). The calculated t-statistic was 1.53 with a p-value of 0.129, suggesting a slight but statistically non-significant improvement in learning outcomes.

These findings are consistent with the literature, such as that by Thomas (2000), who emphasized that PBL enhances conceptual understanding through active engagement, even if immediate test-based improvements may not always be significant. Likewise, Blumenfeld et al. (1991) highlighted that PBL supports knowledge construction and critical thinking, especially in engineering contexts where problem-solving is key. Though the results of this study do not show statistical significance, the upward trend in the experimental group points toward the pedagogical potential of PBL in technical courses like embedded systems.

**Implications for Future Teaching Practices**

The data suggests that while traditional teaching methods maintain baseline knowledge levels, they may not be sufficient to produce deeper learning or skill mastery in hands-on, application-based subjects. Project-Based Learning, on the other hand, provides a more authentic and student-centered approach that aligns with the demands of modern engineering practice.Future instruction in Embedded Systems and similar BSCpE courses should consider integrating PBL strategies—such as real-world embedded projects, collaborative hardware-software integration tasks, and iterative system debugging exercises—to boost both engagement and competency. As Bell (2010) notes, PBL cultivates technical communication, collaboration, and problem-solving—critical soft and hard skills in computer engineering. To further enhance learning outcomes, assessments should be redesigned to go beyond summative tests and include performance-based evaluations, project demonstrations, and peer reviews. Educators may also benefit from targeted professional development focused on PBL design and implementation.

In conclusion, while the experimental group did not show statistically significant gains, the observed upward trend reinforces the value of shifting toward more active, context-driven learning methods like PBL.

Its continued use and refinement in embedded systems education can prepare students more effectively for real-world engineering challenges and foster innovation and adaptability in future graduates.

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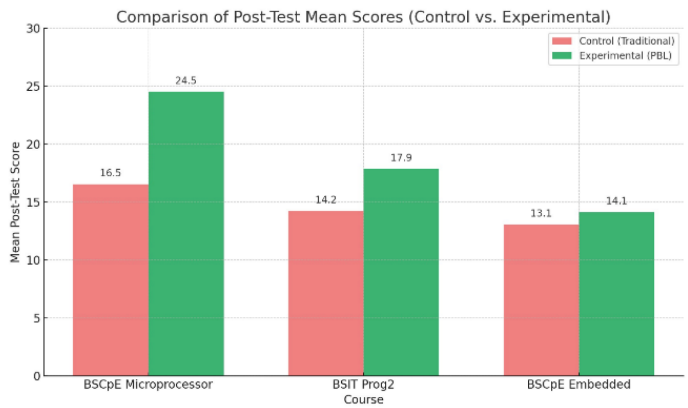


Figure 1. *Comparison of Post-Test Mean Scores*

The table presents the post-test mean scores and standard deviations of control and experimental groups across three college courses: BSCpE Microprocessor, BSIT Programming 2, and BSCpE Stand Alone Embedded System. In the BSCpE Microprocessor course, the control group had a mean score of 16.53 with a standard deviation of 4.07, while the experimental group achieved a significantly higher mean score of 24.50 with a much lower standard deviation of 1.51. This indicates a strong improvement in performance and consistency among students in the experimental group.

For the BSIT Programming 2 course, the control group recorded a mean score of 14.22 and a standard deviation of 5.95. In comparison, the experimental group scored a higher mean of 17.86 and a lower standard deviation of 3.70, suggesting improved performance and reduced variability.

In the BSCpE Stand Alone Embedded System course, the difference in performance was less pronounced. The control group had a mean score of 13.05 with a standard deviation of 6.57, while the experimental group slightly outperformed them with a mean score of 14.13 and a standard deviation of 5.43.

Overall, the data shows that the experimental groups consistently outperformed the control groups in all three courses, with the most notable improvement observed in the BSCpE Microprocessor course. These results suggest that the experimental instructional approach may have a positive impact on student learning outcomes.

## CONCLUSION AND RECOMMENDATION

The findings of this study provide clear evidence that Project-Based Learning (PBL) offers significant advantages over traditional teaching methods in enhancing the academic performance and skill development of students in both the Bachelor of Science in Computer Engineering (BSCpE) and Bachelor of Science in Information Technology (BSIT) programs. Students exposed to PBL consistently demonstrated higher post-test scores, especially in the Microprocessor and Computer Programming 2 courses, with results showing statistically significant improvements. These outcomes affirm the value of PBL in fostering deeper understanding, improved problem-solving abilities, and practical application of knowledge in real-world contexts.

Although the Stand-Alone Embedded System course showed only slight improvements under PBL, the general trend across the data suggests that PBL is an effective pedagogy in computing education. The variation in performance may reflect the complexity of the course content, differences in project implementation, or the students' adaptation to project-based methodologies. Overall, the study concludes that while traditional teaching remains foundational, integrating PBL significantly enriches the learning process, better preparing students for the demands of the industry by developing both technical and soft skills. Educational institutions are therefore encouraged to consider broader adoption of PBL in computing curricula.

• **Curriculum Enhancement:** Integrate Project-Based Learning as a core instructional strategy in both BSCpE and BSIT courses, particularly in subjects that require practical application and system integration.

• **Faculty Development:** Provide training for instructors on designing, implementing, and assessing PBL activities to ensure effective delivery and consistency.
• Infrastructure Support: Invest in adequate hardware, software, and lab resources to support hands-on project implementation.
• **Assessment Improvement:** Develop more robust rubrics and feedback systems to holistically evaluate both individual and group performance in PBL tasks.
• **Further Research**: Conduct longitudinal studies to track the long-term effects of PBL on graduate employability, innovation capability, and professional readiness.

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