# A New Paradigm: Exploring the Effects of PBL and Other Pedagogical Methods on Freshman Engineering Learning Outcomes

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*Abstract—*

**Context**

**This paper explores the implementation of project-based learning (PjBL) within a freshman engineering applied physics course. PjBL offers a dynamic approach, engaging students in real-world problem-solving scenarios that enhance their understanding of theoretical concepts. With a growing emphasis on experiential learning in STEM education, this study investigates the efficacy of PjBL in fostering both conceptual understanding and practical skills among freshman engineering students. While existing research suggests PjBL promotes deeper learning outcomes and better retention, further exploration within the context of applied physics is warranted.**

**Purpose**

**This study investigates the comparative effects of project-based learning (PjBL) and traditional lecture-based instruction on student learning outcomes in a freshman engineering applied physics course. The hypothesis is that PjBL will lead to superior learning outcomes compared to traditional instruction and other conventional methods. This study aims to gain insights into the potential benefits of adopting PjBL in engineering education and its implications for enhancing student success in applied physics courses.**

**Approach**

**Sixty-three students enrolled in a freshman engineering applied physics course participated in this study. Students experienced a variety of pedagogical methods, including PjBL. PjBL activities promoted active engagement, problem-solving skills (abilities to apply theoretical knowledge in structured scenarios and adapt to complex situations), and real-world application of theoretical concepts. Pre- and post-assessment tests measured baseline knowledge and learning outcomes, while student feedback surveys assessed perceptions of learning experiences, engagement levels, and satisfaction with the teaching methods.**

**Results**

**Quantitative data from pre- and post-assessment scores were analyzed to identify significant differences in learning gains across pedagogical methods. Qualitative data from student surveys were analyzed thematically to uncover common perceptions and experiences. Post-implementation assessments revealed higher levels of conceptual understanding, problem-solving proficiency, and critical thinking skills among students engaged in PjBL activities compared to those in traditional lecture-based instruction.**

**Conclusion**

**The implementation of PjBL in the freshman engineering applied physics course led to significant improvements in student learning outcomes. Post-implementation assessments revealed higher levels of conceptual understanding, problem-solving proficiency, and critical thinking skills among students who engaged in PjBL activities compared to those who experienced traditional lecture-based instruction. These findings align with existing research suggesting that PjBL enhances student engagement, promotes deeper learning, and better prepares students for real-world applications in STEM education.**

***Keywords*— Project Based Learning, Traditional Lecture Based Instructions, Other Pedagogical Methods, Freshman Engineering**

## I. INTRODUCTION

The instructional approaches that rely on lectures are outdated. Goel credits the great scientist Socrates with saying, "I cannot teach anybody anything; I can only make them think." Galileo expressed the same idea, saying, "You cannot teach a man anything; you can only make him find for himself." "I do not teach my pupils; I only attempt to provide conditions in which they can learn," is another quote from Einstein. (Goel). The phrases are appropriate for the application of teaching and learning methods in the Applied Physics freshman engineering course. This course is essential in laying the groundwork for a variety of engineering specializations, as it provides the necessary foundation.

The shift from pre-university education to engineering courses at the college level creates a number of problems for students who are just starting out in their engineering studies. Even in applied physics, the specific problems are preventing students from learning and engaging with the subject matter. Some of these issues are: i) gaps in foundational knowledge as a result of a diverse educational background and inadequate pre-university preparation; ii) transition from high school to college as a result of a shift in teaching methods and a late admissions process; iii) language and communication as a result of medium instructions and communication skills; iv) a lack of practical exposure as a result of a theoretical focus and limited lab infrastructure; v) socioeconomic backgrounds; vi) technological adaptation; vii) outdated curriculum, etc., (Sukackė et al.; Mills and Treagust). Freshman engineering students who continue to struggle academically may experience rising levels of stress and a higher percentage of dropping out of engineering college. The driving force behind the substantial shift in engineering education over the past few decades has been the necessity to equip students with the skills necessary to tackle real-world challenges. In this regard, technical universities have committed themselves to playing a significant role in the implementation of a variety of pedagogies in order to assist and engage students in engineering education (Mohamed). Identified problem based learning (PBL) and project-based learning (PjBL) are the best pedagogies to engage the buddy engineers.

PjBL, or Project-based Learning, emphasizes the completion of comprehensive projects that extend over an extended timeframe and necessitate students to participate in thorough research, planning, and development. Applied Physics is an appropriate field of study for those who can gain advantages from acquiring a thorough comprehension of intricate physical principles and their pragmatic implementations. Project-Based Learning focuses on the development of concrete goods or solutions, making it especially advantageous in a subject such as Applied Physics. By applying their theoretical knowledge, students have the opportunity to conduct experiments, construct prototypes, and evaluate their hypotheses, so acquiring practical experience. PjBL enhances student engagement by increasing the relevance and connection of learning to real-world situations (Chen and Yang). As learners explore the driving question they earn and apply functional and problem solving competences (Arcidiacono et al.). Student engagement is defined as a complex concept that encompasses various aspects, such as behavior, emotions, and cognition (Fredricks et al.). Students exhibited elevated levels of motivation and interest in the subject matter when actively participating in PjBL.

PBL, or Problem-Based Learning, typically consists of concise, problem-centered activities that prioritize critical thinking and prompt quick problem-solving. Although it is efficient, it may not offer the same level of immersion with the content as PjBL. PjBL primarily emphasizes the theoretical dimension of problem-solving and may not consistently yield a tangible product or prototype, hence constraining the cultivation of practical skills.

PjBL developed as a significant method among the numerous educational approaches (Kolmos et al.), (Banakhr et al.), particularly for making first-year engineering students interested in the subject matter. In the field of engineering, the term "project" is commonly used to refer to a "piece of work" which is often specified once the customer's needs has been taken into consideration (Mills and Treagust). Almost each task that an engineer will perform in the course of their professional practice will be connected to a respective project. There will be a range of time frames for the projects. Basically the projects are classified three types 1) Assignment Project – under teacher controlled 2) Subject Project – Student have a free choice & 3) Problem Project – problem oriented learning process etc., (Anette Kolmos).

TABLE 1
Progression of PBL

| Aspect | Details |
|---|---|
| Origin | Frankfurt School critical pedagogy movement of the 1960s |
| Initial Adoption | Early 1970s in Humanities and Social Sciences faculties of the "New Universities" in Denmark and Germany(Whitehead) |
| First Integration in Engineering | 1974 at Aalborg University Centre in Northern Jutland, Denmark(Servant-Miklos and Spliid) |
| Initial Reception | Met with skepticism by engineering educators |
| Recognition of Potential | Engineering educators saw potential for educating work-ready engineers with strong collaboration and problem-solving skills(Thomas) |
| Evidence of Effectiveness | Consistently high ratings for work-readiness of graduates from PBL engineering schools(Mitchell et al.; Kolmos et al.; Mann et al.) |
| Popularization | PBL became one of the most popular pedagogical approaches in engineering education literature (Du and Kolmos) |

The table 1 summarizes the origins, adoption, effectiveness, and popularization of Project-Based Learning in engineering education.

The present paper addressed Research Questions (RQ)

RQ1) what extent does Project-Based Learning (PjBL) influence the degree of engagement among first-year engineering students (Cruz and Rincon)in comparison to the more traditional method of instruction, which is based on lectures?

RQ2) In comparison to other instructional approaches, what are the perspectives and levels of satisfaction that first-year engineering students have about project-based learning?

Students are given the opportunity to work on real-world projects in environments that are based on project-based learning, which assists them in developing skills and competencies that are necessary for working in real-world environments and across industries(Kolmos et al.) (Hong et al.). PjBL has a wide range of advantages, including the fact that it allows students to work on real-world, client-centered challenges, which in turn improves their knowledge, comprehension of the particulars of future jobs and also accomplish industry needs(Uziak). Students are more likely to be engaged in the learning process and interested in their future occupations when they participate in PjBL (Du et al.). Students are highly motivated to acquire more in-depth topic knowledge, and they become active participants in the learning process by applying theoretical information to practical applications in the workplace(Anette Kolmos). PBL also encourages independent thought, creativity, and critical thinking among its participants. The program places an emphasis on teamwork and gives students the opportunity to study from a variety of sources(Mills and Treagust). Some students even become specialists in certain fields and take on the role of instructors.

## II. METHODS

A total of sixty-three first-year students of Data Science program from a private engineering college, autonomous, located in Hyderabad, Telangana, who were enrolled in a course on applied physics were the subjects of this research study. Over the course of a semester that lasted sixteen weeks, this class met for three hours each week. The content of this course was broken down into five different modules: quantum physics, semiconductor devices, optics and nano-materials, laser and fibre optics, dielectric materials, and magnetic materials, as well as energy sources. The group consisted of 42 males and 21 females in total. There are 15 teams formed with each team of size four members and one team with team size of three members. A quantitative survey conducted to find out the impact of project based learning and also compared the two mid-term continuous internal assessments of sixty three students.

According to Sukacke and Jeon et al., (Jeon and Jarrett) the following six sequence of actions was taken in order to adopt PBL for the current course in applied physics. This facilitated the project's implementation into two distinct assessment phases and allowed for submissions to be organized based on teams participating in session-wise activities, as outlined in Table 2.

1. **Question:**
   Teachers or external stakeholders present a query or problem to answer. Student teams reflect and ask questions.
2. **Plan & Define:**
   A problem or circumstance is set by teams. Brainstorming yields solutions and a plan for product development.
3. **Research:**
   Student research links scientific concepts to the project. Reviewing literature, learning from similar experiences, and understanding stakeholders' settings are included.
4. **Produce:**
   Students collaborate to develop a final solution. This spiral approach to learning encompasses prototype development, verifying with teachers, classmates, and stakeholders, and piloting deployment. The method improves the product.
5. **Improve:**
   Taking into account instructor, peer, and stakeholder feedback, ideas or products are improved.
6. **Present:**
   Teacher receives oral presentations, posters, and scientific papers of the end product or solution.

TABLE 2
IMPLEMENTATION OF PBL STEPS

| Duration | Progress of the project | Session wise Activity | Implementation PBL Steps | Assessment of course project |
|---|---|---|---|---|
| 4th Week | Problem Identification/ PBL - introduction | Brainstorming | Orientation | Phase 1 MID I Technical report writing (10 M) |
| 5th Week | Literature survey | Think Pair Share | Identifying/ Defining | |
| 6th Week | Report writing - presentation | Flipped classroom | Planning/ Reporting | |
| 11th Week | Design progress | Jigsaw | Implementation | Phase 2MID II Presentation of project (10 M) |
| 12th Week | Prototype preparation/ testing | Demonstration | Implementation/ Improvement | |
| 14th Week | Prototype submission | Presentation | Evaluating | |

The first step of the project involves the production of a project design technical report (phase 1) that addresses a real-world problem at the identified course level. The development of critical abilities such as the integration of previous information, teamwork, decision-making, and acquiring and using of technical knowledge is essential. The second component is conducting experimental tests. The process involves the development of prototypes, conducting tests, and presenting the findings (phase 2). The primary goals of the project were to enhance engineering decision-making, foster critical thinking, and gain practical experience in equipment utilization. Additionally, the project aimed to promote teamwork skills and identify potential challenges for future design assignments.

In accordance with the course syllabus, every student is required to participate in the course projects by picking topics that are relevant to real-world problems or situations that are of interest to them. Student teams, each of which consists of four individuals, are responsible for selecting the themes to be discussed. Students are given a choice to select the team members (heterogeneous). Every team must present a literature review and project name. We ensure thorough research and relevance of the chosen themes through this preliminary submission. Upon completion of the literature survey (I midterm), we expect the teams to submit a draft report. This report includes the design process, the projected findings, and the methodology. We review this draft report as part of the first round of midterm tests. This gives the instructors the opportunity to provide early feedback and direct the teams in the appropriate direction.

Students advance to the next phase of synthesis and application by making use of the report that has been revised based on the feedback that they have received. They will move forward with the preparation of the prototype once they have achieved a level of experience in the domain skills that are necessary for their project. Following the completion of the prototype fabrication, students are required to deliver a presentation in addition to presenting the prototype model that is operational. Students have the opportunity to exhibit their practical abilities and the extent to which their academic knowledge can be used during this stage, which is an extremely important stage. Under the second set of midterm assessments, both the presentation and the prototype are evaluated using the rubrics that have been provided. The final presentations, which include demonstrating the prototypes and explaining the process of design and implementation, offer a full review of the work and accomplishments that the students have accomplished throughout the semester. The implemented process of PBL has important stages as per the literature as mentioned (Sukackė et al.).

## III. Results

Students are required to take the first midterm (MID I) assessment after they have completed eight weeks and two and a half modules of the curriculum. This evaluation is comprised of a test that is worth 25 marks, a student presentation that is worth 10 points, and an assignment that is worth 5 marks. After another eight weeks and an extra two and a half modules, students will face the second midterm (MID II) assessment, which will once again consist of a test worth 25 marks, a student presentation for 10 marks, and an assignment worth 5 marks. The results, which are provided in table 3 and Fig 1, demonstrate that there was a significant improvement in the performance of the students from MID I to MID II. There is a comprehensive summary of these enhancements in Table 4, which includes:

**Grade Enhancement from B to A:** Five students advanced their grades from B to A.

Grade **Enhancement from C to A:** Six students improved their grades from C to A.

**Grade Enhancement from D to A:** Eight students elevated their grades from D to A.

**Grade Enhancement from C to B:** Seven students moved from C to B.

**Grade Enhancement from D to B:** Nine students progressed from D to B.

**Grade Enhancement from D to C:** Nine students upgraded their grades from D to C.

The methodologies of Project-Based Learning have been shown to have a good influence, as demonstrated by these developments. As the students were at the first stage of the project-based learning implementation, they were concentrating on gaining knowledge of the fundamental ideas and getting started on their project work. PBL had allowed students to fully engage in collaborative teamwork and practical application of their knowledge by the time they reached MID II. This was reflected in the students' improved performance and higher grades. This process illustrates that problem-based learning) is successful in generating deeper comprehension, improved teamwork, and improved academic outcomes than traditional methods.

TABLE 3
CONTINUOUS INTERNAL EVALUATION

| Continuous Internal Evaluation | | | | |
|---|---|---|---|---|
| Exam/Category | A(>=31) | B(24 to30) | C( 16 to 23) | D(<=15) |
| MID I | 13 | 6 | 14 | 30 |
| MiD II | 28 | 20 | 12 | 3 |

TABLE 4
CIE PERFORMANCE ANALYSIS

| | **Performance Analysis** | | | |
|---|---|---|---|---|
| **Category** | **A** | **B** | **C** | **D** |
| **A** | **10** | **0** | **0** | **0** |
| **B** | **5** | **1** | **0** | **0** |
| **C** | **6** | **7** | **3** | **0** |
| **D** | **8** | **9** | **9** | **3** |

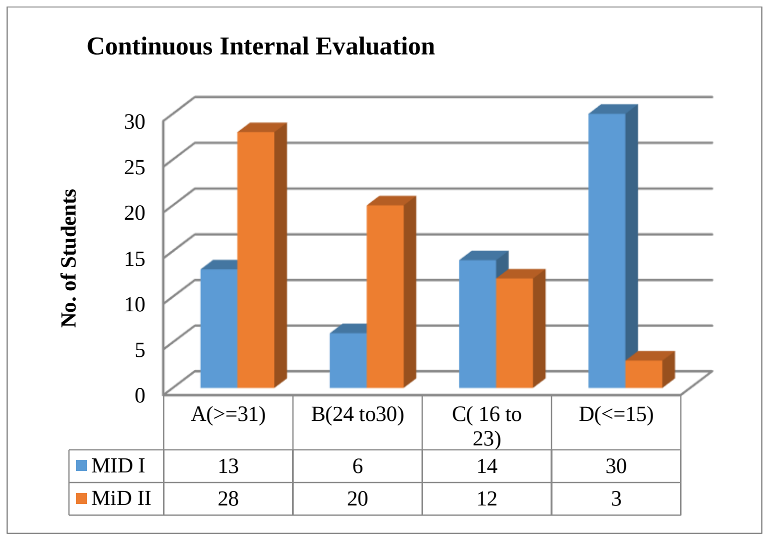

Fig. 1. Continuous Inter Evaluation of MID I & MID II

Overall, 16 teams participated and submitted 14 different titles for applied physics course-level projects. The use of PjBL ensures that students in the Applied Physics course actively participate in learning through the process of problem-solving based on real-world scenarios. In addition to fostering the development of critical thinking abilities, this systematic approach, which incorporates ongoing evaluation and feedback, also helps students acquire a profound comprehension of physics principles.

**Qualitative Survey:**

On the other hand, out of 63 people that were assigned to the survey, only 36 (20 male 16 female) were present for the survey, which resulted in a sample size of 36.

TABLE 5
SURVEY ANALYSIS

| S.NO | Aspect | Strongly Agree | Agree |
|---|---|---|---|
| 1 | Overall experience with PjBL in this course | 61% | 32% |
| 2 | Understanding of applied physics concepts | 8% | 92% |
| 3 | PjBL influenced problem-solving skill | 8% | 86% |
| 4 | PjBL impacted critical thinking skills | 25% | 75% |
| 5 | PjBL affected ability to work in teams and collaborate with peers | 47% | 47% |
| 6 | Engaging in PjBL activities | 28% | 61% |
| 7 | PjBL activities motivate you to learn more about applied physics | 5% | 53% |
| 8 | Engaging in group activities like jigsaw or peer learning | 19% | 75% |
| 9 | PjBL affect your interest in the subject | 58% | 33% |
| 10 | Performance in applied physics before participating in PjBL activities | 19% | 36% |
| 11 | Performance in applied physics after participating in PjBL activities | 33% | 61% |
| 12 | "PjBL helped me achieve a better understanding and application of applied physics concepts compared to traditional teaching methods." | 17% | 69% |
| 13 | PjBL activities affect your engagement in the applied physics course | 11% | 58% |
| 14 | PjBL affect enthusiasm for learning applied physics | 11% | 86% |
| 15 | PjBL activities help you understand the real-world applications | 8% | 56% |
| 16 | Understanding the real-world relevance of applied physics | 50% | 44% |
| 17 | PjBL impact your ability to apply theoretical knowledge to practical problems | 58% | 33% |
| 18 | Overall satisfaction with the PjBL experience | 69% | 28% |

Along with above eighteen aspects as shown in the table 5, another five more aspect feedbacks also collected in survey. Those are

1. Engaging Aspects of PjBL

Students identified several aspects of PjBL that they found most engaging:

Peer collaboration (39%): A substantial number of students emphasized that working with their classmates was the most captivating part. This implies that the focus on collaboration in PjBL effectively increases student involvement.

Practical Experience (22%): The tangible, hands-on aspect of PBL was another captivating component, demonstrating that students value and get advantages from experiential learning experiences.

Flexibility and Creativity in Projects (36%): The ability to adapt and the chance to be innovative were also greatly appreciated, suggesting that PjBL cultivates a learning atmosphere where students may freely express their ideas and engage in unconventional thinking.

2. Motivational Factors

When asked what motivated them the most during PjBL activities, students responded as follows:

Collaboration (53%): More than half of the students were motivated by the collaborative features of PBL, highlighting the significance of teamwork in boosting student motivation and engagement.

Freedom to Explore and Create (17%): The capacity to independently investigate many subjects and generate inventive solutions was a major driving force, underscoring the importance of student autonomy in the learning process.

Real-World Application and Concept (17%): The practicality of PBL exercises in real-life scenarios inspired students, highlighting the significance of learning within a specific context. Feedback and Interaction with Instructor (14%): The presence of interaction and feedback from instructors was found to be encouraging, highlighting the importance of ongoing guidance and assistance in a Problem-Based Learning (PBL) environment.

3. Relevance to Real-World Situations

Students found the following PjBL activities most relevant to real-world situations:

Experiments (42%): The act of conducting experiments was considered the most significant activity, indicating that practical experimentation helps connect theoretical knowledge with real-life implementation.

Case Studies (31%): The analysis of case studies was also considered very relevant, suggesting that students appreciate the practical application of theoretical knowledge to real-life situations.

Design projects, which accounted for 25% of the activities, demonstrated the need of creating and designing solutions in order to comprehend real-world applications.

4. Valuable Skills Gained

The survey also asked students about the most valuable skills gained from PBL activities:

Collaboration and Teamwork (61%): The majority of students expressed that collaboration and teamwork were the most valuable skills acquired, highlighting the significance of Project-Based Learning (PBL) in nurturing crucial interpersonal skills. Teamwork and collaboration were significantly enhanced by PjBL, resulting in improved students' capacity to work effectively in groups (Alves et al.).

Critical Thinking (22%): A significant number of students recognized the need of enhancing their critical thinking abilities through PBL. They acknowledged that PBL effectively stimulates them to scrutinize and assess information.

Application of Theoretical Knowledge (17%): The capacity to utilize theoretical knowledge in real-life scenarios was identified as a valuable talent, demonstrating the efficacy of Problem-Based Learning (PBL) in connecting theory and practice.

5. Suggestions for Improvement

Students provided several suggestions for improving PBL activities:

Increased inclusion of real-world case studies (36%): A substantial proportion of students recommended integrating additional real-world case studies to augment the practical applicability of PBL activities. Project-based learning (PjBL) served as a means to connect academic learning with practical, real-life applications (Cruz and Rincon). Enhanced Structure (28%): Several students expressed a need for enhanced structure, highlighting a desire for more explicit instructions and expectations.

Enhanced cooperation possibilities (25%): A recommendation was made to increase possibilities for cooperation, indicating that students really appreciate the teamwork component of PBL.

In response to student comments, there is a need for increased instructor feedback, as several students have expressed the necessity of receiving continual assistance and guidance.

Overall Satisfaction: The general contentment with PjBL was significantly high. Students valued the organization and results of the project-based learning method, indicating a preference for PjBL over conventional lectures. The practical experience, combined with the freedom and ingenuity permitted in assignments enhanced the learning process, making it more satisfying and productive.

And Fig 2 & Fig 3 shows the student presentations and working prototype demonstration videos.

Fig 2: Students Presentations

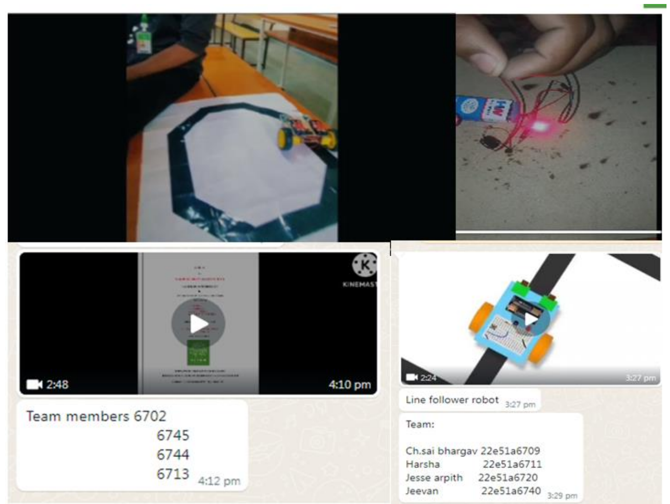


Fig 3: Working Prototype Demonstration Videos

**T-Test**

A paired-samples t-test was conducted to determine the effect of exercise on a peer tutoring.

H0: There is a no significant difference between Mid I & Mid II student secured marks (null hypothesis)

H1: There is a significant difference between Mid I & Mid II student secured marks (alternative hypothesis)

TABLE 6
T-TEST

| t-Test Paired Two Sample | MID I | MID II |
|---|---|---|
| Mean | 18.03 | 28.39 |
| Variance | 136.58 | 57.38 |
| SD | 11.68 | 57 |
| Observations | 63 | 63 |

From the table 6 t-test shows that there is a significant difference between the group that exercised before Mid II (M=28.39; SD=7.57) and the group with no exercise after Mid I (M=18.03; SD=11.68); t (62) = 2.00 p< 0.001.

There is a large difference between the Mean and Standard Deviation values in t-test, the calculated value of t is greater than the critical value of t (p value of 5 %). Hence the null hypothesis H0 strongly rejected and strongly agreed the alternative hypothesis H1. It reveals that students' performance in Mid II improved noticeably as compared to Mid I with the adoption of a peer tutoring pedagogy.

This means that the overall performance of the students has improved significantly from MID I to MID II.

In this study, 63 students are evaluated in two internal tests (MID I and MID II). A paired sample t-test was used to see if MID I to MID II scores improved statistically. The results show a significant improvement, suggesting treatments between tests worked. Tracking student success is essential for constant internal evaluation. The results of 63 students in two successive exams, MID I and MID II, are examined to determine if they have improved. MID I and II scores from 63 students were gathered. The two evaluation scores were compared using a paired sample t-test. We reject the null hypothesis and find that scores improve significantly from

MID I to MID II since the p-value is much lower than 0.05. Significant score increases indicate that students' performance increased significantly between examinations. Effective teaching, increasing student motivation, and focused interventions after MID I may have contributed to this improvement. This study found significant student performance improvement between MID I and MID II. Future studies could identify the causes of this improvement to improve instructional tactics.

**Limitations:** Due to the fact that the survey was carried out with a smaller percentage of students, it is possible that the results could not offer an accurate reflection of the entire student population. It is possible that the findings would be different if the participants were more numerous and diversified. The evaluation was carried out over the course of two midterm periods that were contained inside only one semester. To get a complete understanding of the impact that Project-Based Learning has on student performance and the retention of knowledge, a study that is conducted over a longer period of time is required. The analysis was based on standard evaluation techniques (tests, presentations, and assignments), which may not have been able to completely capture the overall benefits of problem-based learning, such as better critical thinking, creativity, and problem-solving skills. The success of PBL is primarily dependent on their ability to effectively collaborate as a team. It is difficult to ascribe performance increases entirely to the PBL strategy because of the possibility that the outcomes could be influenced by the fact that students' interpersonal skills and team chemistry could vary.

**Future work:** Conduct research over time to evaluate the long-term effects of PjBL on student learning outcomes, knowledge retention, and real-world skill application. Expand the study to include a diverse student sample to validate findings and ensure the ability to generalize across academic environments and communities. Expand evaluation methodologies to include critical thinking, creativity, and problem-solving skills, in addition to traditional academic performance indicators. Explore the impact of team composition on PBL outcomes, including cooperation, project success, and individual learning. To optimize resources and enhance PBL adoption, consider utilizing technology, industry collaborations, peer mentorship programs. Invest in faculty training programs to provide instructors with PBL facilitation abilities, such as project management, collaborative facilitation, and assessment procedures.

## IV. Conclusion

This paper conducted a systematic analysis of project-based learning in an applied physics course for freshmen engineers. Compared to other traditional lecture-based teaching and learning methods, this leads to enhanced student learning outcomes such as problem-solving skills, critical analysis of the problem, project design and execution, teamwork, and engagement in PjBL. Students demonstrate an interest in participating in the PjBL activities within the stipulated time frame. Additionally, students are improving their language communication abilities, presentation skills, and technical proficiency. Simultaneously, some issues arise, including time management, insufficient resources, communication gaps between the guide and students, and delayed responses to their inquiries. Students don’t turn up to interact with the teacher/supervisor. They observed an uneven distribution of their teamwork, yet they gained knowledge from their mistakes. (Miranda et al.). As the successors in implementing PBL, faculty members have benefited from engaging students, enhancing their performance, and collecting continuous feedback, despite the challenges of limited resources and a shorter academic time frame (Graham and Crawley), (Alves et al.) . These findings align with existing research that suggests PBL enhances student engagement, promotes deeper learning, and better prepares students for real-world applications in STEM education.

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## APPENDIX I

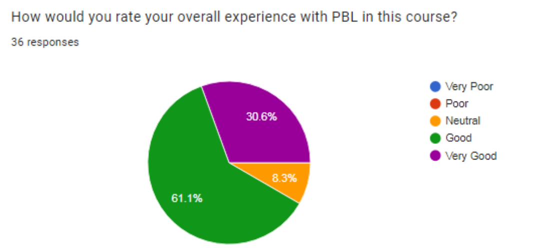
TABLE 7

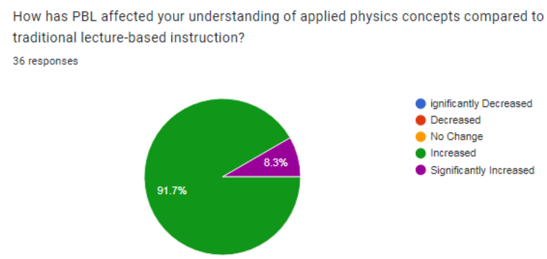
1. PRE & POST ASSESSMENTS MARKS OF I CSD STUDENTS

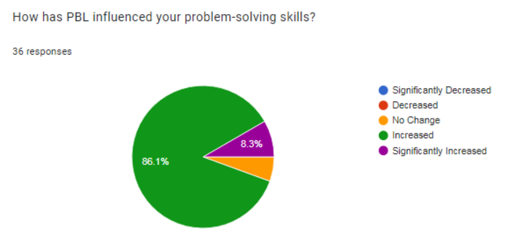
| S.No | Roll Number | MID II | MID I | Difference |
|---|---|---|---|---|
| 1 | 6701 | 36 | 34 | 3 |
| 2 | 6702 | 32 | 17 | 16 |
| 3 | 6703 | 31 | 7 | 24 |
| 4 | 6704 | 39 | 40 | -1 |
| 5 | 6705 | 39 | 40 | -1 |
| 6 | 6706 | 24 | 13 | 12 |
| 7 | 6707 | 31 | 3 | 28 |
| 8 | 6708 | 14 | 0 | 14 |
| 9 | 6709 | 36 | 19 | 17 |
| 10 | 6710 | 24 | 12 | 12 |
| 11 | 6711 | 25 | 31 | -6 |
| 12 | 6712 | 32 | 30 | 2 |
| 13 | 6713 | 29 | 22 | 7 |
| 14 | 6714 | 33 | 23 | 11 |
| 15 | 6715 | 24 | 9 | 15 |
| 16 | 6716 | 26 | 33 | -7 |
| 17 | 6717 | 20 | 4 | 16 |
| 18 | 6718 | 29 | 11 | 18 |
| 19 | 6719 | 30 | 16 | 15 |
| 20 | 6720 | 33 | 37 | -4 |
| 21 | 6721 | 29 | 14 | 15 |
| 22 | 6722 | 33 | 30 | 3 |
| 23 | 6723 | 19 | 1 | 18 |
| 24 | 6724 | 31 | 23 | 8 |
| 25 | 6725 | 14 | 0 | 14 |

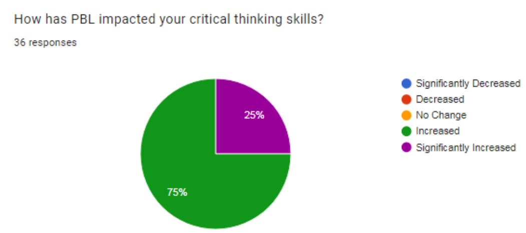
| | | | | |
|---|---|---|---|---|
| 26 | 6726 | 34 | 30 | 5 |
| 27 | 6727 | 0 | 0 | 0 |
| 28 | 6728 | 22 | 20 | 3 |
| 29 | 6729 | 23 | 3 | 20 |
| 30 | 6730 | 32 | 13 | 19 |
| 31 | 6731 | 38 | 32 | 7 |
| 32 | 6732 | 29 | 19 | 11 |
| 33 | 6733 | 29 | 18 | 12 |
| 34 | 6734 | 32 | 16 | 17 |
| 35 | 6735 | 28 | 14 | 15 |
| 36 | 6736 | 27 | 7 | 20 |
| 37 | 6737 | 19 | 14 | 6 |
| 38 | 6738 | 36 | 31 | 5 |
| 39 | 6739 | 21 | 12 | 9 |
| 40 | 6740 | 28 | 18 | 10 |
| 41 | 6741 | 17 | 5 | 13 |
| 42 | 6742 | 39 | 40 | -1 |
| 43 | 6743 | 32 | 15 | 17 |
| 44 | 6744 | 16 | 9 | 7 |
| 45 | 6745 | 32 | 13 | 19 |
| 46 | 6746 | 22 | 0 | 22 |
| 47 | 6747 | 21 | 13 | 8 |
| 48 | 6748 | 37 | 35 | 2 |
| 49 | 6749 | 35 | 29 | 6 |
| 50 | 6750 | 25 | 0 | 25 |
| 51 | 6751 | 34 | 4 | 30 |
| 52 | 6752 | 39 | 30 | 10 |
| 53 | 6753 | 38 | 37 | 2 |
| 54 | 6754 | 39 | 27 | 13 |
| 55 | 6755 | 25 | 15 | 11 |
| 56 | 6756 | 28 | 23 | 5 |
| 57 | 6757 | 39 | 37 | 2 |
| 58 | 6758 | 32 | 11 | 21 |
| 59 | 6759 | 21 | 14 | 7 |
| 60 | 6760 | 29 | 32 | -3 |
| 61 | 6761 | 24 | 16 | 8 |
| 62 | 6762 | 21 | 16 | 5 |
| 63 | 6763 | 33 | 9 | 24 |

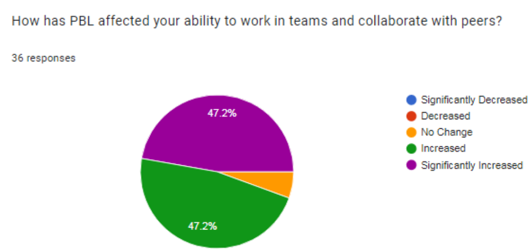
## 2. Google Form Survey Pie Charts

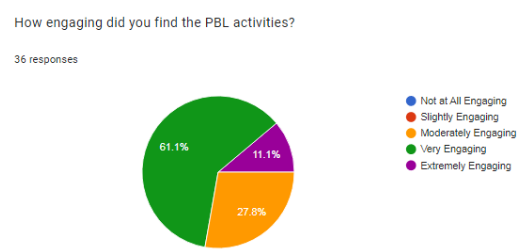


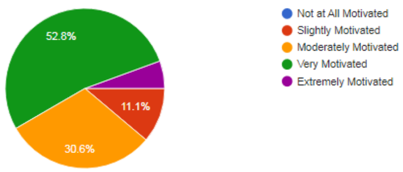



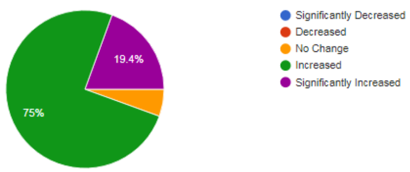
Did PBL activities motivate you to learn more about applied physics?

36 responses



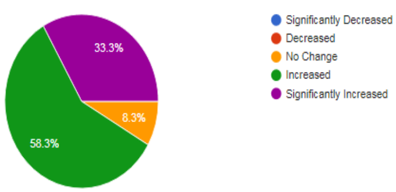

Did engaging in group activities like jigsaw or peer learning sessions provide different insights into physics concepts than studying individually?

36 responses



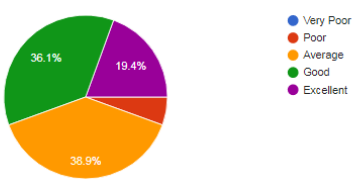

Compared to traditional lecture-based instruction, how did PBL affect your interest in the subject?

36 responses



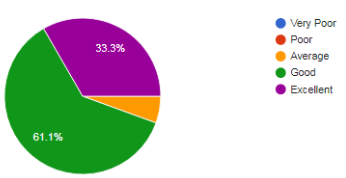

How would you rate your performance in applied physics before participating in PBL activities?

36 responses



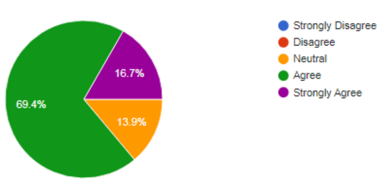

How would you rate your performance in applied physics after participating in PBL activities?

36 responses



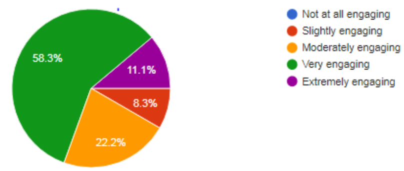

To what extent do you agree with the following statement: "PBL helped me achieve a better understanding and application of applied physics concepts compared to traditional teaching methods."

36 responses



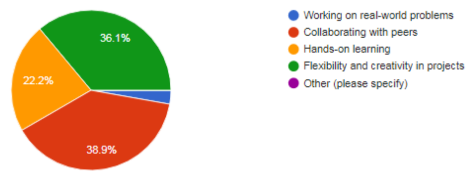

How did PBL activities affect your engagement in the applied physics course?

36 responses



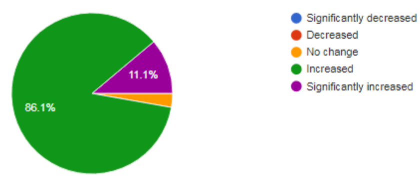

Which aspect of PBL did you find most engaging?

36 responses



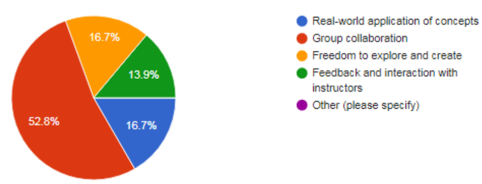

How did PBL affect your enthusiasm for learning applied physics?

36 responses



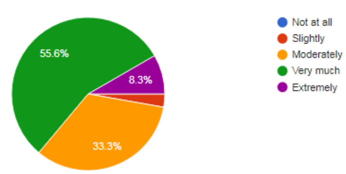

What motivated you most during PBL activities?

36 responses



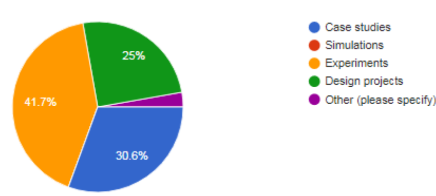

How did PBL activities help you understand the real-world applications of applied physics concepts?

36 responses



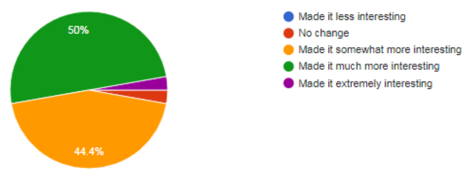

Which PBL activity did you find most relevant to real-world situations?

36 responses



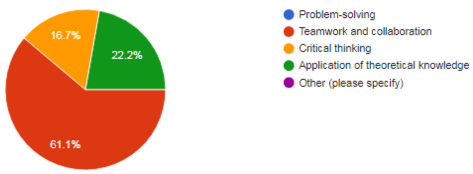
How has understanding the real-world relevance of applied physics through PBL influenced your perspective on the subject?

36 responses



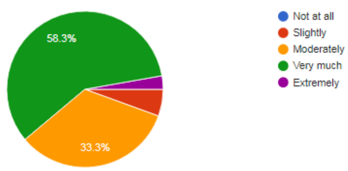

What was the most valuable skill you gained from participating in PBL activities?

36 responses



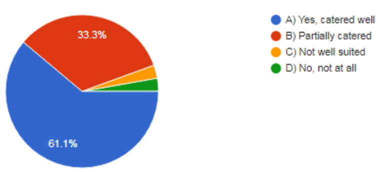

How did PBL activities impact your ability to apply theoretical knowledge to practical problems?

36 responses



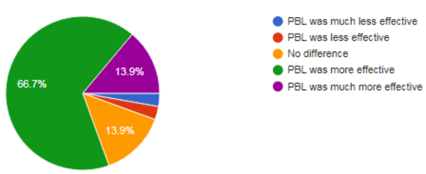

Do you feel that the diversity of pedagogical approaches used in the course catered to different learning styles and preferences?

36 responses



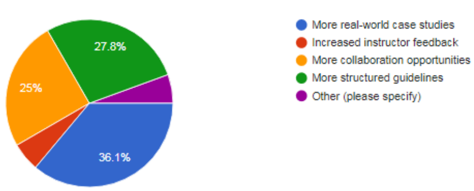

How would you compare your learning experience with PBL to traditional lecture-based instruction?

36 responses




What suggestions do you have for improving PBL activities?

36 responses




Overall, how satisfied are you with the PBL experience in the applied physics course?

36 responses