Educational Administration: Theory and Practice
2024, 30(4), 3391-3402
ISSN: 2148-2403
https://kuey.net/

Research Article

Effects Of Project-Based Learning On Students' Learning Performance And Engagement In Computer Science

Xue Wang[1], Jirarat Sitthiworachart[2]

[1*]King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, Email: 1402902828@qq.com
[2]King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, Email: Jirarat.si@kmitl.ac.th

***Corresponding Author:** Xue Wang
King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand, Email: 1402902828@qq.com

Citation: Xue Wang, Jirarat Sitthiworachart, (2024), Effects Of Project-Based Learning On Students' Learning Performance And Engagement In Computer Science, *Educational Administration: Theory and Practice*, *30*(4), 3391-3402
Doi: 10.53555/kuey.v30i4.1169

ARTICLE INFO

ABSTRACT

Attention has been drawn to the benefits of integrating project-based learning (PjBL) into educational curricula to enhance student engagement. This study investigated how well project-based learning fosters student engagement and achievements in computer science courses. Qualitative and quantitative research methods were used for this experiment. A total of 60 first year undergraduate students included in the study were divided into the two following groups: experimental group (n=30) and control group (n= 30). National Survey of Student Engagement' (NSSE) based on Coates' five-dimensional framework theory of student engagement was used to collect the data. The results showed that there was no significant difference in the pretest scores between the experimental group and the control group ($p > 0.05$) before the intervention. However, after the experiment, the post test scores of the experimental group were significantly higher than those of the control group ($p < 0.01$), indicating an improvement in engagement. The mean grades and mean engagement of the experimental group were also higher compared to the control group. The difference in engagement between the experimental group before and after the intervention was statistically significant ($Z=-3.522$, $p < 0.05$), with the median data after intervention being higher than before. These findings suggest that highly contextualized project-based learning has a positive impact on student engagement and achievements.

Keywords : Project-based learning, Computer science, Student engagement, Student achievement, Higher education

1. INTRODUCTION

Since the 21st century, industries have been emphasizing the need for graduates with soft skills such as good communication, flexibility, and teamwork. Consequently, higher education institutions have been striving to equip students with both hard skills, like cognitive knowledge and professional expertise (Vogler et al., 2017), and soft skills, such as problem-solving and teamwork. However, achieving this goal is challenging due to the dominance of traditional learning methods in the education system. This can result in students having a superficial understanding of the subjects they study (Guo et al., 2020). Therefore, it is crucial to enhance student participation, for instance, through project-based learning. Student input plays a vital role in determining the quality of higher education outcomes. It helps teachers gain better insights into student learning quality and effective learning mechanisms, guiding schools and educators in making necessary improvements. The National College Student Engagement Survey in the United States, based on the theory of student engagement, assesses the quality of higher education by investigating the degree and characteristics of undergraduate engagement in educational activities. It provides empirical data to support internal reforms in colleges and universities. However, some studies have indicated that learner enthusiasm is weak and student engagement is low during actual teaching processes.

The study focus on student engagement and achievement, specifically PjBL model and its corresponding

constructivism learning theory. Considering the teaching resources of Hebei University of Engineering and the actual situation of students, the literature was analyzed to design a student engagement scale in the PjBL environment. This scale can serve as a reference for teachers to measure student engagement in PjBL. By utilizing both quantitative and qualitative empirical methods, this paper investigates undergraduates' engagement in the PjBL setting and provides a theoretical reference for teachers to effectively guide students' engagement in PjBL. This research contributes to the further development of personalized learning for students and enriches the theory of student engagement.

2. LITERATURE REVIEW

2.1 Project-Based Learning

PBL is often considered a teaching method where students respond to real-world problems or challenges through a long-term process of inquiry(Chiang & Lee, 2016). It guides students in researching and comprehending complex problems that require resolution. Project-based learning initiates the learning process through practical cases or encountered problems (Lisa & Lauren, 2013). By organizing projects that involve students in real-life situations, PBL promotes the exploration and application of themes to solve complex problems relevant to their professional practice (Latimer & Raiodan, 2011). It typically begins with posing questions to collect and integrate new knowledge gained through experience and activities. This approach also aims to encourage students to integrate multiple disciplines in collaborative projects, providing meaningful opportunities for content exploration and collaborative experimentation (Belwal et al., 2020). According to Carnawi et al. (2017), project-based learning is a student-centered approach that utilizes projects as learning tools to achieve mastery of concepts, creativity, and knowledge. It serves as an alternative to traditional teaching, which is often speaker-centered and primarily focuses on student activities to produce effective outcomes. The principle of project-based learning is to emphasize the development of skills that enable students to overcome real-life problems and utilize optimized learning resources for collaborative inquiry, leading to a more comprehensive understanding and improvement of their abilities. By leveraging their abilities, students can effectively solve problems, grasp concepts, and establish principles for approaching problems, thereby acquiring new knowledge directly from meaningful learning experiences (Bilgin et al., 2015; Rahardjanto, Husamah, & Fauzi, 2019; Zouganeli et al., 2014).

Project-based learning, guided by constructivist theory, emphasizes that students should focus on complex problems and engage in inquiry-based learning in practical situations to enhance their various abilities. Constructivism learning theory emphasizes student-centered learning, asserting that students are active constructors of knowledge(He, 1998). Teachers play a supportive role in facilitating students' construction of knowledge, rather than simply imparting knowledge to them. This approach places importance on students, as well as the role of 'context' and 'collaborative learning' in knowledge construction. Within the constructivist teaching mode, this study explores a well-established teaching paradigm called scaffolding teaching. Scaffolding teaching is proposed as a concept building upon Vygotsky's(1978) theory of the 'Zone of Proximal Development'. It consists of several components: 1. Scaffolding; 2. Entering the situation; 3. Independent Exploration; 4. Collaborative learning; 5. Effect evaluation; The evaluation content includes: (1)Self-learning ability; (2)Contribution to group collaborative learning; (3)Whether to complete the construction of knowledge.

2.2 Student Engagement

Student engagement refers to the effectiveness of a student's learning process during educational activities(Kahu, 2013). Engagement occurs when students actively explore their existing knowledge and insights in educational scenarios (Attard & Holmes, 2020). Therefore, student engagement is measured by the extent to which students invest their time and energy in academically related activities. This includes participating in group discussions, interacting with teachers, and completing learning activities.

According to Skinner and Pitzer (2018), student involvement has a positive impact when students actively participate in all learning activities and adhere to established norms, such as completing assignments on time.

2.3 Student Achievement

Student achievement is a measure of the knowledge acquired by a student within a specific period of time, with educators teaching students according to specific standards or goals at each learning stage. Research in higher education suggests that student engagement is a crucial factor in determining students' success in learning, regardless of the university curriculum or instructional format (Trowler & Trowler, 2010). Student achievement not only grows within the program's scope but also extends to other areas of knowledge.

2.4 Research Objectives

Based on the current trend of rapid development of the Internet, we must reform the current education model. To make an in-depth and accurate evaluation of higher education, it is necessary to evaluate the teaching process, reform the existing evaluation methods and evaluate the learning process and effect according to student engagement. Taking Project-Based Learning as an example, this study explores student engagement and achievement under different learning environments by building a relational model, and explores the main

factors affecting student engagement, so as to explain the mechanism of learning engagement. To verify the effectiveness of the intervention strategy, interventions were implemented. The research objectives are:
a) To study the impact of learning activities (PjBL) on student engagement;
b) To study the impact of learning activities (PjBL) on student achievement.

2.5 Research Questions

In recent years, there has been an increase in the number of researches studying PBL approaches in learning environments. In the studies related to PBL, it has been concluded that this approach has contributed positively to students' achievement (Musa, 2012). PBL creates an enjoyable learning atmosphere and influences student engagement (Zen, 2022). Therefore, this study is based on project-based learning (PjBL) to explore the differences in engagement and achievement among undergraduates using various learning methods. So three research questions are raised:
1. Do the students who learn with project-based learning show better learning achievements than those who learn with the traditional teaching?
2. Do the students who learn with project-based learning show higher learning engagement than those who learn with the traditional teaching?
3. Do students before the project-based learning intervention show higher learning engagement than those after the project-based learning intervention?

2.6 Conceptual Framework

This study constructs a student engagement model in PjBL environment. The model is a structural model of the relationship between learning activities, learning outcomes, and student engagement. As shown in Figure 2.1.

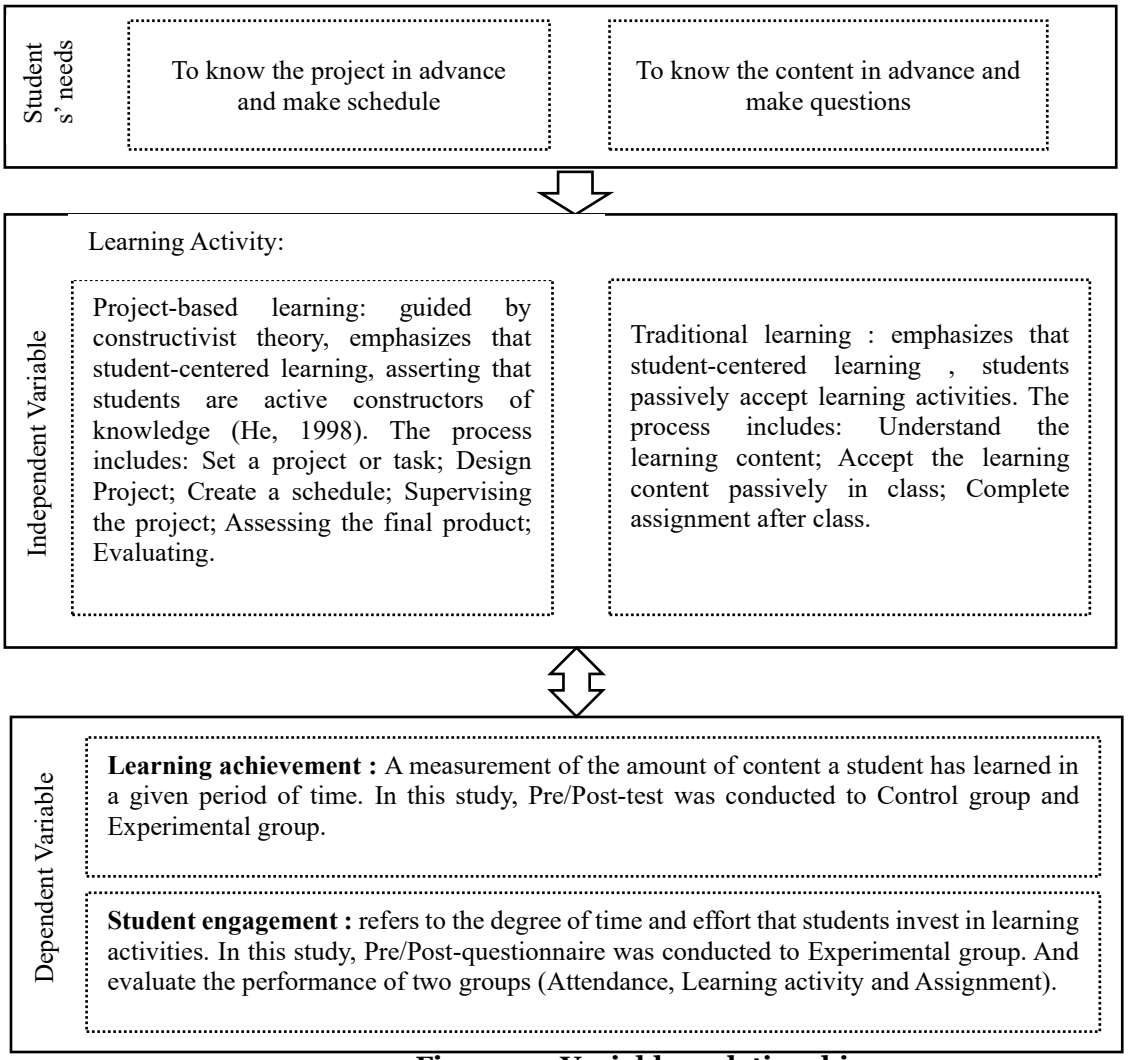


Figure 2.2 Variables relationship

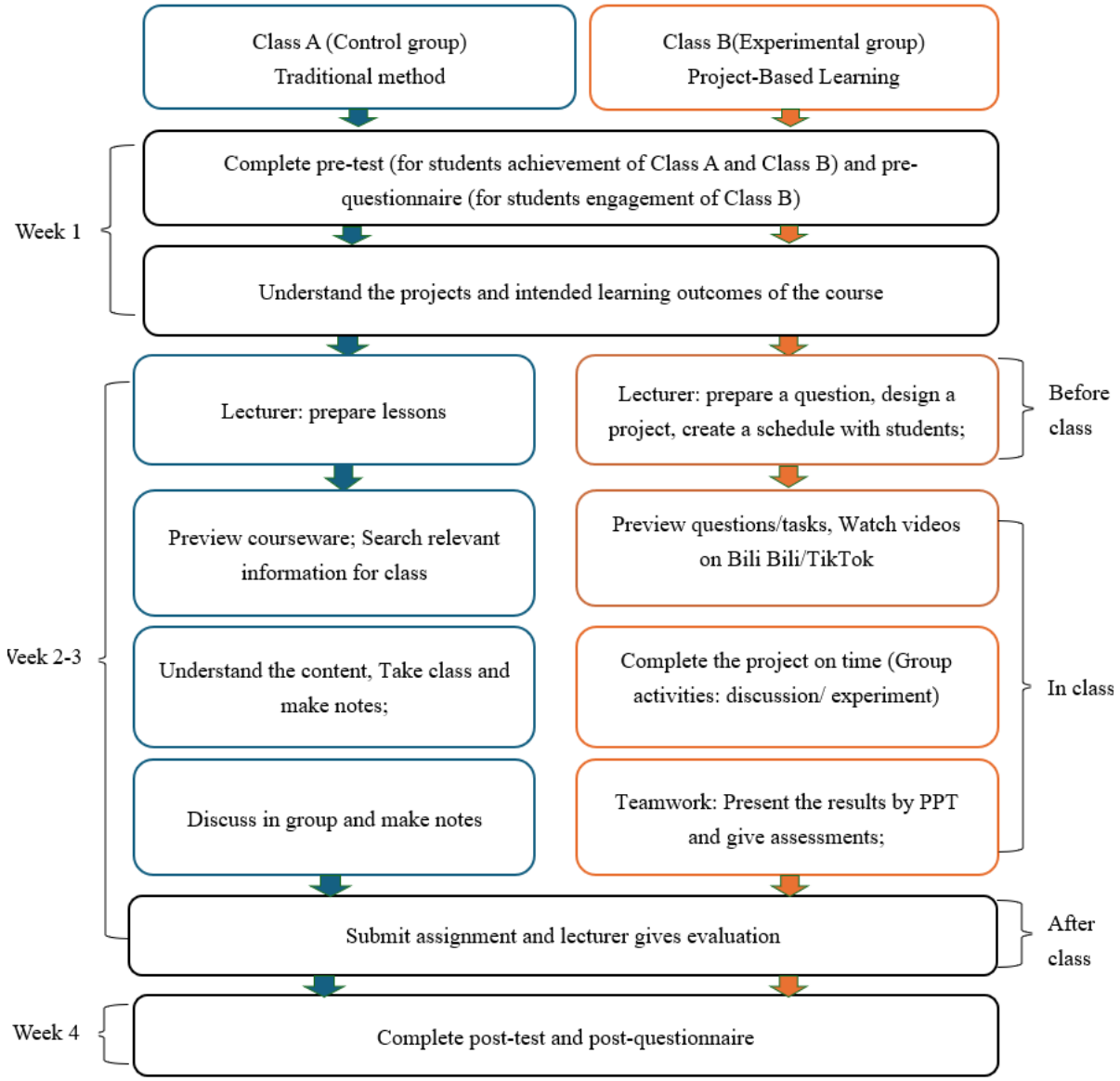
3. RESEARCH METHODOLOGY

3.1 Participant

The students selected in this study is freshmen majoring in Computer Science, Hebei University of Engineering that includes 60 cases. Two classes of this major were selected by random sampling, in which the target population divide into the experimental group(N=30, Male=12, Female=18) and the control group(N=30, Male=14, Female=16). Their age is 18-20 years old. The lecturer (n=1) who participated in the experiment has taught Computer Science for 6 years and has rich teaching experience.

3.2 Experiment Procedure

First, two classes were randomly selected as Class A (control group) and Class B (experimental group). ①In 1st week, a pre-test and pre-questionnaire were conducted to ensure that the students were at the same level. Students need to understand project and intended learning outcomes. ②During the experiment (2nd -3rd week), the intervention (PjBL) was implemented in Class B, and the traditional method was followed in Class A. Before class, lecture need to provide a question, design a project and create the schedule with students. In class, students carried out plans according to the schedule, and the lecturer supervised and guided the process. After class, students completed assignment and wrote a report to reflect and feedback. ③In 4th week, post-test and post-questionnaire were conducted, then data was collected and analysed, which included the data from the pre/post-questionnaires, pre/post-tests and performance. Student achievement was measured through the pre/post-tests, while student engagement was assessed through the pre/post questionnaires and performance in the class (attendance, activities, assignments).



3.3 Course Process

For Project-Based Learning model, Josh Bersin (2008) believes that the PjBL process consists of Analysis, Design, Development, Implement and Evaluation. The course process is designed by combining the

constructivist learning theory and ADDIE model. A project in this learning model consists of challenging problems and complex tasks that require students to independently investigate, make decisions, design, and solve problems. Therefore, this model can be implemented in science education through various steps, including observation, association, experimentation, discussion, and communication (Lestari & Juanda, 2019). The steps of Project-based learning model are as follows: 1) Start with a Challenging Question: Learning begins with a driving question that asks students to perform an activity; 2) Design Project: Planning is a collaborative effort between students and lecturer who wish to take ownership; 3) Create a schedule: The lecturer and students jointly arrange the schedule of activities to complete the project. The time should be clear and can guide students to manage; 4) Project supervision (supervision of students and project progress): The supervisor is responsible for supervising the students' activities during the project. This step is done for the convenience of the students during the project; 5) Assessment results: Assessments are designed to help teachers measure student achievement and assess student progress; 6) Evaluating: At the end of the learning process, lecturer and students reflect on the activities and project outcomes.

Thus, Project-based learning is student-centered, requiring students to acquire and integrate new knowledge from project outcomes guided by a lecturer who acts merely as a facilitator (Harland, 2003). The diagram below illustrates the course flow design for project-based learning and traditional learning. It outlines the steps that both the experimental and control groups, consisting of 30 students each, need to follow during the intervention. In the group activities, which are more suitable for project-based learning, there are approximately 4-5 students per group. (Zhang & Ma, 2023). As shown in Table 3.1.

Table 3.1 Course Design for Project-Based Learning (Continued)

		Lecturer	Student
Exp-group	Before	1.Give courseware to students; 2.According to teaching content and goal to prepare a question.	1.Preview courseware; 2. Making a plan and schedule with lecturer
	In class (collaboration between students & lecturer)	3.Generally explain courseware; 4.Tell students the question; 5.Supervise project and give assessment.	3.Understand the content and question; 4.Watch videos on Bili Bili and TikTok; 5.Complete the project and make a summary on time (Teamwork: discussion/ experiment, 4-5 person/group).
	After	6.Give evaluation and feedback to students.	6. Make a report or Present the results in the form of PPT;(Assignment)
Ctrl-group	Before	1. Give courseware to students; 2. Prepare lessons;.	1.Preview courseware; 2.Find question out and search relevant information.
	In class	3.Explain courseware in detail; 4.Give assignment.	3.Take lesson and understand the content 4.Make notes;
	After	5.Assessment and Feedback.	5. Complete the assignment and submit it; 5. Reflection and giving feedbacks.

3.4 Measurement

Indiana University developed the 'National Survey of Student Engagement' (NSSE) based on Coates' five-dimensional framework theory of student engagement and the educational practice theory of learning engagement. NSSE is an important tool for evaluating the quality of higher education and student engagement. Building upon Astin's (2012) research, the study designs a survey scale of student engagement by referring to NSSE and NSSE-China. The questionnaire 'Student Engagement in Project-based Learning Environment' (as Appendix I)was compiled to understand the current situation of student engagement in a project-based learning environment. The questionnaire is divided into two parts. The first part collects basic information about the college students participating in the experiment, such as grade, gender, and subject. The second part measures student engagement. In addition, student engagement is measured by observing student performance, including attendance, learning activities, and assignments. Student achievement is measured through pretest and post-test(as Appendix II).

4. DATA ANALYSIS

The study utilized the random sampling method to select two classes. To ensure that the students' achievement were at the same level, the lecturers conducted a pre-test (refer to Appendix II)for two groups (control group and experimental group).

Additionally, a pre-questionnaire and pre-test were administered to the experimental group. Following the experimental intervention, a post-test (refer to Appendix II) was conducted for both the control group and the experimental group, along with a post-questionnaire for the experimental group. The SPSS statistical software was employed in this study to perform a Paired Sample T-test on the pre-questionnaire and post-questionnaire of the experimental group.

The experiment involved the collection of experimental data, including pre-test and post-test, pre-questionnaire and post-questionnaire. Subsequently, these data were analyzed from three perspectives:

1. The pre-test of the experimental group was compared with the control group to ensure that the indicators of both groups were at the same level.
2. The post-test results of the experimental group were compared with the control group to observe the differences in results after the intervention.
3. The engagement in class of both groups was compared after the intervention to observe any differences.

4. Paired sample analysis was conducted on the pre-questionnaire and post-questionnaire of the experimental group.
Finally, the data differences mentioned above were analyzed, leading to the acquisition of the experimental results.

4.1 Reliability Analysis

Reliability analysis is used to study the authenticity and accuracy of quantitative data. From the data in the Table 4.1, it can be observed that Cronbach's Alpha are 0.890 and 0.921 respectively, indicating that the reliability of the research data is high.

Table 4.1 Reliability analysis

N of Items	Sample Size	Cronbach's Alpha
15 (Pre Exp)	30	.890
15 (Post Exp)	30	.921

4.2 Validity Analysis

Validity analysis is conducted to assess the appropriateness of the design of quantitative data. The KMO (Kaiser-Meyer-Olkin) statistic is used for analysis. From the data in the Table 4.2, it can be found that KMO were 0.701 and 0.735 (KMO>0.7), p <0.05, which shows that the questionnaire are suitable for extracting data.

Table 4.2 Validity analysis

Pre 2	KMO		.701
	Bartlett's Test of Sphericity	Approx. Chi-Square	398.302
		df	105
		Sig.(*p*)	0.000
Post 2	KMO		.735
	Bartlett's Test of Sphericity	Approx. Chi-Square	341.221
		df	105
		Sig.(*p*)	0.000

4.3 Comparison of Two Groups' Data

SPSS adopted the K-S and S-W methods to test for normal distribution. The results of this normality test are shown in the Table 4.3.

Table 4.3 Tests of Normality (Continued)

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Method	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	Traditional learning	.180	30	.014	.958	30	.268
	PjBL	.122	30	.200	.970	30	.550
Post test	Traditional learning	.152	30	.076	.934	30	.064
	PjBL	.197	30	.004	.905	30	.011
Performance	Traditional learning	.357	30	.000	.701	30	.000
	PjBL	217	30	.001	.835	30	.000
Engagement	PjBL	.359	30	.000	735	30	.000

①The Sig (p) values of the pre-test and post-test are both greater than 0.05, indicating that the data follows a normal distribution. An independent sample test can be used to examine whether there are significant differences between the pre-test and post-test; As shown in the Figure 4.1.

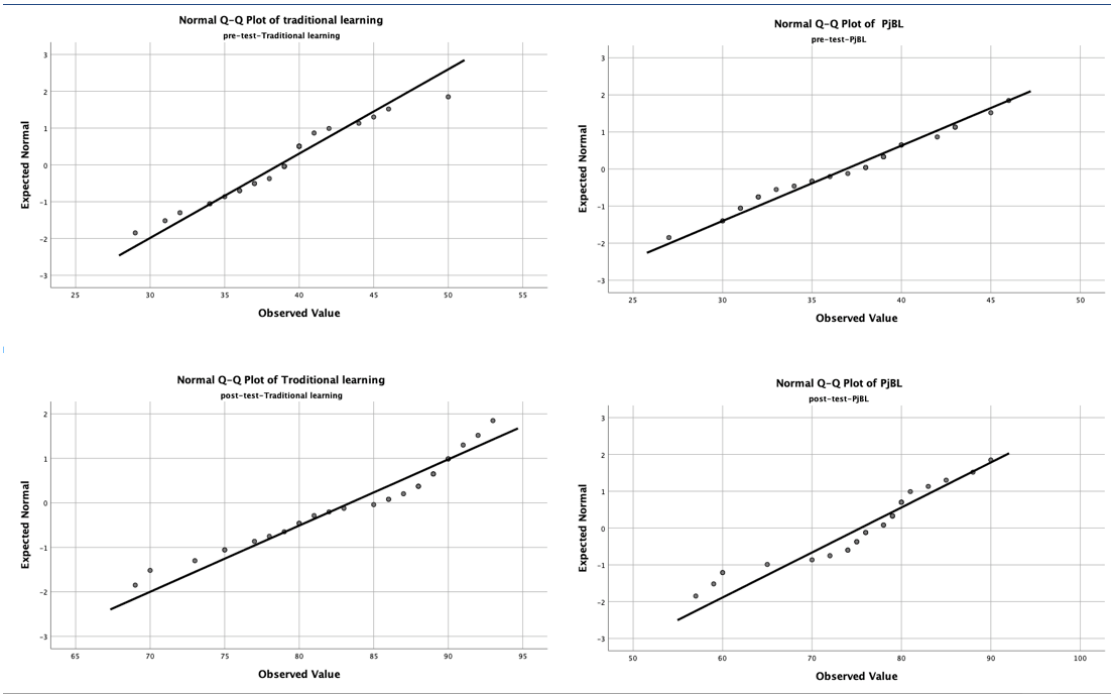


Figure 4.1 Normality Of Pre And Post Test

2The Sig (p) values for performance in class (attendance/ activities/ assignment) is less than 0.05, which is not follow a normal distribution. As a result, an independent sample test using Mann-Whitney U should be conducted for students' performance in class;

3And engagement in the pre and post questionnaire is less than 0.05 indicating that it is not follow a normal distribution. Therefore, a paired sample test using the Wilcoxon Signed Ranks should be conducted for the engagement in the pre and post questionnaire. As shown in the Figure 4.2.

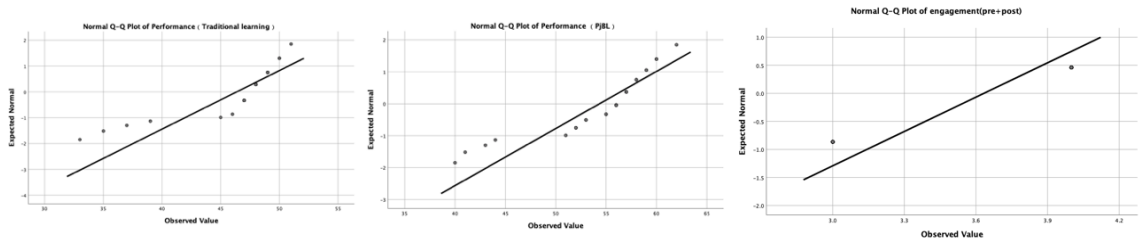


Figure 4.2 Normality Test Of Performance And Engagement

4.3.1 Comparison of Pretest and Posttest

From Table 4.4, it can be observed that the mean values of pre-test are 38.67 and 36.90 respectively, and the Sig(p) value of the pretest is greater than 0.05, indicating that there is no significant difference in the data between the two groups. For the post test, the mean values of post-test are 83.43 and 75.43 respectively, the Sig(p) value is less than 0.05, suggesting a significant difference in the data between the two groups.

Table 4.4 Independent Sample Test of Two Groups' Pretests and Posttest

	Method	N	Mean	Std. Deviation	Std. Error Mean	t	df	Sig(2-tailed)
Pretest	Traditional learning	30	38.67	4.365	.797	1.471	58	.147
	PjBL	30	36.90	4.923	.899			
Posttest	Traditional learning	30	75.43	6.719	1.227	4.140	58	.000
	PjBL	30	83.43	8.178	1.493			

4.3.2 Performance in Class

SPSS adopts the Mann-Whitney U method to conduct independent sample test on the data. As shown in the Table 4.5. The result shows Sig (p) <0.01, indicating a significant difference between the two

groups. Additionally, the Mean Rank of the experimental group is higher than that of the control group.

Table 4.5 Mann-Whitney U Test of Participation In Experimental and Control group

	Variable	N	Mean Rank	Mann-Whitney U	Asymp. Sig. (2-tailed)
Performance	Traditional learning	30	18.98	104.500	.000
	PjBL	30	42.02		

4.3.3 Pre and Post-questionnaire of the Experimental Group

As the Table3 show, data did not follow a normal distribution, the Wilcoxon Signed Ranks Test was used to determine if there were any significant differences in this set of data. The results are shown in the Table 4.6, $Z=-3.522$, $p<0.05$, a statistically significant difference in engagement between the pre-questionnaire and post-questionnaire.

Table 4.6 Paired sample Test

		Wilcoxon Signed Ranks Test	
Engagement	Median	Z	P
pre	3.5	-3.522	.000
post	4.5		

4.4 Experimental Results

From above data analysis, it can be concluded that there is no significant difference between the pre-test of experimental and control group. However, there is a significant difference between the post-test of the control and the experimental group. The Mean of experimental group in posttest and performance were higher than control group. Furthermore, there is a significant difference in the experimental group after the intervention, and the Median of the post-questionnaire being higher than the pre- questionnaire.

4.5 Qualitative data analysis

Numerous studies have shown that the PjBL approach to learning can effectively capture students' attention and encourage active engagement. This approach proves beneficial in both synchronous and asynchronous classes, as it enhances students' focus and comprehension of the provided materials and exercises. Consequently, this increased student engagement positively influences their learning outcomes. Thus, it is evident that student attention and involvement play a significant role in determining learning success. The higher the level of interest and engagement, the easier it becomes to pay attention and retain acquired knowledge. The following are the findings from interviews conducted with lecturers and students during the trial:

In the context of PjBL teaching, students have demonstrated positive responses towards learning activities. Simultaneously, the lecturer actively provides real-time feedback and guidance during students' presentations and lively discussions, creating an enjoyable and burden-free learning experience. This approach positively influences students' engagement. The PjBL method proves highly effective in delivering immediate feedback to students when they ask questions. Additionally, this method facilitates seamless remote communication between students and teachers, enabling teachers to provide comprehensive explanations and share relevant learning materials. [Interviewee L]

During the interview, a student who impressed us with the PjBL approach revealed the same thing:

I prefer the PjBL to the traditional method of studying computer courses.The learning project allows me to identify and address any challenges encountered during the learning process through group discussions and explanations from lecturers. This approach facilitates my understanding of the material. Additionally, the availability of engaging video tutorials provides flexibility for both teachers and students, creating a relaxed and enjoyable learning environment without feeling overwhelmed. [Interviewee S1].

The above statement highlights the comprehensive nature of the PjBL approach, which includes various learning activities such as group discussions, practical exercises, teacher-student interaction, and providing direct feedback to students. These activities, combined with a wide range of digital resources including text, images, and video tutorials, make the learning process more engaging.

The success of student engagement and achievement largely depends on the dedication of teachers in serving students, both online and offline. Therefore, multimedia distance learning and social media play a crucial role in supporting effective teaching, as confirmed by interviews with lecturers.

However, lecturers often do not have enough time to show up when students need help. Therefore, I will share some links and websites where they can access a variety of study materials and media that suit their needs, including downloading video tutorials to make it easier for them to understand the study projects. They learn through video tutorials and watch the video repeatedly until they master it. [Interviewee L]

My classmates and I are always active when using digital media, and it is interesting to combine synchronous teaching with asynchronous teaching. Because through the teaching analysis provided by the method of using digital multimedia and social media, we have enough time to watch and understand the

content of learning. [Interviewee S2]

It is evident that lecturers rely heavily on digital learning tools for their success. Whether students are engaged in online or in-person learning, their interest and motivation to participate in the content taught by lecturers plays a crucial role.

A great class, in addition to interactive communication and digital media, also requires self-directed learning, such as good preparation before class, as expressed by the following lecturers:

The more students interact and ask questions outside of class, the more actively they participate in self-directed learning before class, which is not found in the regular class. [Interviewee L]

In interviews with students, some students stated that:

Since we will make sufficient preparation before class, for example, look up materials and watch the lecturers provide various materials for students, including text, images or video tutorials, we will have enough time to solve the main problems in the learning process in class, which makes us have a lot of time to discuss with classmates, and the lecturers interact with each other in real time. Therefore, in this learning process, I feel very relaxed and free of fear and anxiety, which is a learning experience that they can't get completely in the traditional class. [Interviewee S3]

After asking the questions"What are your views on the PjBL approach? Do you think PjBL is a major trend in the future development of education?", a few students responded negatively:

In my opinion, this teaching method cannot completely replace traditional learning, because there are still drawbacks in some aspects, such as group discussion and interaction, time cannot be fully used, and even some students do not participate in the completion of group homework. [Interviewee S4]

But most students still believe that PjBL will be the development trend of education in the future, and traditional learning will be gradually replaced by new teaching methods.

I feel comfortable and enjoy the whole learning process, especially when I finish the assigned project individually or in a group. Individual practice will bring me confidence, while group practice will bring me a sense of responsibility and teamwork. These are the necessary abilities we need when we enter the society. [Interviewee S5]

With the rapid development of the Internet, I think education reform is also imperative to develop digital education as much as possible, which helps to improve the teaching quality of teachers and the learning efficiency of students. [Interviewee S6]

5. DISCUSSION

The main objective of this study is to compare the impact of project-based teaching and traditional teaching on college students' academic performance and engagement. Additionally, the study investigates the results before and after the intervention. The key difference between the two teaching methods is that the experimental group followed a schedule based on Project-based Learning, while the control group received traditional teaching methods.

Based on the data from question 1, the post-test Sig(p)<0.01, indicating a significant difference between the two groups. The mean scores for the experimental and control groups were 83.43 and 75.43, respectively. The implementation of project-based learning resulted in a greater improvement in college students' grades compared to traditional methods. This finding aligns with Musa's (2012) research, which also demonstrated the positive impact of project-based learning on student achievement.

Regarding the data obtained from question 2, the Sig(p)<0.01, indicating a significant difference between the two groups. The mean rank of the experimental group was higher than that of the control group. This suggests that when using project-based learning, students' performance in class attendance, activities, and assignments increased more compared to when using traditional methods.

The data obtained from question 3 revealed a Z=-3.522, p<0.05, indicating a statistically significant difference in engagement between the pre-questionnaire and post-questionnaire. The engagement level reported in the post-questionnaire was significantly higher than that in the pre-questionnaire. This finding is consistent with the results proposed by Zen (2022), which highlight the positive effect of project-based learning on student engagement and performance in class.

The PjBL approach has an impact on student engagement in the classroom. Additionally, the results indicate that there is a correlation between the method, student engagement, and academic achievement. Based on the tutor's feedback after the experiment, students responded positively to the learning activities in real-life situations when using PjBL. This is because the project's guidance alleviates the students' sense of burden during the learning process. This finding has implications for increasing student engagement. The success of the PjBL model lies in the effectiveness of real-time feedback provided during the questioning interaction between teachers and students.

6. CONCLUSION

6.1 Conclusion and Discussion

Student engagement is a crucial factor in assessing the quality of student learning. This study focuses on a computer science course that incorporates Project-based Learning (PjBL) and targets undergraduate students. The aim is to investigate the influence of PjBL on student engagement and learning outcomes. Based on the

student engagement theory and the characteristics of PjBL, a model encompassing student engagement, learning achievement, and learning environment is developed, along with corresponding research hypotheses. To achieve the research objectives, a questionnaire on PjBL and traditional learning was compiled by referencing the NESS questionnaire and other established questionnaires. The study employs quantitative methods to analyze the impact on students.

6.2 Limitations

The sample for this study consists of undergraduates from Hebei Engineering University who are studying computer science courses in a PjBL (Project-Based Learning) environment. It should be noted that the PjBL environment is not widely implemented throughout the entire university, which limits the number of learners included in the survey sample. Therefore, the generalizability of the study's results needs further improvement. In order to validate suggestions for improving student engagement in a PjBL environment, practical testing is necessary. However, it is important to acknowledge that implementing these suggestions may be challenging due to limited personal ability and time constraints. Therefore, suggestions for increasing student engagement in PjBL have not yet been tested in practice.

6.3 Looking to the Future

Based on the limitations of this study, future research should focus on conducting more comprehensive investigations into the impact of blended learning on student engagement. This research should delve into specific factors and dimensions that influence engagement, and provide targeted recommendations for enhancing student engagement in a blended teaching environment.

REFERENCES

1. Astin, A. W., & Antonio, A. L. (2012). *Assessment for excellence: The philosophy and practice of assessment and evaluation in Higher Education*. Rowman & Littlefield Publishers.
2. Attard, C., & Holmes, K. (2020). “it gives you that sense of hope”: An exploration of technology use to mediate student engagement with mathematics. *Heliyon*, *6*(1). https://doi.org/10.1016/j.heliyon.2019.e02945
3. Belwal, R., Belwal, S., Sufian, A. B., & Al Badi, A. (2020). Project-Based Learning (PBL): Outcomes of students’ engagement in an external consultancy project in Oman. *Education + Training*, *63*(3), 336–359. https://doi.org/10.1108/et-01-2020-0006
4. Bersin, J. (2008). *The Training Measurement Book: Best Practices, proven methodologies, and practical approaches*. Pfeiffer.
5. Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The Effects of Project Based Learning on Undergraduate Students’ Achievement and Self-Efficacy Beliefs towards Science Teaching. EURASIA Journal of Mathematics, Science and Technology Education, 11(3). https://doi.org/10.12973/eurasia.2014.1015a
6. Carnawi, C., Sudarmin, S., & Wijayati, N. (2017). Application of Project Based Learning (PBL) Model for Materials of Salt Hydrolysis to Encourage Students’ Entrepreneurship Behaviour.
7. Chiang, C. L., & Lee, H. (2016). The effect of project-based learning on learning motivation and problem-solving ability of vocational high school students. *International Journal of Information and Education Technology*, *6*(9), 709–712. https://doi.org/10.7763/ijiet.2016.v6.779
8. Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of Project-based learning in Higher Education: Student outcomes and measures. International Journal of Educational Research, 102, 101586. https://doi.org/10.1016/j.ijer.2020.101586
9. Harland, T. (2003). Vygotsky’s zone of proximal development and problem-based learning: Linking a theoretical concept with practice through action research. Teaching in Higher Education, 8(2), 263–272. https://doi.org/10.1080/1356251032000052483
10. He Kekang. (1998). Constructivism—The Theoretical Basis for Innovating Traditional Teaching (1). Journal of Education (3), 29-31.
11. Kahu, E. R. (2013). Framing student engagement in Higher Education. *Studies in Higher Education*, *38*(5), 758–773. https://doi.org/10.1080/03075079.2011.598505
12. Lattimer, H., & Riordan, R. (2011). Project-based learning engages students in meaningful work. Middle School Journal, 43(2), 18–23.
13. Lestari, I., & Juanda, R. (2019). Komparasi Model Pembelajaran Problem Based Learning dan Project Based Learning Terhadap Hasil Belajar Siswa Pada Materi Perangkat Keras Jaringan Internet Kelas IX SMP Negeri 5 Sungai Kakap Kabupaten Kubu Raya.
14. Lisa Barron, & Lauren Wells (2013). Transitioning to the Real World through Problem-Based Learning: A Collaborative Approach to Teacher Preparation.. Journal of Learning in Higher Education.
15. Musa, F., Mufti, N., Latiff, R. A., & Amin, M. M. (2012). Project-Based Learning (PjBL): Inculcating soft skills in 21st Century workplace. *Procedia - Social and Behavioral Sciences*, *59*, 565–573. https://doi.org/10.1016/j.sbspro.2012.09.315
16. Rahardjanto, A., Husamah, H., & Fauzi, A. (2019). Hybrid-PjBL: Learning Outcomes, Creative Thinking Skills, and Learning Motivation of Preservice Teacher. International Journal of Instruction,International Journal of Instruction.

17. Skinner, E. A., & Pitzer, J. R. (2012). Developmental Dynamics of Student Engagement, Coping, and. Everyday Resilience. In Handbook of Research on Student Engagement (pp. 21–44). https://doi.org/10.1007/978-1-4614-2018-7_2
18. Trowler, V., & Trowler, P. (2010). Student engagement evidence summary.
19. Vogler, J. S., Thompson, P., Davis, D. W., Mayfield, B. E., Finley, P. M., & Yasseri, D. (2017). The hard work of Soft Skills: Augmenting the project-based learning experience with interdisciplinary teamwork. *Instructional Science*, *46*(3), 457–488. https://doi.org/10.1007/s11251-017-9438-9
20. Vygotskiĭ, L. S., Cole, M., Stein, S., & Sekula, A. (1978). *Mind in society: The development of Higher Psychological Processes*. Harvard University Press.
21. Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1202728
22. Zen, Z., Reflianto, Syamsuar, & Ariani, F. (2022). Academic achievement: The effect of project-based online learning method and student engagement. *Heliyon*, *8*(11). https://doi.org/10.1016/j.heliyon.2022.e11509
23. Zouganeli, E., Tyssø, V., Feng, B., Arnesen, K., & Kapetanovic, N. (2014). Project-Based Learning in Programming Classes - the Effect of Open Project Scope on Student Motivation and Learning Outcome. IFAC Proceedings Volumes, 47(3), 12232–12236. https://doi.org/10.3182/20140824-6-za-1003.02412

APPENDIX I STUDENT ENGAGEMENT IN PROJECT-BASED LEARNING ENVIRONMENT

Part 1 Basic Information	
What's your gender?	○Male ○Female
What grade are you in now?	○Freshman ○Sophomore ○Junior ○Senior
What's your major?	○Management ○Economics ○Computer science ○Other
Have you ever participated in blended learning?	○yes ○no
What's your favorite manner of learning?	○Online learning ○Traditional learning ○Blended Learning
What is the learning method in this time?	○Traditional learning ○Blended learning
How many hours do you study per day?	○1-2 hours ○2-3 hours ○3-5 hours ○More than 5 hours
How about your final grades last semesters?	○Excellent ○Good ○Medium ○Marginal ○Not well

Part 2 Student Engagement	Strongly Agree	Agree	General	Disagree	Strongly Disagree
I can get a good performance(in/after class)in this course.					
In class, I take the initiative to team up with my classmates to discuss and study.					
When I am in class, I feel curious about what we are learning.					
Online learning tools motivate me to learn.					
Digital technologies increase my engagement.					
To me, it is very important that the technologies/ applications optimize my learning.					
My engagement in school work would increase if IT were used.					
We should use digital technologies to support learning activities.					
I can easily concentrate when using a mobile phone/computer/tablet to learn.					
I take the initiative to use other IT resources.					
When doing schoolwork, I try to relate what I'm learning to what I Already know.					
When I study, I try to connect what I am					

learning with my own experiences.	
Before I begin to study, I think about what I wanna get done.	
I think blended learning is a good development in the future.	
I got a good grade in the final exam.	

APPENDIX II TEST ITEMS FOR STUDENT ACHIEVEMENT

Part I Multiple choice

1. The computer widely used at present is ().
2. General Purpose computers vs. special purpose computers ().
3. The development of microcomputers is usually marked by ().
4. The computer used in the aircraft's navigation system is ().
5. The following statement () is correct.
6. Computer updates are usually based on ().
7. The personal computer (PC) belongs to the () class of computers.
8. The I/O device of a computer uses asynchronous serial transmission to transmit character information, the format of character information is: 1 bit start bit, 7 bit data bit, 1 bit check bit, 1 bit stop bit. If 480 characters are transmitted per second, the data transmission rate of the device is () bps.
9. The way in which different signals are time-shared on the same signal line is called ().
10. The main advantage of the computer using the bus structure is easy to achieve building blocks, while ().

Part II Fill in the blanks

11. The important index to measure the bus is (), the highest that the bus itself can achieve ().
12. According to the different parts of the bus connection, the bus can usually be divided into (), () and communication bus.
13. According to the different data transmission mode, the bus can be divided into () and ().
14. The bus arbitration control can be divided into () type and () type two.
15. During the operation, the doctor often stretches out his hand and waits for the nurse to hand over the scalpel. After the doctor holds it tightly, the nurse will let go. If the doctor and the nurse are regarded as two communication modules, the above series of actions are equivalent to the _____ method of _____ communication.
16. Plug and Play means _____. _____ The bus standard has this function.
17. _____ The first electronic computer successfully developed in the year of _____.
18. The development of computers is that _____ is getting smaller,_____ is getting faster,_____ is getting bigger and _____ is getting lower and lower.
19. _____, or AI for short, aims to empower computers with thinking, judgment, and learning from humans.
20. Although the computer has changed radically since its early days, the features of _____ remain unchanged.

Part III Calculation and practical exercises

21. Set the CPU a total of 16 address lines, 8 data lines, and MREQ(low level effective) for memory access control signal, W/R for read and write command signal (high level for read, low level for write). The following memory chips exist :ROM(2Kx8 bit, 4Kx4 bit, 8Kx8 bit)RAM(1Kx4 bit, 2Kx8 bit, 4Kx8 bit), and 74138 decoder and other gate circuits (gate circuit self-determined). Try to select a suitable chip from the above specifications, and draw the connection diagram of CPU and memory chip. Requirements:
    (1) The minimum 4K address is the system program area, and the 4096~16383 address range is the user program area.
    (2) Indicates the type and number of selected memory chips. (3) Draw the chip selection logic in detail.