

# Engineering Education Transformation: Project-Based Learning's Effect on Problem-Solving and Lifelong Learning

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**Abstract-**This paper examines the traditional model of classroom instruction method has its limitations in engaging students and fostering deep understanding. In response, educators have increasingly turned to flipped classroom pedagogy, a method that reverses the traditional order of instruction by delivering content outside of class and utilizing class time in class activities. This research paper investigates the efficacy of flipped classrooms pedagogy in enhancing student participation and improving learning outcomes. A ensemble approach was implemented, using quantitative analysis of student performance data with qualitative assessments of student experiences and perceptions. The findings reveal promising benefits of flipped classroom implementation, including increased student engagement, improved understanding of course material, and enhanced critical thinking skills. However, challenges such as technological barriers and student resistance to independent learning were also identified. The discussion highlights the implications of these findings for educators and proposes new approaches for future study and practice

**Keywords-**Critical thinking skills, PBL pedagogy, Learning outcomes, Student engagement, Student participation, Technological barriers

## I. INTRODUCTION

The traditional model of classroom instruction, characterized by teacher-led lectures followed by homework assignments, has been the dominant approach in education. this model has met criticism for its passive nature and limited effectiveness in engaging students and promoting deep learning. In response to these challenges, educators have explored alternative pedagogical

approaches, one of which is the Project Based Learning model. The Project Based Learning reverses the traditional order of instruction by delivering content outside of class, typically through video lectures or online modules, and using class time for interactive activities, discussions, and collaborative projects. This paper aims to investigate the efficacy of Project Based Learning pedagogy in enhancing student engagement and improving learning outcomes.

The Project Based Learning model is an innovative approach to teaching and learning that has gained significant attention in recent years. By reversing the traditional classroom structure, the Project Based Learning model aims to enhance student engagement, promote active learning, and improve overall learning outcomes. This document provides a comprehensive overview of the key aspects of the flipped classroom, from its benefits to the strategies for successful implementation and evaluation. Additionally, it explores the role of technology in supporting the Project Based Learning model and offers practical recommendations for educators looking to adopt this approach in their own classrooms. By incorporating a combination of pre-recorded lectures or instructional videos and in-class activities, the Project Based Learning model empowers students to take ownership of their learning and encourages collaboration and critical thinking skills.



Fig 1: Project Based Learning/teaching

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## **II. ROLE OF PBL IN EDUCATION**

The term project-based learning has been used very often by most language teachers for project work; however, such short of activities have often failed to drive a maximum benefit of PBL itself. Teachers very often get trapped with the ambiguity of PBL. Sometime a very simple activity of the students who can produce a certain product like their video conversation is included in the category of PBL. However, in this activity, the students tend to attend without inputting to the group process. Only one of the pupils completed the exercise. The remaining children just sit around and engage in a conversation, which squanders precious teamwork time and time needed to learn information and other vital time to learn the usage of the English language.

The teacher concentrated only on the students' product, which was physical; they neglected the development in language and the development in the subject area. At times, the students face difficulties with their project work as a result of either overwhelming teacher control or the absence of feedback and support. Teachers who are overly controlling do not allow students to be responsible or own their learning actively, and this negatively affects the development of a sense of responsibility in them. Not only that but it often leads to repeating the same project in subsequent lessons without any changes if students are not allowed to provide feedback on their experience with their project.

Students may become feeling powerless and disconnected when they hardly control the projects they select or the learning process itself. These points challenge teachers to have a practical and well-defined framework that is designed specifically for the language learning context. It helps teachers to clarify the different stages and learning objective of project-making. Finally, it can assist students with comprehending the procedure and objectives when they take on new responsibilities, develop ongoing relationships with their peers, and get ready to exhibit their work to others (Greenier, 2018).

To make PBL more effective, teachers have to give up some control so that the students regard them as facilitators. It is important that the feedback on student's project experiences be obtained to make improvements for every period of time. It has been proposed that feedback is a fundamental element in training that improves learning and related motivation for the acquisition of knowledge and skills (Ching & Hsu, 2013). This, however, is not enough, as the complete abdication of teacher control without any guidance in the relevant areas of language, content, or even the process of the project may leave students disoriented. Accordingly, while there should be direction by the teacher, a balance needs to be struck for achieving maximum benefits of PBL in the language classroom (Alan & Stoller, 2005).

PBL has proven to be an effective approach that encompasses

academic, social, and linguistic communication skills while working with real problems or situations in an English language learning environment (Yazdanpanah, 2019). With this in mind, under PBL, students actively participate in group work and construct their knowledge pertaining to authentic real-life challenges. In addition, Thomas (2000) states that PBL comprises five criterions:

- a. PBL are central, not peripheral to the curriculum,
- b. PBL are focused on questions or problems that "drive" students to encounter (and struggle with) the central concepts and principles of a discipline;
- c. Projects involve students in a constructive investigation;
- d. Projects are student-driven to some significant degree;
- e. Projects are realistic, not school-like.

Considering the points mentioned above, it is clear that careful planning that integrates intercultural and English-language learning aims are crucial for PBL activities' success in an EFL context. In the process of completing project activities, the students form a very strong link with other people and their projects. Such activities also allow the students to have more opportunities to have interpersonal interaction, cooperation, coordination, and collaboration with others. PBL is regarded one of the very effective techniques which involve the student, interpret educational material in an interesting way, gives new knowledge, but also helps in developing traits that are required for working with others and even resolving conflicts (Chmelárová & Pasiar, 2017). Planned activities of Stoller (1997) and Sheppard and Stoller (1995) can be utilized by the teacher for optimal realization of benefits which PBL may bring into their teaching-learning process. These proposed activities are believed to possess possibilities of authentic experience, critical and creative thinking, and capability of decision making. Teachers can use properly designed activities which are recommended by Stoller (1997) and Sheppard and Stoller (1995) for complete realization of the benefits of PBL.

- Scholastic results: PBL is associated with a medium-large positive effect on students' scholastic results.

It is linked to a positive effect with medium-large magnitude in students' academic performance [27]. If we compare the impact with that of other programs internationally evaluated, like the Education Endowment Foundation, for example [40], PBL is more effective than that attributed to programs based on student feedback, on meta-cognition and self-regulation of learning promotion and on personalized tutorials.

The primary studies support this conclusion: the causal evidence is very limited, but in the right direction, and inclines to a slightly positive direction for learning. Quasi-experimental studies provide much more evidence and have a positive and medium impact on learning. The positive effect may appear on conceptual and procedural knowledge.

About content, and other studies stress that students can integrate conceptual knowledge applied through PBL [29]. Our literature review also clearly indicates some studies

whose impact is zero, at least is limited to certain capacities, even having negative impacts [30][31] [32] [33]. These mixed findings may be attributed to the different type of learning experience assessed and to PBL's high sensitivity to the context and the conditions under which it is implemented. They may also stem from differences in evaluation methodologies. More reasons why most effects may not last long-term are: most of the studies measure the learning outcomes soon after the program ends, thus we can evaluate the effect only short-term. • Affective and motivational aspects of learning.

PBL is associated with a positive impact on student satisfaction with the teaching experience, although the evidence is mixed with regard to the effects on their motivation for learning, involvement and assistance. Students generally present positive attitudes toward this methodology [34]. PBL is usually perceived in a positive light by students, which makes them judge it as more effective than traditional methodologies [35]. This subjective perception is likely associated with some of the effects PBL is associated with a medium-large positive effect on students' outcomes in academic performance.

PBL is associated with a positive effect on student satisfaction with their learning experience, although evidence is mixed as regards the effects on their motivation for learning, involvement and help. when PBL is applied, students can have a better perception of science and higher expectations about leading a scientific career [9], a positive self-concept image [11] and improved self-efficacy perception [8]. However, when the effect of PBL on the intrinsic motivation and involvement of students is measured, less consistent results are obtained. We consider that based on our review of 10 primary studies, we understand that PBL has a nonsignificant impact concerning motivation and involvement. Moreover, if one measures the effects on attendance and completion rates of student programs, results are equally inconclusive.

From five key studies analyzed, it is found that there is an extremely modest effect on levels of attendance and on preventing students from dropping out. These results caution us in being very careful not to confuse our stimulation of the students in terms of satisfaction with the use of PBL compared with traditional approaches with the real influence upon their intrinsic motivation and their attendance in class. The first is easier to attain, while the second one is more challenging. • Crosscutting skills. The key question is whether PBL results in the acquisition of some key crosscutting skills, such as creativity, critical thinking, or digital competence; here, there is no evidence. There is an evident and general lack of assessment on the personal and social skills developed through PBL [29].

However, some reviews state PBL to be an effective methodology for training complicated processes such as

planning, problem solving, and decision-making [35]. There are two significant studies that have shown to criticize the impact of PBL-with critical thinking and creativity- but such impacts were not significant statistically. More positive outcomes come out from qualitative appraisals of other reviewed primary studies. For example, an experimental study [36] indicates positive outcomes for teamwork skills in the context of computer usage in secondary school. The second relevant experimental study within the area of language in some secondary schools in United Kingdom [33] demonstrates probably a positive impact on the collaborative and self-control skills of the students.

#### *A. In-Class Active Learning Strategies*

The Project Based Learning model allows for more time to be dedicated to active learning activities during class. Teachers can leverage a variety of strategies to engage students and promote deep learning, such as small- group discussions, problem-solving exercises, case studies, or hands-on demonstrations.

#### *B. Collaborative Learning*

Encourage students to work in small groups to discuss, analyze, and apply the concepts they've learned outside the classroom. This fosters active engagement, critical thinking, and the development of teamwork and communication skills.



Fig 2: Collaborative Learning

#### *C. Problem-Based Learning*

Present students with real-world problems or case studies and guide them through the process of identifying key issues, generating solutions, and evaluating the effectiveness of their approaches. This promotes problem-solving skills and the application of knowledge.

Fig 3: Hands-On Activities

### **III. IMPLEMENTATION OF PROPOSED WORK**

Incorporate hands-on activities, simulations, or experiments that allow students to actively explore and apply the concepts they've learned. This kinesthetic learning experience can deepen their understanding and engagement with the material.

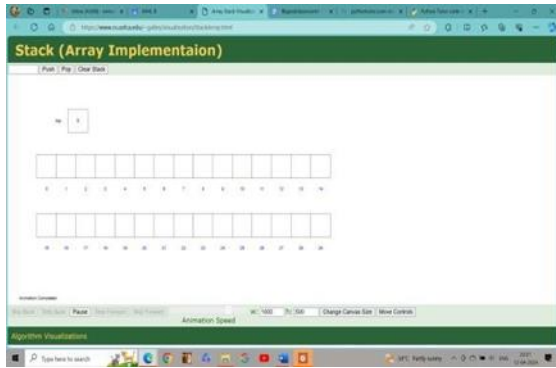


Fig 4: Simulation



Fig 5: Pythontutor

#### IV. CASE STUDY

##### 1. Implementation of the PBL:

Step1: Divide the entire class into small groups of five students each. Group will be formed based on the learning pace and marks obtained in the mid examination.  
 Step 2: Assigning different topics of the same chapter/content to each group and provide required resources.  
 Step 3: Ask students to work within their groups (expert groups) and become knowledgeable on their assigned topic. Students can use the materials or resources provided.  
 Step 4: student groups are asked to create a website/application/poster/video



Step 5: In their groups students take turns to explain ,teach their assigned topic to the group members  
 .Students can ask questions and provide feedback among

themselves.

Step 6: Finally conclude activity with a class discussion, along with the feedback from the students on how they explained they assigned topic, their challenges during preparation and teaching to peers.



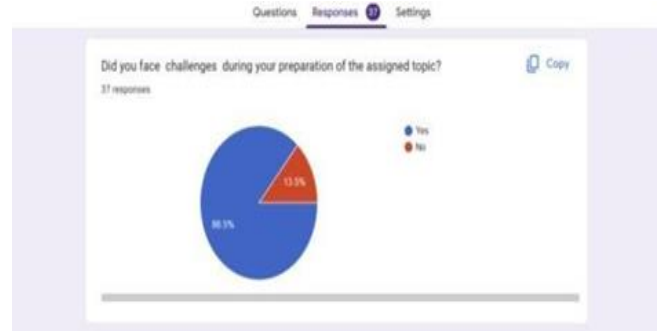
Fig 6: Questionnaire in classroom

#### QUESTIONNAIRE:

1. Rate your overall experience with jigsaw activity on the scale of 1-5
2. Did you understand assigned topic after jigsaw activity?
3. •Yes
4. •No
5. How effectively did your peers in the group collaborate during the activity?
6. •Good
7. •Better
8. •No collaboration
9. Did you prepare well to teach your assigned topic to your peers?
10. •Yes
11. •Somewhat prepared
12. •No
13. What are the challenges you faced during your preparation of the assigned topic?
14. What are the steps that helped you to understand the topic?
15. What qualities of you have improved by participating in the activity?
16. Were you able to teach the assigned topic to your peers?
17. •Yes
18. •No
19. Any comments on activity?

#### QUESTIONNAIRE REPORTS





*THE ASSESSMENT USED IN THE CLASSROOM IS FLEX QUIZ*

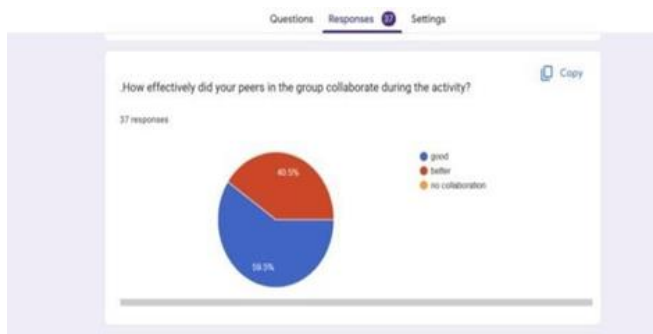


Fig 7: Assessment through quiz

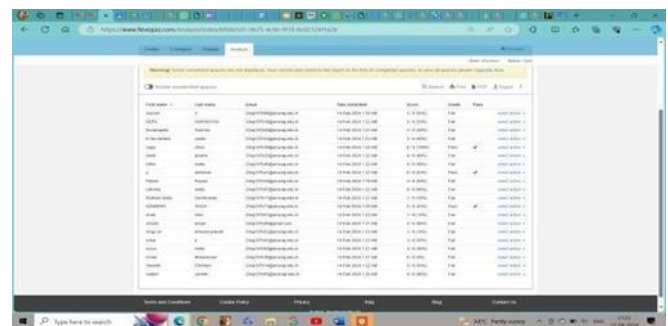
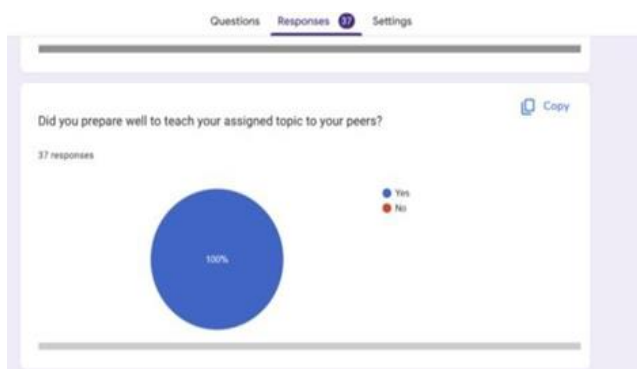


Fig 8: Assessment Results

## V. RESULTS AND DISCUSSION FINDINGS AND REFLECTIONS:

Many students reported feeling more motivated to learn in the Project Based Learning environment, as they appreciated the opportunity to actively participate in class discussions and collaborate with their peers. Educators also noted an improvement in teacher-student interactions, as the Project Based Learning model allowed for more personalized feedback and one-on-one support during class sessions. However, challenges such as technological barriers and student resistance to independent learning were also

The findings from this study suggest several potential benefits of the Project Based Learning model:

**Increased student engagement:** Many students reported feeling more engaged and motivated to learn in the Project Based Learning environment, as they appreciated the opportunity to actively participate in class discussions and collaborate with their peers. **Improved understanding and retention of content:** Students demonstrated a deeper understanding of the course material and showed greater retention of key concepts compared to traditional lecture-based instruction.

**Enhanced critical thinking and problem-solving skills:** The Project Based Learning approach encouraged students to take ownership of their learning and develop critical thinking skills through hands-on activities and collaborative projects. **Positive teacher-student interactions:** Educators noted an improvement in teacher-student interactions, as the Project Based Learning model allowed for more personalized feedback and one-on-one support during class sessions.

The Project Based Learning model offers numerous benefits that can transform the educational experience for both students and teachers. By moving the direct instruction component of the lesson outside the classroom, students could engage with the content at their own pace, pausing, rewinding, and revisiting the material as needed[33]. This allows for more efficient use of class time, enabling teachers to facilitate active learning activities, such as discussions, problem-solving exercises, and collaborative projects.

The Project Based Learning also encourages students to take a more active role in their learning, fostering a sense of ownership and responsibility. This approach has been shown to improve student engagement, as students are more motivated to come to class prepared and ready to participate. Additionally, the personalized nature of the Project Based Learning allows teachers to better address the diverse learning needs and preferences of their students.

The following rubrics were followed for evaluating the projects done by the students

Criteria	Exemplary (5)	Proficient (4)	Basic (3)	Needs Improvement (1-2)
<b>Project Design and Planning</b>	Thorough planning with clear goals, timelines, and creative resource allocation.	Adequate planning with clear goals and logical timeline; minor adjustments.	Some planning, but goals or timeline lack clarity.	Little or no planning, goals unclear, minimal structure.
<b>Research and Information Gathering</b>	Uses diverse, reliable sources; synthesizes information effectively.	Sufficient sources; demonstrates understanding, minor synthesis gaps.	Limited sources, minimal synthesis of information.	Lacks adequate sources or synthesis, weak understanding.
<b>Problem Solving and Critical Thinking</b>	Strong problem-solving with innovative, well-reasoned approaches; real-world connections.	Effective problem-solving, some real-world connections.	Problem-solving skills evident but underdeveloped.	Minimal evidence of critical thinking or real-world relevance.
<b>Collaboration and Communication</b>	Highly collaborative, effectively communicates, respects group dynamics.	Good collaboration and communication; minor participation issues.	Limited collaboration; communication gaps.	Minimal collaboration, ineffective communication.
<b>Presentation and Final Product</b>	Engaging, well-organized, creative, high-quality visuals.	Clear and organized presentation, visually appealing with minor issues.	Presentation is complete but lacks organization or visual appeal.	Disorganized or poorly presented.

Fig 9: Rubrics

### 1. Challenges in Project Based Learning Implementation Student Resistance:

Some students may initially be resistant to the Project Based Learning approach, as it requires them to take a more active role in their learning. Addressing this challenge may involve providing clear communication about the benefits of Project Based Learning and offering support and resources to help students adapt to the new learning environment[38].

### 2. Faculty Preparation

Implementing the Project Based Learning model successfully requires a significant investment of \*time and effort from faculty members in terms of content creation, lesson planning, and classroom facilitation. Providing professional development opportunities and support resources can help faculty members overcome this challenge. Assessing Student Learning

To ensure that students are effectively learning in a flipped classroom, it is important to implement appropriate assessments. These assessments should be varied and aligned with the learning objectives, allowing students to demonstrate their understanding of the material in different ways. Furthermore, providing prompt and constructive feedback on assessments can enhance students' learning and engagement in the flipped classroom.

### 3. Technological Barriers

Ensuring that all students have access to the necessary technology, such as devices and reliable internet connectivity,

can be a logistical challenge. Addressing this issue may involve exploring alternative delivery methods or providing access to technology resources on campus.

This section summarizes the findings of our study on the Project Based Learning feedback was taken from the students 37 students have responded on the implementation of flipped classroom.

#### Individual responses of students



Fig 9: Feedback Results

Overall, the findings of this study have important implications for educators seeking to enhance classroom engagement and promote deep learning among their students. The Project Based Learning model presents a promising approach to enhancing classroom engagement and improving student learning outcomes. By leveraging technology to deliver content outside the classroom and dedicating class

time to active learning activities, the Project Based Learning model empowers students to take a more active role in their learning and enables teachers to provide more personalized support and guidance.

As the adoption of the Project Based Learning model continues to grow, it is essential to further explore the long-term impact on student learning, identify best practices for implementation, and address any challenges that arise. Ongoing research, collaboration among educators, and willingness to adapt and innovate will be crucial in ensuring the continued success and evolution of the Project Based Learning approach in education. Additionally, it will be important to consider the accessibility and equity of the Project Based Learning model, ensuring that all students have equal opportunities to engage and learn. By taking these factors into account, educators can continue to refine and enhance the Project Based Learning approach, ultimately leading to improved educational experiences and outcomes for students.

Furthermore, it is important to assess the impact of the Project Based Learning model on students' self-regulation skills and metacognitive development. Understanding how students can actively monitor their learning, set goals, and reflect on their progress will provide valuable insights for educators and help them tailor their instructional strategies accordingly. By incorporating these elements into the implementation of the flipped classroom, educators can further promote student autonomy and foster a deeper level of engagement in their learning journey.

## VI. CONCLUSION AND FUTURE WORK

In conclusion, the findings of this study suggest that Project Based Learning pedagogy holds promise in enhancing student engagement and improving learning outcomes. By shifting the focus from passive listening to active participation and inquiry-based learning, educators can create more interactive and student-centered learning environments. However, challenges such as technological barriers and student resistance to independent learning must be addressed to fully realize the potential of Project Based Learning approaches. Further research is needed to explore the long-term impact and scalability of Project Based Learning pedagogy across different educational contexts.

As future work, The Project Based Learning model has been shown to be effective in improving learning outcomes by promoting active learning and engagement. With the increasing use of technology in education, there is potential to further enhance the Project Based Learning experience using artificial intelligence (AI). One way to incorporate AI into Project Based Learning is using voice-over-style lectures. These lectures can be personalized and tailored to each student's current knowledge using natural language

processing. This approach has been shown to improve academic performance, particularly in challenging questions. Another way to incorporate AI into the Project Based Learning is through the use of chatbots. Chatbots can provide 24/7 assistance and personalized support to students, helping to address common complaints of flipped learning such as lack of guidance at home and inability to get help during pre-class learning. Chatbots can also be used to enhance pre-service teachers' questioning skills through simulations of student-teacher interactions

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