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ENHANCING THE QUALITY OF GENERAL PHYSICS EDUCATION THROUGH PROJECT-BASED LEARNING: A STUDY AT THE UNIVERSITY OF INFORMATION TECHNOLOGY AND COMMUNICATIONS

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Abstract:
The article explores the impact of Project-Based Learning (PBL) on General Physics education. The study, conducted with 120 students at a Vietnamese university, utilizes a mixed-method approach combining theoretical research, expert opinions, and data analysis. It examines the shift from traditional teaching to PBL, emphasizing hands-on, real-world problem-solving to improve understanding and application of physics concepts. The findings indicate significant positive outcomes in student engagement, understanding, and satisfaction. The study also discusses the challenges and considerations in implementing PBL, the importance of teacher training, and the potential for scalability and long-term impact in diverse educational settings.

Keywords: project-based learning; general physics education; teacher training in PBL; scalability of educational methods; Vietnam

1. Introduction

In the evolving landscape of higher education, the traditional methods of teaching have been under scrutiny for their effectiveness in imparting practical knowledge and skills. Particularly in the realm of science education, such as General Physics, the necessity for innovative teaching methodologies is more pronounced. This study focuses on the implementation of PBL in General Physics courses at the University of Information Technology and Communications, aiming to assess its impact on the quality of education. The concept of PBL, as a pedagogical approach, has gained significant momentum in recent years.

Butler et al. (2014) and Nguyen et al. (2023) defines PBL as a model that organizes learning around projects or complex tasks precipitated by an in-depth inquiry process, often involving student design and problem-solving. In the context of physics, this

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approach shifts the focus from traditional lecture-based teaching to an interactive, hands-on experience where students engage in projects that require applying theoretical concepts to real-world scenarios.

The rationale behind adopting PBL in physics education hinges on several educational theories. According to Jonassen (2010) and Linh et al. (2023), constructivist learning theory, which posits that learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences, underpins PBL. This aligns with the nature of physics as a subject that fundamentally relies on the application of concepts to understand the physical world.

Furthermore, research by Prince and Felder (2006) indicates that active learning strategies, such as PBL, have a positive impact on student attitudes and improvements in their learning performances, particularly in STEM (Science, Technology, Engineering, and Mathematics) education. In physics, where abstract concepts can often be challenging for students, PBL offers a tangible and engaging way to explore these ideas.

The effectiveness of PBL in physics has been documented in various studies. A notable example is the work of Alexander (2017) and Tuan (2021), who found that students engaged in PBL showed significantly higher achievement in physics concepts compared to those in traditional lecture settings. This is attributed to the deeper engagement and practical application of knowledge in PBL settings.

The current study aims to extend this research by evaluating the impact of PBL on the quality of General Physics education in a specific university setting. The research involves 120 students from the University of Information Technology and Communications in Vietnam. The study uses a mixed-method approach, combining theoretical research, expert opinions, and data analysis using the SPSS software, to address the research question.

This introduction sets the stage for a detailed exploration of the literature surrounding PBL, the methodology used in this study, the results, and discussions thereof, followed by recommendations and conclusions. The study seeks to contribute to the broader understanding of the effectiveness of PBL in higher education, specifically in the context of physics education in Vietnam.

2. Literature Review

The integration of PBL into General Physics education represents a significant shift from traditional pedagogical approaches. This section reviews the existing literature on PBL, particularly focusing on its implementation in physics courses, its pedagogical underpinnings, and the outcomes of such educational strategies.

2.1. Pedagogical Foundations of PBL

Project-Based Learning is deeply rooted in constructivist theories of education, as proposed by Dewey (1986) and later expanded by Piaget (1970) and Vygotsky (1978). These theories emphasize the role of active engagement and experience in the learning process. Constructivism posits that knowledge is constructed by learners as they engage with the world around them (Bruner, 1961). PBL, in this context, acts as a medium through which students actively construct their understanding of physics concepts through hands-on projects and real-world problem-solving.

Bell (2010) and Alexander et al. (2014) highlighted that PBL facilitates not just content knowledge but also skill development in areas such as critical thinking, problem-solving, and collaboration. These skills are particularly vital in the study of physics, which requires a deep understanding of concepts and the ability to apply them in practical scenarios.

2.2. Implementation of PBL in Physics Education

The implementation of PBL in physics has been explored in various educational settings. Efstratia (2014) described the key components of PBL as an instructional method, which includes student-centered learning, a driving question or problem, investigative activities, and reflection. In the context of physics, these components translate to students engaging in projects that address real-world physics problems, conducting experiments, and reflecting on their findings.

Studies by Geier et al. (2008) and Linh et al. (2023) demonstrated that students in physics classrooms who adopted PBL strategies showed greater engagement and a deeper understanding of physical concepts compared to traditional lecture-based classes. This was attributed to the active learning environment fostered by PBL, where students are not passive recipients of information but active participants in the learning process.

2.3. Effects of PBL on Student Outcome

Research on the outcomes of PBL in physics education has shown positive results. Capraro and Slough (2008) found that PBL not only improved students' physics content knowledge but also enhanced their problem-solving skills. This is particularly significant in physics education, where the ability to apply theoretical concepts to solve problems is crucial.

In a study by Han, Capraro, and Capraro (2015), students exposed to PBL in physics courses exhibited higher motivation and better retention of concepts. The interactive and engaging nature of PBL was cited as a key factor contributing to these outcomes.

2.4. Challenges and Considerations in PBL Implementation

Despite its benefits, the implementation of PBL in physics education is not without challenges. Ertmer and Simons (2006) pointed out that successful PBL implementation requires careful planning and a shift in the role of the teacher from a disseminator of knowledge to a facilitator of learning. There is also the challenge of aligning PBL activities with curriculum standards and assessment methods.

Another consideration is the preparation and training of teachers to effectively implement PBL strategies. Frank, Lavy, and Elata (2003) noted that teacher preparedness is critical for the success of PBL in physics education, as teachers need to be equipped with the skills to guide inquiry, manage project activities, and assess student learning in a PBL environment.

2.5. Future Directions in PBL Research

Future research in PBL, as suggested by Holm (2011), should focus on longitudinal studies to assess the long-term impact of PBL on students' understanding of physics and their ability to apply these concepts. Additionally, research into the scalability of PBL and its effectiveness in diverse educational settings would provide valuable insights for educators and policymakers.

3. Material and Methods

The Material and Methods section of this study outlines the framework and procedures employed to investigate the effectiveness of PB) in enhancing the quality of General Physics education at the University of Information Technology and Communications.

3.1. Research Design

The study adopts a mixed-method research design, integrating both quantitative and qualitative approaches. This design facilitates a comprehensive understanding of the impact of PBL on student learning outcomes in General Physics. Quantitative data was gathered through pre- and post-test assessments and student performance records, while qualitative data was collected via student surveys, interviews, and classroom observations.

3.2. Participants

The study involved 120 undergraduate students enrolled in the General Physics course at the University of Information Technology and Communications, Vietnam (Table 1).

Table 1: General Information about Research Subjects

Sex					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	68	26.7	56.7	56.7
	Female	52	43.3	43.3	100.0
	Total	120	100.0	100.0	
Years of Study					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	1st	23	19.2	19.2	19.2
	2nd	86	71.7	71.7	90.8
	3th	11	9.2	9.2	100.0
	Total	120	100.0	100.0	

These students were divided into two groups: a control group, which continued with traditional lecture-based teaching, and an experimental group, which participated in PBL activities.

3.3. Implementation of PBL

In the PBL group, students engaged in a series of projects throughout the semester. These projects were designed to cover the core topics of the General Physics curriculum. Each project involved a real-world problem, requiring students to apply physics principles to develop solutions. The projects encouraged collaborative work, critical thinking, and practical application of theoretical knowledge.

3.4. Data Collection Methods

To measure the learning outcomes, both the control and experimental groups were given standardized tests at the beginning and end of the semester. These tests were designed to assess their understanding of General Physics concepts. Students in the PBL group were surveyed about their experiences, focusing on engagement, understanding of physics concepts, and perceptions of the learning process. Additionally, interviews were conducted with a select group of students to gain deeper insights. Observations were made in both traditional and PBL classrooms to note teaching methods, student engagement, and classroom dynamics.

Quantitative data from the tests were analyzed using statistical methods, with the SPSS software being utilized for data processing. Comparative analysis was conducted to examine the differences in learning outcomes between the control and experimental groups. Qualitative data from surveys, interviews, and observations were analyzed thematically to identify common patterns and insights regarding the PBL experience.

3.5. Limitations

The study acknowledges certain limitations, such as the sample size and the specific context of the University of Information Technology and Communications, which may affect the generalizability of the findings. Additionally, the short duration of the study may not fully capture the long-term impacts of PBL on students' understanding of physics.

4. Results and Discussion

4.1. Design of the Interview Questionnaire

The interview questionnaire was designed based on previous studies on PBL (Problem-Based Learning) and the researcher's experience. In addition to collecting personal information, the questionnaire includes 15 questions divided into three groups (Table 2). The questions are designed on a 5-point Likert scale ranging from strongly disagree to strongly agree.

Table 2: Main Content of the Interview Form

Section 1: Engagement and Participation 1. I found the PBL activities in physics to be engaging. 2. PBL encouraged me to participate more actively in class discussions. 3. Working on projects made me more interested in physics topics. 4. PBL facilitated greater collaboration with my peers.
Section 2: Understanding and Application of Physics Concepts 5. PBL helped me understand physics concepts better than traditional lectures. 6. I felt more confident in applying physics concepts in real-world situations because of PBL. 7. PBL encouraged me to think critically and solve complex problems. 8. The projects helped me retain physics concepts longer.
Section 3: Overall Learning Experience and Satisfaction 9. I am satisfied with the PBL approach used in our physics course. 10. PBL has improved my overall learning experience in physics. 11. I would recommend PBL to other students for learning physics.12. The PBL method was well-organized and effectively implemented.

4.2. Interview Results

Table 3: General Information about Research Results

Reliability statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**Number of Items**
.841	0.838	12

Item Statistics			
	Mean	**Std. Deviation**	**N**
Q1	4.2083	.81885	120
Q2	3.9667	.81924	120
Q3	4.0333	.79846	120
Q4	4.0667	.83750	120
Q5	4.2750	.77744	120
Q6	4.0917	.71002	120
Q7	4.0750	.72370	120
Q8	4.1917	.73674	120
Q9	4.2583	.70408	120
Q10	4.0500	.68415	120
Q11	4.1250	.64251	120
Q12	4.1250	.73978	120

Item-total Statistics					
	Scale Mean If Item Deleted	**Scale Variance If Item Deleted**	**Scale Variance Item - Total Correlation**	**Squared Multiple Correlation**	**Cronbach's Alpha If Item Deleted**
Q1	45.2583	23.605	.667	.991	.815
Q2	45.5000	24.108	.588	.940	.822
Q3	45.4333	23.861	.651	.800	.817
Q4	45.4000	23.351	.683	.954	.814
Q5	45.1917	25.753	.408	.400	.836
Q6	45.3750	27.631	.193	.327	.850

Q7	45.3917	27.148	.253	.423	.847
Q8	45.2750	26.520	.332	.428	.841
Q9	45.2083	24.654	.633	.988	.820
Q10	45.4167	25.926	.457	.915	.832
Q11	45.3417	25.471	.570	.745	.825
Q12	45.3417	24.479	.622	.937	.820

The results obtained from the student questionnaire, designed to assess the effectiveness of PBL in a General Physics course, offer insightful data regarding students' perceptions and experiences. With a sample size of 120 respondents, the study analyzed the mean scores and standard deviations for each question on a 5-point Likert scale.

4.2.1. Student Engagement and Participation

Questions Q1 through Q4 focused on students' engagement and participation. The results indicated high levels of engagement (Q1: M = 4.21, SD = 0.82) and active participation (Q2: M = 3.97, SD = 0.82) in PBL activities. These findings are consistent with the research of Bell (2010), which emphasized the engagement benefits of PBL in educational settings. Furthermore, the increased interest in physics topics (Q3: M = 4.03, SD = 0.80) and collaborative learning (Q4: M = 4.07, SD = 0.84) aligns with the assertions of Bradley-Levine & Mosier (2014) regarding the interactive nature of PBL.

4.2.2. Understanding and Application of Physics Concepts

Responses to questions Q5 through Q8 reveal that PBL positively impacted students' understanding and application of physics concepts. The mean scores (Q5: M = 4.28, SD = 0.78; Q6: M = 4.09, SD = 0.71) suggest that students felt more confident in comprehending and applying physics principles due to PBL, supporting the findings of Alexander et al. (2014). The enhanced problem-solving skills (Q7: M = 4.08, SD = 0.72) and retention of concepts (Q8: M = 4.19, SD = 0.74) are in line with Capraro and Slough's (2008) observations on the effectiveness of PBL in STEM education.

4.2.3. Overall Learning Experience and Satisfaction

The final section of the questionnaire (Q9 to Q12) assessed overall satisfaction with the PBL method. High satisfaction levels (Q9: M = 4.26, SD = 0.70) and improved learning experiences (Q10: M = 4.05, SD = 0.68) were reported, indicating a positive reception of PBL. These results echo the sentiments of Han, Capraro, and Capraro (2015), who noted the motivational benefits of PBL. The willingness to recommend PBL (Q11: M = 4.13, SD = 0.64) and satisfaction with its organization and implementation (Q12: M = 4.13, SD = 0.74) further substantiate the perceived efficacy of PBL in enhancing physics education.

4.3 Discussion

The study's findings provide strong evidence for the positive impact of PBL on student engagement, understanding, and overall satisfaction in a General Physics course. The high mean scores across all questions indicate that students not only engaged more deeply with the subject matter but also developed key skills such as critical thinking and problem-solving. This aligns with the theoretical underpinnings of constructivist learning, which suggest that active engagement in learning activities leads to a deeper understanding of content (Jonassen, 2011).

Moreover, the low standard deviations suggest a general consensus among students regarding the benefits of PBL. This uniformity in responses reinforces the reliability of the results and the effectiveness of PBL in this educational context.

However, it is important to note the limitations of the study. The specific context and sample size may not fully represent the diverse range of student experiences in different educational settings. Future research could expand on these findings by exploring the long-term impacts of PBL and its scalability in various academic environments.

5. Recommendations

The implementation of Project-Based Learning (PBL) in General Physics courses, as demonstrated by this study at the University of Information Technology and Communications, has shown significant positive outcomes. These results guide us toward several key recommendations to optimize the use of PBL in physics education. Firstly, integrating real-world projects into the curriculum can significantly enhance student engagement and the practical application of physics concepts. This approach not only makes learning more relevant but also helps students understand the real-world implications of their studies.

Another crucial factor in the successful implementation of PBL is the training and development of faculty members. Educators play a pivotal role in facilitating PBL, and their ability to guide inquiry, manage project dynamics, and assess student performance is essential. Therefore, investing in training programs that equip educators with these skills is paramount. Additionally, fostering a collaborative learning environment is vital. Encouraging group projects and peer-to-peer interactions can enhance the understanding and retention of physics concepts. This collaborative approach not only aids in learning but also in developing important soft skills like teamwork and communication.

6. Conclusion

Customization of PBL activities to cater to diverse learning styles is also important. Tailoring these activities ensures that all students, regardless of their educational background or learning preferences, can benefit from this approach. Alongside customization, implementing continuous assessment strategies and providing regular feedback can significantly aid the learning process. This ongoing assessment helps students adjust to the PBL methodology and understand their progress in real-time.

Looking forward, exploring the scalability of PBL in different educational settings and across diverse student populations will be crucial. This scalability is important for understanding the broader applicability of PBL in various educational contexts. Furthermore, conducting long-term studies to assess the sustained impact of PBL on student learning, career choices, and professional skills in physics is recommended. Such longitudinal research would provide deeper insights into the long-term benefits and potential challenges of implementing PBL.

In conclusion, the study underscores the effectiveness of Project-Based Learning in enhancing the quality of education in General Physics courses. The results clearly indicate that PBL not only improves student engagement and understanding of complex physics concepts but also enhances overall satisfaction with the learning experience. These findings align with the broader educational research advocating for active, inquiry-based learning methods, particularly in STEM fields. While acknowledging the limitations of the study, such as its specific context and sample size, the evidence presented strongly supports the adoption and further exploration of PBL in physics education. Ultimately, by fostering active learning, collaboration, and practical application of knowledge, PBL stands out as a transformative educational approach, preparing students for both academic success and future professional challenges in the dynamic field of physics.

Conflict of Interest Statement

The author declares no conflicts of interest.

About the Author

Duong Thi Thu Huong is a master's degree holder who researches modern teaching methods, the application of information technology in education, and the use of experiments in teaching. She currently works at the University of Information Technology and Communications, a university located in the mountainous region of Northern Vietnam. She also regularly investigates and applies new teaching methods, including project-based learning, in her classrooms.

References

Alexander, C., Kneze K., G., Christensen, R., Tyler-Wood, T., & Bull, G. (2014). The impact of project-based learning on pre-service teachers' technology attitudes and skills. *Journal of Computers in Mathematics and Science Teaching*, *33*(3), 257-282.

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House, 83(2), 39-43. doi:10.1080/00098650903505415

Bradley-Levine, J., & Mosier, G. (2014). Literature review on project-based learning. *University of Indianapolis Center of Excellence in Leadership of Learning*.

Bruner, J. S. (1961). "The Act of Discovery." Harvard Educational Review 31: 21-32. *Bruner 2131 Harvard Educational Review 1961*.

Butler, A. C., Marsh, E. J., Slavinsky, J. P., & Baraniuk, R. G. (2014). Integrating cognitive science and technology improves learning in a STEM classroom. *Educational Psychology Review*, *26*, 331-340.

Capraro, R. M., & Slough, S. W. (2008). Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach. Rotterdam: Sense Publishers.

Dewey, J. (1986, September). Experience and education. In *The educational forum* (Vol. 50, No. 3, pp. 241-252). Taylor & Francis Group.

Efstratia, D. (2014). Experiential education through project-based learning. *Procedia-social and behavioral sciences*, *152*, 1256-1260.

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL Implementation Hurdle: Supporting the Efforts of K-12 Teachers. Interdisciplinary Journal of Problem-based Learning, 1(1), 40-54. doi:10.7771/1541-5015.1005

Frank, M., Lavy, I., & Elata, D. (2003). Implementing the Project-Based Learning Approach in an Academic Engineering Course. International Journal of Technology and Design Education, 13(3), 273-288. doi:10.1023/A:1026192113732

Geier, R., et al. (2008). Standardized Test Outcomes for Students Engaged in Inquiry-Based Science Curricula in the Context of Urban Reform. Journal of Research in Science Teaching, 45(8), 922-939. doi:10.1002/tea.20248

Han, S., Capraro, R., & Capraro, M. M. (2015). How Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL) Affects High, Middle, and Low Achievers Differently: The Impact of Student Factors on Achievement. International Journal of Science and Mathematics Education, 13(5), 1089-1113. doi:10.1007/s10763-014-9526-0

Holm, M. (2011). Project-Based Instruction: A Review of the Literature on Effectiveness in Prekindergarten through 12th Grade Classrooms. InSight: Rivier Academic Journal, 7(2).

Jonassen, D. H. (2010). Learning to Solve Problems: A Handbook for Designing Problem-Solving Learning Environments. New York: Routledge.

Linh, N. Q., Ouyhuk, P., & Vilay, T. (2023). Fostering students' problem-solving and creative abilities through the experiential activity "Green Power" [Bồi dưỡng năng lực giải quyết vấn đề và sáng tạo cho học sinh thông qua hoạt động trải nghiệm "Nguồn điện xanh"]. *Vietnam journal of Education*, *23*(05), 35–40. From https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/663

Nguyen, Q. L., Vu, T. T. Y., Duong, V. T., & Nong, M. A. (2023). Teacher competencies need to be fostered to successfully implement STEM education-oriented teaching: case study in Thai Nguyen province [Những năng lực giáo viên cần được bồi dưỡng để triển khai thành công dạy học theo định hướng giáo dục STEM: nghiên cứu trường hợp tại tỉnh Thái Nguyên]. *Vietnam journal of Education*, *23*(06), 51–57. From https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/676

Piaget, J. (1970). Science of Education and the Psychology of the Child. New York: *Trans. D. Coltman.* Orion.

Prince, M., & Felder, R. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. Journal of Engineering Education, 95(2), 123-138. doi:10.1002/j.2168-9830.2006.tb00884.x

Tuan, N. V. (2021). Organizing teaching project "Some applications of differential equations" in teaching advanced mathematics for engineering students [Tổ chức dạy học dự án "Một số ứng dụng của phương trình vi phân" trong dạy học môn toán cao cấp cho sinh viên khối ngành kĩ thuật]. *Vietnam Journal of Education*, *496*(2), 14–19. From https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/48

Vygotsky, L. S. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

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