JOURNAL OF RESEARCH, INNOVATION, AND STRATEGIES FOR EDUCATION
VOL. 1, NO. 1, PP. 41-57, JULY 2024
https://doi.org/10.70148/rise.4

Integrating Problem-Based Learning and Design Thinking: Innovative Approaches to Enhancing Student Engagement

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ABSTRACT

Design thinking is a suitable strategy for educators to implement in secondary education. However, 45% of teachers never applied in teaching and learning (T&L). One effective approach to integrating design thinking skills in learning is through problem-based learning (PBL). PBL allows secondary students to develop self-directed learning, teamwork, communication and critical thinking skills. This study aims to explore how design thinking skills can be use in PBL. In this study, Form 4 secondary students from Batu Pahat, Johore were chosen using purposive sampling using a quantitative approach with an adaption a set of questionnaires. Through the descriptive statistics analysis the results indicate majority of the samples strongly agreed PBL have helped them to work in group (5.00), PBL should be kept as part of T&L process (4.25). For design thinking samples felt in; Empathize, comfortable to deal the unsolved problems with their group (4.88), Identify, important to discuss in a group how to reframe the initial problem in order to achieve a good result (4.63), Ideate, comfortable to accept the group's decision (4.88), Build, comfortable to create something new (4.50), Test, failure is part of learning process and learnt from the mistakes made (4.63). Overall, PBL in lessons proved to be effective, fostering students' critical thinking and teamwork skills as students adapted cognitive and social constructivism and design thinking enhancing critical thinking and teamwork of students. However, future researchers are recommended to expand the samples size, applied technological tools in lesson and applied different topics in Computer Science.

ARTICLE HISTORY
Received 5 July 2024
Revised 14 July 2024
Accepted 28 July, 2024

KEYWORDS
Problem-based learning; design thinking; learning strategies; teaching and learning; constructivism

1. Introduction

In the 21st century, or Pembelajaran Abad ke-21 (PAK21), learning has advanced significantly through the use of technological tools, offering a variety of approaches and activities that educators can implement in teaching secondary students. This era emphasizes student-centered learning in the classroom under the guidance of

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educators. One effective approach is problem-based learning (PBL). Mustaffa et al. (2016) conclude that PBL helps students develop crucial thinking and soft skills necessary for the demands of modern education. Suprapto et al. (2017) support this, noting that PBL techniques surpass traditional methods by fostering higher-order thinking skills, problem-solving abilities, teamwork, and self-confidence. Ginaya et al. (2020) also report successful PBL implementation in classrooms. Thus, PBL is an active learning strategy that significantly enhances student learning (Tatar & Oktay, 2011).

Design thinking skills can be a valuable pedagogical approach in the classroom. According to Henriksen et al. (2017) design thinking techniques foster cognitive habits that help teachers and students solve creative problems. Where according to Tsai (2018), also found that design thinking encourages the development of students' higher-order thinking abilities, interactive teamwork, personalities, and learning strategies. Implementing design thinking in education can make students more creative and better at problem-solving during teaching and learning activities. Students can use design thinking in various subjects, as shown by Andrew D. Watson (2015) who found that students began applying design thinking outside the classroom. However, Li & Zhan (2022) noted that while design thinking shows pedagogical promise for K-12 education, there is currently no empirical data to support its efficacy.

1.1 Problem Background

Design thinking is a suitable strategy for educators to implement in classroom activities or learning approaches. According to Pratomo et al. (2021) in Indonesia, implementing design thinking in studies significantly improves students' creativity and alertness. Md Hashim et al. (2019) highlighted that the empathy phase of design thinking helps students better understand people from diverse backgrounds, languages, races, and cultures. Empathy also plays a crucial role in problem-based learning. Tu et al. (2018) suggested that the design thinking method enhances instruction, encourages student participation through interviews during the empathize stage, deepens discussions on design-related topics, improves teaching, fosters positive student-teacher interactions, and increases student focus. However, despite the benefits Noh & Karim (2021) found that in Malaysia, 45% of teachers have never applied design thinking in their teaching and learning (T&L) sessions due to a lack of awareness and understanding of how to conduct it. Additionally, 70% of teachers rarely use creative thinking skills in T&L. This indicates that the application of design thinking skills in Malaysian classrooms is still below 70%-80%. Consequently, the lack of design thinking adoption by educators may lead to student inactivity, lack of imagination, and a non-innovative learning environment.

One effective way to integrate design thinking skills into learning activities is through problem-based learning (PBL). PBL allows students to develop self-directed learning, teamwork, project management, communication, and critical thinking skills. Design thinking encourages students to focus on end-user needs and create innovative solutions through collaboration and iteration, making it a valuable technique for PBL. Silva et al. (2018) noted that PBL significantly enhances students' academic performance by combining theory and practice, increasing their desire to learn. Effective PBL requires strategic planning (Zhou et al., 2013) and past research suggests implementing good strategies to ensure efficiency (Yuan et al., 2011). While many studies have proven PBL's effectiveness in teaching and learning, there is a lack of research on PBL with a design thinking approach for secondary school Computer Science students. PBL is often tested in medical and nursing schools, but, Morrison et al. (2015) suggest that Computer Science might pose different cognitive demands and problem-solving requirements. Rahmayani (2021) recommends further research on PBL, especially in the context of its application in Computer Science education.

1.2 Problem Statement

There are plenty of learning strategy that can be implement during T&L in the classroom by the educator. As it shows that learning strategy will impact the learning achievement of the students (Sulisworo & Suryani, 2014). Along with that, educator have to play an important role in order to make sure the learning strategy, learning environment and technological tools used during the process of T&L in the classroom with students from secondary grade went smoothly and students able to achieved something meaningful at the end of the lesson. Entering the year of 2023, the current learning style has now shifted to the 21st century as it is more to student-centered learning where educator will remain as facilitator in the classroom. One of the learning strategies that could be implement by the

educator is PBL, as in PBL student will able to work in a group with friends but according to Anggraeni (2021) group work in PBL is necessary, but it also presents drawbacks such as disunity, inconsistencies in time management and unbalanced assignments. These issues may occur due to lack of technological elements used in the strategy, lack of critical thinking skills applied and educator do not require the students to use the design thinking skills. Where a study by Noh & Karim (2021) shows that only 30% of educator applied critical thinking in the T&L. Can be seen that the students rarely be getting the opportunity to enhance and practice their knowledge of critical thinking. Therefore, this research study indicates to find out does design thinking is suitable to be adapted in the learning using PBL in the classroom and does PBL shows a significant result of students' performances.

1.3 Research Objectives

- To develop lesson using problem-based learning approach.
- To explore the perceptions of students regarding the integration of problem-based learning in design thinking.

1.4 Research Questions

- How could problem-based learning be used in a lesson?
- What are the perceptions of students regarding the integration of problem-based learning using each step of design thinking in the lesson?

2. Literature Review

2.1 Design Thinking

Design thinking is a collaborative method that is iterative and non-linear that focuses on designers and users. Razzouk & Shute (2012) describe design thinking as a creative and analytical process that allows for experimentation, model development, prototyping, feedback collection, and redesign. This method aims to find solutions to issues, helping to understand human needs, generate ideas during brainstorming, and implement practical approaches in prototyping and testing. It is particularly effective in addressing complex problems.

Design thinking brings numerous benefits. It provides innovative solutions based on actual user experiences, as shown by Smith et al. (2015) who found that it helps students understand the imaginative and complex processes behind digital fabrication. Educators are encouraged to incorporate design thinking in teaching and learning, as B. Utami et al. (2019) suggest that it enhances critical reading, logical thinking, and problem-solving skills. In the context of 21st-century learning, which emphasizes student independence and critical thinking, design thinking is an appropriate method for problem-solving in various educational projects, such as problem-based and project-based learning.

Future researchers interested in design thinking can conduct experimental studies to further assess and promote this approach, Razzouk & Shute (2012) suggest. The design thinking process involves five key stages which empathize is understanding and sharing the emotions of others (Wina Smeenk et al., 2016), identify is thoroughly understanding and defining the issues or problems (Kimbell, 2011), ideate is generating ideas creatively, individually or in groups, through brainstorming, mind-mapping, sketching and storyboarding to solve the issues and build is developing an initial version of the product or solution at minimal cost to identify any errors or issues (Gregor Gabrysiak et al., 2011) and test phase is evaluating concepts and prototypes to ensure they meet user demands and solve genuine problems(Deitte & Omary, 2019).

2.2 Problem-Based Learning

Problem-based learning (PBL) serves both as a curriculum and a teaching strategy that fosters lifelong learning, critical thinking, and interpersonal skills through tackling open-ended and complex problems. Students learn to solve

real-world issues, helping them grasp ideas and principles more effectively (Carvalho, 2016). Visschers-Pleijers et al. (2006) highlighted that in PBL, students collaborate in groups to identify what they need to understand to solve a problem, with educators acting as facilitators rather than knowledge providers. This approach has been shown to be beneficial across various educational settings. Doukanari et al. (2020) stated PBL provides significant opportunities for interdisciplinary learning, enabling students to integrate prior knowledge, existing skills, and life experiences. Given the importance of teamwork and problem-solving in technology education, PBL is likely the most effective pedagogy for this subject. Moreover, PBL engages students in authentic challenges, enhancing their intrinsic motivation to learn both inside and outside the classroom by encouraging them to develop design-based solutions.

2.2.1 Effectiveness of Problem-Based Learning

The use of Project-Based Learning (PBL) in education has shown positive impacts, as evidenced by multiple studies. Jabarullah & Iqbal Hussain (2019) conducted a study on technical and vocational students in Malaysia, finding that PBL enhances students' motivation, lateral thinking, and 21st-century skills such as communication, teamwork, creativity, and critical thinking. The study also highlighted that effective PBL fosters skills in risk-taking, communication, problem-solving, and innovation. Additionally, Funa & Prudente (2021), demonstrated that PBL is beneficial for secondary school students, particularly in science subjects. Their study found that PBL outperforms conventional teaching methods in promoting conceptual understanding, critical thinking, problem-solving skills, and motivation.

Furthermore, Mercy et al. (2020) also focused on secondary school students, revealing that PBL improves critical thinking, problem-solving, and self-efficacy skills compared to traditional teaching methods. This suggests that PBL can enhance student engagement and critical thinking abilities in secondary education. A part of that, Ghani et al. (2021) asserted that PBL instills confidence, practical knowledge, and a sense of authority in students preparing for professional careers by enhancing problem-solving, communication, critical thinking, and teamwork skills. Rahmad Timor et al. (2021) points out that PBL is a productive teaching technique that increases student motivation and learning outcomes through a learner-centered approach that integrates theory and practice, thereby improving critical thinking, problem-solving, communication, and teamwork abilities.

2.3 Learning Theory of Constructivism

Constructivism, as developed by Jean Piaget and L. Vygotsky, is a philosophical perspective on learning, knowledge acquisition, and socialization (Savery & Duffy, 1995). It is often used to shape curricula, assessments, and teaching and learning practices (Svein Sjøberg, 2010). According to Cobern (1993) constructivism is a theory of how students learn, suggesting that students construct their own knowledge based on prior information and experiences Jadallah (2000). Patrick Lowenthal (2008) describes constructivism as a theory where knowledge is created internally rather than acquired from an external objective reality, and notes that it effectively represents diverse viewpoints on learning and knowledge acquisition.

A core element of constructivism is that knowledge does not exist outside of human thinking and the mind (Hendry et al., 1999). Therefore, educators often use Problem-Based Learning (PBL) within constructivist frameworks to integrate students' experiences. Constructivism emphasizes the active role students play in developing their own understanding by reflecting on past experiences, forming mental images, and integrating new knowledge into existing cognitive structures (Harlow et al., 2006). As can be seen, constructivism highlights the part that students can play in developing their own understanding instead of merely obtaining knowledge, students are now able to carefully consider their past experiences, conjure up mental imagery, and incorporate new knowledge into mental structures. However, an educator needs to be mindful that each student will have their own special knowledge and experience that they will bring into the classroom.

3. Method

3.1 Research Design

This research study wants to identify either design thinking skills can be use in PBL and to explore student's perceptions of using design thinking in PBL. Therefore, research design that this study considers to use is descriptive quantitative research design.

3.2 Research Procedure

Students have to work in group in two hours to complete the task given through a set of question (refer Appendix A) and are required to follow around seven steps in order to help answer the initial research study questions. These seven PBL steps are expected to be completed by the target samples. In Shalini (2018) first step is collective brainstorming, where students discuss and understand the given issues. The second step is creating a problem statement, where students identify and agree on the issue to address. The third step involves engaging teams by assigning roles and fostering teamwork. The fourth step is information gathering and processing, where students compile information in a mind-map and select the best solutions after evaluating pros and cons. In the fifth step, discussion and reflection, students test their prototypes and consider additional approaches. The sixth step is presenting their findings to the class. The final step in PBL involves the researcher providing feedback to samples to assess the application of constructivism theory, both cognitive and social.

As for design thinking, the samples are required to follow the five steps of design thinking as outlined by Paul Brian (2012) firstly, empathize by communicating with their group members to address issues in PBL. Second, identify solutions through group discussions. Third, ideate by brainstorming and documenting their ideas in mind maps or other forms. Fourth, build or prototype by transforming ideas into a tangible product or output. Finally, test the output to determine if further improvements are needed or if the end results are satisfactory.

3.3 Research Samples

The samples for this research are selected from Form 4 students who took Computer Science in 2023 at a secondary school in Batu Pahat, Johore. This study uses non-probability sampling and specifically employs purposive sampling to select students based on specific criteria. The criteria are Form 4 students who took Computer Science in 2023. Therefore, 20 students who meet these criteria will be chosen for the study.

3.4 Research Instruments

The instruments needed is a set of close ended questionnaire built via Survey Heart, a set of PBL activity where the question used adapted from the textbook (refer Appendix A) and Google Slides for samples to develop their work. As the questionnaire is divided into three sections to address the study's research objectives and questions. The number of items is adapted from previous scholars, as shown in Table 3.1 below:

Table 3.1

Adapted Items Used in Questionnaire

Part	Adaptation
How PBL able to be used in a lesson	Sattarova et al. (2021)
What are the perceptions of students regarding the integration of problem-based learning using each step of design thinking in the lesson	Ladachart et al. (2021) & Dosi et al. (2018)

Moreover, five-points of Likert Scale will be used in the questionnaire. Pescaroli et al. (2020) stated that the Likert scale can be utilized in many different fields, from social science to engineering. In table 3.2 below shows the five-points in the Likert scale that will be implement by this research study.

Table 3.2

Five-Points of Likert Scale

Scale	Five-Point
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

Additionally, as shown in the table 3.3 below is the items distribution for the questionnaire. The total items used in the questionnaire are 36 items that divided into three part which Part A demography, Part B how PBL able to be used in a lesson, and Part C what are the perceptions of students regarding the integration of problem-based learning using each step of design thinking in the lesson.

Table 3.3

Items Distribution in Questionnaire

Part	Total of Items
A: Demography	4
B: How could problem-based learning be used in a lesson?	10
C: What are the perceptions of students regarding the integration of problem-based learning using each step of design thinking in the lesson	22
Total of items	36

3.5 Validity and Reliability

To ensure the research instruments are valid and consistent, validity and reliability tests were conducted. This ensures the findings are accurate and useful for future studies. Most importantly, the instruments must effectively address the research objectives and questions. Ayodele (2012) mentioned that both quantitative and qualitative educational research can benefit from validity and reliability, and focusing on these aspects can minimize challenges in educational research.

3.5.1 Validity

In the validity phase, two experts, lecturers from the Faculty of Social Sciences and Humanities at University Technology Malaysia (UTM), were selected to assess the survey questionnaire instruments. These lecturers, who hold PhDs in Educational Technology and are knowledgeable about education, learning strategies, and pedagogy. Researcher incorporated all their comments and recommendations into the revised questionnaire, which was then distributed to the sample.

3.5.2 Reliability

For reliability testing, 10 students who took Computer Science in 2022 used the validated questionnaire items. Kimberlin & Winterstein (2008), emphasized that reliability testing ensures the research instrument consistently and accurately measures the same construct. Thus, this study will use test-retest reliability, which assesses consistency over time by repeating the test with the same group. Aboagye et al. (2016) noted that test-retest reliability indicates the instrument's stability.

Additionally, Cronbach Alpha will be used to ensure instrument reliability. Wadkar et al. (2016) stated Cronbach Alpha is effective for estimating the reliability of individual or combined items in a test. A Cronbach Alpha value of 0.61 or

higher, as stated by Christmann & Van Aelst (2006) indicates acceptable reliability. The reliability testing with 10 students was analyzed using SPSS version 26, and the results are shown in Table 3.4 below.

Table 3.4

Reliability Value of This Study

Part	Value of Cronbach Alpha	Reliability Value
B	0.757	Good and Acceptable
C	0.734	Good and Acceptable
D	0.898	Good
Overall, of B, C and D	0.832	Good

As shows in table 3.4 above, can be seen that the result shows in Part B is 0.757, Part C is 0.734 and Part D is 0.898. The overall value for Part B, C and D indicates a number of 0.832. Therefore, the items in the questionnaire are applicable to be used in this study.

3.6 Data Collection Method

This study used the Survey Heart platform to distribute closed-ended questionnaires to the samples for data collection. Survey Heart allows for offline form creation and provides immediate alerts to the researcher when responses are received.

3.7 Data Distribution

An online method was used to distribute questionnaires via Survey Heart to the samples through WhatsApp immediately after the observation phase. Samples had two weeks to complete the survey. This method reduced time and travel expenses, aligning with Décieux et al. (2015) who noted the low cost and speed of online surveys. Additionally, immediate assistance was provided to secondary school students if they had any questions.

3.8 Data Analysis

The data obtained from the survey method via Survey Heart was analyzed using SPSS version 26 through descriptive statistics. In quantitative research, SPSS is commonly used for data interpretation due to its simplicity and suitability.

According to Horan (1982) mean and standard deviation are examples of descriptive statistics that help infer group characteristics. In descriptive statistics, frequency is expressed as a percentage, and mean scores are generated through SPSS. The mean score determines whether the studied elements are high, medium, or low. The measurement scale of the mean score is shown in Table 3.5 below:

Table 3.5

Likert Scale Mean Score Interpretation

Mean Score	Level of Inclination
1.00 – 2.40	Low
2.41 – 3.80	Medium
3.81 – 5.00	High

4. Results

Based on data collected through a questionnaire distributed via Survey Heart, the table below presents the findings on respondents' demographics and answers to each research question:

4.1 Respondents' Demography

The demographic data of respondents is divided into four categories: gender, race, form, and Computer Science exam grades. Table 4.1 below shows the distribution of these demographics for 20 samples, presented as percentages and frequencies.

Table 4.1

Respondents' Demography

Part	Frequency	Percentage %
Gender		
Male	15	75.0
Female	5	25.0
Race		
Malay	20	100.0
Indian	0	0
Chinese	0	0
Others	0	0
Form		
1	0	0
2	0	0
3	0	0
4	20	100.0
5	0	0
Grades obtained in Computer Science examination.		
A	3	15.0
B	4	20.0
C	5	25.0
D	2	10.0
E	3	15.0
Failed	3	15.0

Table 4.1 shows the demographic distribution of the 20 respondents in this study. Among them, 15 (75.0%) are male, and 5 (25.0%) are female. All respondents are Malay and in Form 4. Regarding grades in the Computer Science examination, 3 (15.0%) scored an A, 4 (20.0%) scored a B, 5 (25.0%) scored a C, 2 (10.0%) scored a D, and 3 (15.0%) each scored an E or failed.

4.2 How could problem-based learning be used in a lesson?

Table 4.2

Mean score for How PBL able to be used in a lesson.

No	Items for How could PBL able to be used in a lesson	Mean	Standard Deviation	Mean Score
5.	In your opinion, PBL sessions should be kept as part of the learning process in the class?	4.25	0.463	High
6.	In your opinion, PBL sessions have helped your ability to work in groups?	5.00	0.000	High
7.	In your opinion, PBL sessions have improved your understanding of the lessons for Human Computer Interaction?	3.88	0.835	High

8.	In your opinion, PBL sessions have helped you to understand better about the theoretical part in Human Computer Interaction?	4.38	0.518	High
9.	In your opinion, PBL sessions have helped you to understand better about the practical part in Human Computer Interaction?	4.13	0.835	High
10.	In your opinion, PBL have motivated you to regularly cooperated to work in a group?	4.13	1.356	High
11.	The content used in this PBL sessions were good.	4.50	0.535	High
12.	The 2 hours provided to discuss in group for activity in PBL is enough.	3.38	1.061	Medium
13.	PBL activity should be used a realistic and a real situation.	4.50	0.535	High
14.	PBL activity were well organized.	4.25	0.886	High

Based on the data in Table 4.2, the mean value for item 12 is 3.38, indicating that the 2-hour duration provided for group discussions in PBL activities is insufficient. This suggests that students need more time to complete tasks effectively. Overall, the results show that PBL can be effectively used in lessons, as students adapt well to the activities and the PBL approach.

4.3 What are the perceptions of students regarding the integration of problem-based learning using each step of design thinking use in the lesson?

Table 4.3

Mean score for How students tackle the problem-based learning activity in a group using each step of design thinking in Empathize phase.

No	Items for Empathize	Mean	Standard Deviation	Mean Score
15.	I try to understand my group's need during discussion.	4.88	0.354	High
16.	I am comfortable to deal the unsolved problems with my group members.	4.88	0.354	High
17.	I am an open-minded person.	4.00	0.926	High
18.	I like working in a group rather than working alone.	4.13	0.641	High

The results in Table 4.3 show that the Empathize phase in Design Thinking scores highly. This phase effectively aids students in solving PBL activities by facilitating group discussions, with most students preferring to work in groups.

Table 4.4

Mean score for How students tackle the problem-based learning activity in a group using each step of design thinking in Identify phase.

No	Items for Identify	Mean	Standard Deviation	Mean Score
19.	I can accept my group's decisions even I do not agree with them.	3.88	0.641	High
20.	I am able to discuss and share my idea during the group discussion.	4.50	0.535	High
21.	I am able to think of something new that are different from what already exists during the discussion.	3.88	0.835	High
22.	I feel interested to have a better understanding regarding the problem that were given.	4.13	1.356	High

23.	I think it is important to discuss in a group how to reframe the initial problem in order to achieve a good result.	4.63	0.518	High

The data distribution from Table 4.4 pertains to the second phase in Design Thinking, Identify. The overall results indicate a high score for this phase. In conclusion, the Identify phase effectively helps students solve PBL activities, as students find group discussions and idea sharing crucial. Additionally, students show enthusiasm in understanding the issues presented in PBL and demonstrate flexibility and understanding during group decision making.

Table 4.5

Mean score for How students tackle the problem-based learning activity in a group using each step of design thinking in Ideate phase.

No	Items for Ideate	Mean	Standard Deviation	Mean Score
24.	I am comfortable to change my opinion while in discussion.	3.75	1.282	Medium
25.	I am comfortable to accept the group's decision.	4.88	0.354	High
26.	I am comfortable to share my knowledge or idea with my group members.	4.50	0.535	High
27.	I am comfortable to develop new knowledge with my group members.	4.00	1.309	High
28.	I seek for new information when having discussion.	4.25	0.886	High
29.	I like to get feedback from my group members regarding the quality of my idea when in discussion.	4.50	0.535	High

The results in Table 4.5 for the Ideate phase in Design Thinking show a mean value of 3.75 for item 24, "I am comfortable changing my opinion during discussion." This indicates that not all students feel comfortable changing their opinions in discussions. This discomfort may stem from factors such as introversion, lack of confidence, or concern for their friends' feelings to avoid misunderstandings. Overall, the Ideate phase in Design Thinking helps students solve activities in PBL, demonstrating high levels of unity and teamwork as they share ideas during discussions.

Table 4.6

Mean score for How students tackle the problem-based learning activity in a group using each step of design thinking in Build phase.

No	Items for Build	Mean	Standard Deviation	Mean Score
30.	I am comfortable to create something different and new from what already exist.	4.50	0.535	High
31.	I am comfortable to use prototypes to represent my idea.	4.38	0.518	High
32.	I am comfortable to use prototypes as an end result.	4.00	0.926	High

Table 4.6 shows the data distribution for the Build phase in Design Thinking. The results indicate high scores for all items in this phase. In conclusion, the Build phase in Design Thinking effectively helps students solve PBL activities, demonstrating their ability to create new and different things by applying what they've learned to build prototypes.

Table 4.7

Mean score for How students tackle the problem-based learning activity in a group using each step of design thinking in Test phase.

No	Items for Test	Mean	Standard Deviation	Mean Score
33.	My group and I desire to create a new value of the end result.	4.25	0.886	High
34.	My group and I can overcome difficulties that occur at the end result.	4.00	0.756	High
35.	I am capable to discuss in group regarding the mistakes my group members and I have made and learn from it.	4.63	0.518	High
36.	I think failing is importance process in order to learn.	4.63	0.744	High

Table 4.7 shows the high scores for the Test phase in Design Thinking. This phase significantly helps students in PBL by allowing them to identify and correct mistakes from the build phase, leading to improved final products. Additionally, the Test phase provides valuable experience in working under pressure to address any challenges with their projects.

5. Discussion

The discussion is based on data analysis. The data is compared with past studies to determine if it addresses the research questions and fulfills the study's objectives, which are to:

- To develop lesson using problem-based learning approach.
- To explore the perceptions of students regarding the integration of problem-based learning in design thinking.

5.1 The effectiveness of implementing problem-based learning in a lesson

Based on previous observations and data analysis, the descriptive data shows that PBL is effective in lessons according to student perceptions. PBL should be part of the classroom learning process, as indicated by a high mean score of 4.25. All students strongly agreed (mean score 5.00) that PBL helps them work in groups, and the majority (mean score 4.13) agreed that PBL activities motivate them to develop good teamwork. This demonstrates that PBL is a suitable learning approach for educators, promoting both learning and teamwork among students.

Specifically, PBL activities on Human-Computer Interaction (HCI) for Form 4 Computer Science students were deemed realistic and appropriate, as reflected by a high mean score of 4.50. The data further reveals that PBL significantly enhanced students' understanding of HCI (mean score 3.88), theoretical knowledge (mean score 4.38), and practical skills (mean score 4.13). This supports the assertion by Funa & Prudente (2021) that PBL fosters conceptual comprehension, critical thinking, problem-solving abilities, and motivation. Similarly, Mercy et al. (2020) argue that PBL enhances critical thinking, problem-solving, and self-efficacy more effectively than traditional teaching methods.

However, a critical limitation emerges from the allocated time for PBL activities. Students were only given 2 hours to complete the tasks, resulting in a medium mean score of 3.38, which suggests that secondary students require more time to engage deeply and complete PBL activities effectively. Where Kilroy (2004) also mentioned that PBL is often criticized for being time-consuming as it requires significant time for both students and educators to engage deeply with the problems and for effective facilitation. Also Roberto & Ribeiro (2015) stated that here is a risk that students may only acquire superficial knowledge when engaging with PBL, particularly if they are not given enough time to explore the problems in depth. This time constraint highlights the need for a more flexible and extended schedule to fully realize the benefits of PBL in enhancing critical thinking and problem-solving skills.

5.2 The students' perception of using design thinking to solve activity in problem-based learning activity in group

This research also aims to measure the students' perception of design thinking in facilitating their progress in PBL, both in groups and individually. Descriptive data shows that during the Empathize phase, students prefer working in groups (mean score 4.13). The highest mean score in this phase is 4.88, indicating that students make strong efforts to understand their group members' needs and feel comfortable finding solutions together. Many students see themselves as open-minded (mean score 4.00). This suggests that the Empathize phase effectively helps students collaborate and communicate, making each member feel responsible for solving the activity. As to Dosi et al. (2018), the design thinking method enhances instruction and encourages student participation through class interviews during the Empathize stage. Md Hashim et al. (2019) also stated that empathy plays a significant role in PBL, helping students better understand people from diverse backgrounds, languages, races, and cultures.

Secondly, in the Identify phase, most students agreed that group discussions are crucial for figuring out the initial problem to achieve good results, with a mean score of 4.63. They also felt they could share ideas during group discussions (mean score 4.50) and were interested in understanding how to solve activities in PBL (mean score 4.13). Additionally, students accepted group decisions and thought of new ideas different from existing ones (mean score 3.88). Overall, the Identify phase is effective for PBL, teaching students to work in groups and requiring discussions where everyone shares ideas. This supports (Kimbell, 2011) statement that understanding issues helps formulate problems and achieve precise goals. Students learn to negotiate and accept group opinions during this phase.

Thirdly, data from the Ideate phase shows that the highest mean score is 4.88, indicating that most students are comfortable accepting their group's decisions. The mean score of 4.50 shows that students are also comfortable sharing their ideas and prefer receiving feedback to ensure quality. Students are willing to seek new information during discussions (mean score 4.25) and feel comfortable developing new knowledge with their group members (mean score 4.00). However, only some students feel comfortable changing their opinions during discussions (mean score 3.75). This supports Valentim et al. (2017) who found that design thinking is a helpful strategy as Ideate phase helps students generate numerous ideas from each group member, fostering critical thinking and unity within the group.

In the Build phase of design thinking, students showed a high level of comfort and creativity, with a mean score of 4.50. They felt comfortable creating something new and using prototypes to represent their ideas (mean score 4.38) and as end results (mean score 4.00). Both groups used Google Slides for sketching and prototyping, allowing each student to design based on their assigned tasks. Hayes & Games (2008) found that design thinking and computer games engage young people in learning and foster creativity. In this study, Google Slides helped all students develop creativity in designing interfaces, leading to higher engagement. The Build phase effectively helps students solve PBL activities by promoting teamwork and individual responsibility until the final product is achieved. The use of prototypes in PBL showed positive results, with most students feeling comfortable, as stated by Y. Utami et al. (2021) who noted that the Build phase involves developing an early version of a product at minimal cost to detect errors or issues. This phase encourages students to think creatively and step out of their comfort zones.

Lastly, in the Test phase of design thinking, most students felt capable of discussing mistakes with their group members and agreed that failure is an important part of the learning process (highest mean score 4.63). Additionally, students expressed a strong desire to create new value in the end result with their group members (mean score 4.25) and felt they could overcome difficulties that arose (mean score 4.00). Individually, students chose their best ideas to propose to their group, and collectively, they rechecked the final result to ensure everyone's satisfaction, making immediate changes if needed. Erat & Kavadias (2008) emphasized that the testing phase is crucial for evaluating concepts and prototypes to meet user demands and solve real problems. This phase effectively develops students' empathy by considering group members' opinions to achieve a good end result in PBL activities. Students also maintained a positive mindset, recognizing that failure is essential for learning. According to Wloka et al. (2010) testing allows developers to identify potential faults, gain valuable insights, and make necessary adjustments. The Test phase also trains students to work under pressure and resolve any difficulties with their product.

5.4 Recommendation

By conducting the research study and based on the findings obtained in descriptive analysis there are few recommendations that will be suggested to fill in the gap of this research study there are:

(i) Future researcher to applied another topic in Computer Science besides of HCI in order to see the effectiveness of PBL in another topic of Computer Science.
(ii) Added longer time for the activity in PBL as students are not majority agreed that the 2 hours provided is sufficient enough to complete the activity in PBL.
(iii) Applied technological tools for the main medium in the PBL's activity to make students more acknowledge and skillful in using such tools with the passing of time in 21st century.
(iv) The population of samples used in this research study are limited, therefore future researcher is highly recommended to expand the use of samples to see the differences between each of form of upper and lower secondary with the use of PBL in lesson.

5.5 Limitation

The first limitation of this research is that it only involves Form 4 students from a secondary school in Batu Pahat, Johore, who took Computer Science in 2023. Second, the study focuses solely on the topic of human-computer interaction due to time constraints, rather than covering the entire Computer Science subject.

6. Conclusion

All things considered, the findings based on the observation and survey that have obtained in this research study are able to achieve the objectives and also able to answer all research questions. It is clearly shows that the use of PBL is suitable to be used in a lesson where it indicates significant results where it can foster and develop students critical thinking, teamworking and it is clearly shows that the cognitive constructivism theory has been adapted by students as students use their existed knowledge and experiences to forming and developing new information to find the solution of the PBL's activity as individually and grouping. Majority of the students stated that they gained new knowledge by doing the activity in PBL as they will exchange their ideas, sorting out the best among all and proceed until the final product in prototype by designing the interface on Google Slides.

Besides, PBL is required the students to work in group, therefore design thinking skills is required to be used by the students on every step in it by doing the PBL's activity. Nonetheless, it shows that throughout of students having the group work, the social constructivism theory is successfully adapted by them and the use of design thinking also successfully effective to be used by students in PBL's activity. Throughout students doing their work in group, researcher could see that they are all able to recognize the problems in PBL, presented their ideas clearly, and work effectively as a team by debating their ideas in order to get the best solution for the final result and none of the group members are taking advantage for being silent and not giving any ideas and cooperation to the group until the end of design thinking phase which is test.

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Appendix A

PROJECT INFORMATION	
Research Title	Integrating Problem-Based Learning and Design Thinking: Innovative Approaches to Enhancing Student Engagement
Sample	Form 4
Total of sample	20
Subject	Computer Science
Topic	Chapter 3: Human Computer and Interaction
Time provided	1 – 2 hours
QUESTION	
In group	Teacher Malina is a dedicated mathematics teacher who uses the Mathematics Learning Application in TnL sessions in class, but the application fails to attract the attention of her students. Therefore, as a developer of educational applications that comply with the characteristics of human interaction with computers: i. What are the steps for you to help Ms. Malina attract the attention of her students? ii. Produce a prototype in sketch of an interesting Mathematics Learning Application using Google Slides. iii. Present the results of group work at the end of the activity.