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The Effectiveness of Problem-Based Learning on Form Two Students' Academic Performance in Balanced Diet Subtopic

Keberkesanan Pembelajaran Berasaskan Masalah terhadap Prestasi Akademik Pelajar Tingkatan Dua dalam Subtopik Gizi Seimbang

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ABSTRACT

Traditional teaching methods in science education are increasingly recognised as ineffective, often hindering students' understanding of concepts. While Problem-Based Learning (PBL) is acknowledged for its efficacy in fostering problem-solving skills, its adoption in Malaysian secondary schools remains nascent. This study investigates the impact of PBL on Form Two students' academic performance in the "Balanced Diet" subtopic, addressing challenges posed by traditional methods and the perception of science as daunting and unengaging. Employing a quasi-experimental design with a quantitative approach, the study involved 30 Form Two students from SMJK Shan Tao, divided into experimental (PBL) and control (traditional methods) groups. Pre-test and post-test assessments, comprising 15 multiple-choice questions, were conducted to evaluate academic performance. Analysis using independent-sample t-tests in SPSS version 29.0 indicated no significant difference in pre-test scores between groups ($t(30)= -1.486$, $p>.05$), but significant post-test improvement in the experimental group ($t(30)= -6.570$, $p<.05$). These findings suggest that PBL effectively enhances academic performance in the "Balanced Diet" subtopic, supporting its integration in science education to promote critical thinking and engagement. Further research should explore PBL's long-term effects across diverse subjects with larger sample sizes for broader applicability.

Keywords: Traditional Teaching Methods, Science Education, Problem-Based Learning, Academic Performance, Balanced Diet

ABSTRAK

Kaedah pengajaran tradisional dalam pendidikan sains semakin diiktiraf sebagai tidak berkesan, seringkali menghalang pemahaman pelajar terhadap konsep-konsep. Walaupun pembelajaran berasaskan masalah (PBL) diakui berkesan dalam memupuk kemahiran menyelesaikan masalah, penerimaannya di sekolah menengah Malaysia masih baru. Kajian ini mengkaji kesan PBL terhadap prestasi akademik pelajar Tingkatan Dua dalam subtopik "Gizi Seimbang", menangani cabaran yang ditimbulkan oleh kaedah tradisional dan persepsi sains sebagai menakutkan dan tidak menarik. Menggunakan reka bentuk kuasi-eksperimen dengan pendekatan kuantitatif, kajian ini melibatkan 30 pelajar Tingkatan Dua dari SMJK Shan Tao, dibahagikan kepada kumpulan eksperimen (PBL) dan kawalan (kaedah tradisional). Penilaian pra-ujian dan pasca-ujian, yang terdiri daripada 15 soalan pilihan berganda, dijalankan untuk menilai prestasi akademik. Analisis menggunakan ujian-t sampel bebas dalam SPSS versi 29.0 menunjukkan tiada perbezaan yang signifikan dalam skor pra-ujian antara

kumpulan (t(30)= -1.486, p>.05), tetapi peningkatan yang signifikan dalam kumpulan eksperimen pada pasca-ujian (t(30)= -6.570, p<.05). Penemuan ini mencadangkan bahawa PBL berkesan meningkatkan prestasi akademik dalam subtopik "Gizi Seimbang", menyokong integrasinya dalam pendidikan sains untuk mempromosikan pemikiran kritis dan keterlibatan. Penyelidikan lanjut perlu meneroka kesan jangka panjang PBL merentasi pelbagai subjek dengan saiz sampel yang lebih besar untuk aplikasi yang lebih meluas.

Kata Kunci: *Kaedah Pengajaran Tradisional, Pendidikan Sains, Pembelajaran Berasaskan Masalah, Prestasi Akademik, Gizi Seimbang*

INTRODUCTION

The educational landscape in Malaysia is rapidly evolving, demanding innovative teaching approaches to meet the challenges of the 21st century. Science education requires methods that not only impart factual knowledge but also foster students' enthusiasm, creativity, and problem-solving skills. The Malaysian science curriculum emphasises the development of these skills through experiential learning and inquiry-based approaches (DSKP, 2016). However, traditional teaching methods often fall short in achieving these goals, leading to a decline in students' interest and performance in science (Cimer, 2012; Ramasundrum & Sathasivam, 2022).

Problem-based learning (PBL) is a new educational philosophy and manifesto that can be implemented in both primary and secondary levels, fostering active student participation during the learning process (Zakaria et al., 2019). It emphasises on the engagement of students in solving real-world problems to develop critical thinking and problem-solving skills (Nasir & Hadijah, 2019; Trullàs et al., 2022; Wang, 2021). These problems are typically complex and open-ended, designed to capture students' interest and help them acquire subject matter knowledge (Chileya & Shumba, 2020). This is exceptionally different from traditional teaching methods, where knowledge transfer is typically one-way from teachers to students (Zakaria et al., 2019).

PBL is conceptually based upon the constructivist theories, which posits that learners construct knowledge through active engagement and interaction with their environment (Davis et al., 1990; Brooks & Brooks, 1993; Naylor & Keogh, 1999; Jenkins, 2000; Schmidt et al., 2011; Ültanır, 2012). Their specific applications in PBL include connecting new information with prior knowledge, elaborating and constructing the information learned, and engaging in collaborative learning. Students' learning is initiated by a need to solve an authentic problem (Zejnilagić-Hajrić et al., 2015). The 3C3R PBL Problem Design Model, introduced by Hung (2006), provides a structured approach to creating effective PBL problems, ensuring alignment with curriculum standards and fostering deep learning.

Hence, this study will focus on the effectiveness of PBL in teaching the "Balanced Diet" subtopic to Form Two students in Malaysia. While PBL has been widely researched and applied in various educational settings, including medical education, its application in Malaysian secondary schools, particularly in this specific subtopic, has not been empirically explored. By targeting a localised context within Kota Kinabalu, Sabah, this study provides valuable insights into the applicability and effectiveness of PBL in enhancing academic performance and fostering critical thinking skills among students.

This study highlights several key aspects of its importance. First, it addresses the need for innovative teaching methods in science education to improve students' academic performance and engagement. Second, it provides empirical evidence on the effectiveness of PBL in a specific and challenging subtopic, offering practical implications for science teachers. Third, it contributes to the broader understanding of how PBL can be adapted and implemented in different educational contexts, potentially influencing curriculum planning and policy-making.

Problem-Based Learning (PBL)

PBL is an educational approach where learning happens through engaging in the understanding and resolution of a problem (Barrows & Tamblyn, 1980). It was primarily developed from Barrow's model, which he created for medical students at McMaster University Medical School in the early 1970s. Barrows designed scenarios that allowed students to apply their prior knowledge and skills to solve real-world problems (Barrows, 1985). PBL aims to equip students with critical and analytical thinking skills, as well as the ability to find and use the most appropriate learning resources (Chileya & Shumba, 2020).

In PBL, students are given challenging problems and guided by teachers throughout her process. Working in small groups, they critically analyse the problem, explore solutions, and reflect on related content. This collaboration enhances their ability to search for information, access learning resources, and exchange ideas, thus actively engaging in the learning process and developing problem-solving skills (Aidoo et al., 2016).

Lim (2023) highlights the effectiveness of PBL in achieving learning outcomes through critical thinking and problem-solving. PBL benefits both teachers and students by fostering active learning and better classroom management. The collaborative aspect of PBL allows students to build knowledge through social interaction (Ahamad et al., 2017), with group composition playing a crucial role in influencing learning outcomes and motivation. Small group structures in PBL distribute cognitive tasks among members, enhancing problem-solving skills, higher-order thinking, and the construction of shared knowledge.

Additionally, PBL promotes an interdisciplinary approach (Delisle, 1997), requiring students to integrate reading, writing, research, analysis, and calculation across disciplines. This approach helps students see connections between subjects, understand their education as a cohesive whole, and apply knowledge from one field to another, enhancing their academic performance (Ahmad et al., 2023).

Several studies have shown the effectiveness of PBL in improving the students' academic performance. The study of Amiruddin et al. (2021) shown a significant difference in achievement levels favouring the PBL group, underscoring its effectiveness in enhancing learning outcomes in vocational education. Furthermore, Zabit et al. (2017) found a significant improvement in academic achievement among students exposed to PBL, demonstrating its benefits in fostering critical thinking and communication skills in economics education. Ramli et al. (2020) also emphasised that PBL enhances students' problem-solving abilities and overall academic performance in mathematics education.

PROBLEM STATEMENT

Traditional teaching methods in science education have significant limitations that hinder students' understanding and engagement (Cimer, 2012). These outdated pedagogies and lack of innovation contribute to declining student achievement in science (Ramasundrum & Sathasivam, 2022). Moreover, certain science topics, such as the "Balanced Diet" subtopic within the Form Two science syllabus, are particularly challenging, exacerbating students' difficulties in learning (Ogunkola & Samuel, 2011). Students often struggle with memorization and application of knowledge in these areas, highlighting the need for contemporary teaching approaches.

One such approach is PBL, known for its effectiveness in fostering problem-solving skills (Ogunsola et al., 2021). PBL serves as a teaching strategy to improve students' academic performance by encouraging learners to "learn how to learn" by collaboratively solving real-world problems (Chileya & Shumba, 2020). Students collaboratively determine what they know, what they learn, and how to acquire additional information to solve challenges (Koser, 2022). Several studies supported the practical use of PBL in school, as it helps to foster the critical thinking, communication skills, and problem-solving abilities, thereby enhance the overall performance (Zabit et al., 2017; Ramli et al., 2020;

Amiruddin et al., 2021).

RESEARCH OBJECTIVES

This study attempts to achieve the following objectives,

1. To identify the significant mean difference in the pre-test achievement of Form Two students in "Balanced Diet" subtopic based on the control and experimental groups.

2. To identify the significant mean difference in the post-test achievement of Form Two students in "Balanced Diet" subtopic based on the control and experimental groups.

METHODOLOGY

Research Design

The study adopted a quasi-experimental with pre-post-test design, involving two groups selected non-randomly. Each group was tested twice: one with a pre-test before the intervention and once with a post-test after the intervention, with both groups tested simultaneously. This approach allowed for a comparison of academic performance changes between the groups, attributing differences to the PBL intervention.

Population and Sample

The population for this study consisted of Form Two students in all the schools in Kota Kinabalu. The selection of SMJK Shan Tao was based on convenience sampling, as the researcher conducted a teaching practicum at this school, making it convenient to involve this school in the study. The selected school has five Form Two classes. The sample selection was also based on convenience sampling, specifically the classes taught by the researcher. This sample included 15 students from Class 2K (experimental group) and 15 students from Class 2B (control group), providing a total of 30 respondents for the study.

Instrument of the Study

In this study, the term "instrument" referred to the tool the researcher used to gather data from the sample, specifically pre-test and post-test. These tests were chosen because they aligned with the quasi-experimental research design. Both the pre-test and post-test consisted of 15 similar multiple-choice questions based on the learning objectives for the "Balanced Diet" subtopic, derived from the DSKP science Form Two curriculum. The 15 items were designed according to the Bloom's taxonomy cognitive domains: six at the remember level, three at the understand level, one at the apply level and five at the analyse level (Table 1). These tests were then administered to both the experimental and control groups to measure the students' improvement.

Table 1: Test Blueprint

Content Standard	Bloom's Taxonomy				Total Item	Marks (%)
	Remember	Understand	Apply	Analyse		
3.2 Importance of a balanced diet	1, 2, 9, 11, 12, 15	3, 4, 14	13	5, 6, 7, 8, 10	15	100
Total Item	6	3	1	5	15	
Marks (%)	40.00	20.00	6.67	33.33		100

Instrument Validity

The face validity and content validity were examined by an experienced and knowledgeable science teacher in SMJK Shan Tao, who served as the *Ketua Panitia Sains* at the school. The researcher requested the science teacher to analyse both face and content validity using the provided test blueprint. The results of the validity content determined whether each item was appropriately matched to the indicated content area and relevant to the specific learning outcomes in accordance with the Form Two Chapter Three science syllabus (subtopic 3.2 Importance of a balanced diet) as prescribed by the Ministry of Education.

Instrument Reliability

After implementing the pilot test, the reliability of the pre-test and post-test instruments were examined and analysed using the Cronbach's Alpha method through SPSS version 29.0. The findings of reliability analysis from Table 2 showed a Cronbach's Alpha value of 0.801, indicating very good and acceptable reliability for the 15 test items used in the study.

Table 2: Reliability Analysis of the 15 Test Items

Cronbach's Alpha	N of items
0.801	15

Data Analysis Procedures

Inferential statistics were used by the researcher to analyse the data collected, specifically through the independent-sample t-test, as the research aimed to compare the mean scores on the same variable (pre-test or post-test achievement) between two different groups (experimental and control group). All analyses were conducted using SPSS version 29.0 software.

RESULTS

Normality Data Analysis for Pre-Test and Post-Test in Control Group

The Shapiro-Wilk results for the normality tests of pre-test and post-test in control group were shown in Table 3. The significance values for the pre-test ($p = 0.247$) and post-test ($p = 0.789$) were greater than the specific significance value ($\propto = 0.05$). Therefore, the data distribution for both the pre-test and post-test in the control group were normal.

Table 3: Normality Tests of Pre-test and Post-test in Control Group by Shapiro-Wilk

Control Group	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-Test	0.927	15	0.247
Post-Test	0.966	15	0.789

Normality Data Analysis for Pre-test and Post-test in Experimental Group

The normality results for pre-test and post-test in experimental group by Shapiro-Wilk were shown in Table 4. It showed the significance values for the pre-test ($p = 0.734$) and post-test ($p = 0.706$) were greater than the specific significance value ($\propto = 0.05$). This indicated that the data distribution for both the pre-test and post-test in the experimental group were normal.

Table 4: Normality Tests of Pre-test and Post-test in Experimental Group by Shapiro-Wilk

Experimental Group	**Shapiro-Wilk**		
	Statistic	df	Sig.
Pre-Test	0.962	15	0.734
Post-Test	0.961	15	0.706

First Hypothesis Testing, H_{01}

According to Table 5, there is no significant mean difference ($t = -1.486,\ p > 0.05$) in the pre-test achievement of Form Two students in "Balanced Diet" subtopic between the control and experimental groups. Despite the experimental group students obtaining a higher mean value in the pre-test ($M = 6.33,\ SD = 1.877$) compared to the control group students ($M = 5.27,\ SD = 2.052$), the observed mean difference was not statistically significant. This suggested that both groups were equivalent in the pre-test.

Table 5: Independent-Sample T-Test for Pre-Test Achievement with Equal Variances Assumed

	Sample	**N**	**Mean**	**Std. Deviation**	**df**	**t-value**	**Sig.**
Pre-Test	Control Group	15	5.27	2.052	28	-1.486	0.149
	Experimental Group	15	6.33	1.877			

Second Hypothesis Testing, H_{02}

The analysis of independent-sample t-test with equal variances assumed (Table 6) showed that there is a significant mean difference ($t = -6.570,\ p < 0.05$) in the post-test achievement of Form Two students in the "Balanced Diet" subtopic between the control and experimental groups. The experimental group students had a significantly higher mean value in the post-test ($M = 12.13,\ SD = 1.727$) compared to the control group students ($M = 7.67,\ SD = 1.988$). Therefore, it can be concluded that the PBL was effective in improving the academic performance of students in the "Balanced Diet" subtopic.

Table 6: Independent-Sample T-Test for Post-Test Achievement with Equal Variances Assumed

	Sample	**N**	**Mean**	**Std. Deviation**	**df**	**t-value**	**Sig.**
Post-Test	Control Group	15	7.67	1.988	28	-6.570	<.001
	Experimental Group	15	12.13	1.727			

DISCUSSION

The analysis of the first null hypothesis indicated no significant difference in the pre-test achievement of Form Two students in the "Balanced Diet" subtopic between the control and experimental groups. This result aligned with previous study by Dorji (2021), which found no statistically significant difference in pre-test scores between control and experimental groups.

The lack of significant difference suggested that both groups had equivalent initial knowledge before the intervention (Aidoo et al., 2016). It also indicated a comparable understanding of fundamental "Balanced Diet" concepts prior to the intervention (Zejnilagić-Hajrić et al., 2015). Mitchell and Jolley (2013) emphasised that having the same average pre-test scores for both groups eliminated the threat of selection bias. This ensured fair comparisons and accurate conclusions from post-test results, as differences could be attributed to the treatment effects (Dimitrov & Rumrill, 2003).

Ronis (2001) highlighted that PBL, which involved learners actively constructing knowledge through real-world problems, aligned with constructivist theory. Constructivist learning theory posited that students learned by exploring and responding to probing questions, guiding their understanding and knowledge construction (Ssemugenyi, 2023).

In this context, the pre-test established students' prior knowledge, critical thinking skills, and problem-solving abilities. This was done by ensuring students have the same cognitive level through the pre-test conducted. By determining their lower-order cognitive skills before the intervention, teachers set a baseline to determine the impact of PBL on students' cognitive development (Ssemugenyi, 2023). This baseline helped track students' transition from foundational understanding to advanced, higher-order thinking skills as they engaged with PBL activities, allowing for a fair assessment of the intervention's effectiveness during immediate and delayed post-test evaluations.

This aligned with the cognitive theory by Jean Piaget, which highlighted that learning occurs because of the integration of new experiences with prior knowledge and newly acquired knowledge with previous experiences (Khan et al., 2023). The impact of prior knowledge on learning was a significance concern for teachers. Variations in students' existing knowledge base were a key factor contributing to differences in academic performance (Hailikari et al., 2007).

The results of the second null hypothesis showed a significant mean difference in the post-test achievement of Form Two students in the "Balanced Diet" subtopic between the control and experimental groups. This indicated that students exposed to the PBL approach performed better than those taught using traditional teaching method. This finding supported Aidoo et al. (2016), who reported that PBL enhanced science education by fostering critical thinking, process skills, and a positive attitude towards learning. PBL created a student-centered environment where learners actively discovered their strengths and weaknesses, making learning more relevant and engaging.

Similarly, Agbidye et al. (2019) found that Upper Basic II students in Makurdi, Nigeria, taught using PBL outperformed those taught through traditional lecture methods in Basic Science. The study attributed this to PBL's role in engaging students with hands-on experiences, fostering inquiry, and encouraging collaborative discovery, which improved understanding and retention. Both studies highlighted PBL's effectiveness in enhancing academic performance and making science education more interactive and meaningful.

Integrating critical thinking skills within the PBL framework further enhanced students' learning outcomes. Yau et al. (2023) highlighted that critical thinking improved cognitive abilities, fostered creativity, and strengthened problem-solving skills, making students better learners. This involved improving their learning effectiveness and being more analytical, logical, and organised. Additionally, Nur'azizah et al. (2021) found that students equipped with critical thinking skills could provide clear explanations, build foundational skills, draw conclusions, and make well-informed decisions.

Muhibbuddin et al. (2023) emphasised that improving critical thinking in science could be achieved through the habituation of asking and answering questions based on Higher Order Thinking Skills (HOTS). HOTS encouraged students to apply, analyse, synthesise, and evaluate information rather than merely recalling facts, thus promoting deeper understanding and problem-solving capabilities. When students were consistently tested with HOTS-based problems, they gained a deeper conceptual understanding and better retention of the material. Increased mastery of critical thinking directly enhanced analytical skills, helping students mapped out problems and necessary information to solve them, and improved their ability to draw accurate conclusions. Therefore, integrating HOTS and critical thinking within the PBL framework strengthened its effectiveness, promoting deep, meaningful learning and enhancing students' problem-solving skills, as evidenced by various studies.

Teo (2006) emphasised that PBL draws students into the learning process through engaging problems that create tension and drive exploration for solutions. This approach deepens engagement as students

tackle real-world issues, connecting their learning to practical contexts outside the classroom. This relevance enhances their openness to new concepts and ideas, thereby increasing motivation to learn. Similarly, Moreira-Morales & García-Loor (2024) underscored that motivation significantly influences students' metacognitive regulation and academic performance by fostering a positive attitude towards learning and active participation, ultimately leading to substantial learning outcomes.

Teo (2006) also highlighted that in PBL, learners actively construct knowledge by integrating new information and modifying their understanding based on the new data. This outlined how PBL aligned with Piaget's theory of cognitive constructivism. The study of Sharma & Shukla (2023) highlighted that cognitive constructivism was based on the belief that individuals actively built their own knowledge and understanding of the world through their experiences, interactions, and reflections. Likewise, Akpan et al. (2020) idea that when encountering new information, individuals reconcile it with their existing knowledge, leading to active knowledge construction through questioning, exploring, and assessing.
This aligned with the study of Nurbavliyev et al. (2022), which stated that active learning was drawn from constructivist theory, emphasising that learners built their own understanding through active engagement rather than simply receiving information passively. This was because active learning techniques engaged students in both practical and cognitive activities. Moreover, Rahman et al. (2022) highlighted that active learning had the potential to optimise a student's abilities, enabling all students to achieve meaningful and satisfactory academic outcomes. This was supported by the study of Aykan and Dursun (2022), which demonstrated that active learning techniques enhanced students' academic performance and retention of material in the science course.

In short, based on this study, along with the supporting literature, underscored the effectiveness of PBL in enhancing students' academic performance, critical thinking skills, and engagement in learning. By creating a student-centred environment that promoted active learning and critical thinking, PBL not only improved academic outcomes but also fostered a deeper, more meaningful understanding of the subject matter.

IMPLICATION OF THE STUDY

Teachers

The findings of this study have significant implications for teaching strategies. PBL allows teachers to move beyond traditional teaching methods, which often limit student engagement and critical thinking. Instead, PBL fosters an environment where they are actively involved in problem-solving and inquiry, leading to a more comprehensive understanding of complex subjects like "Balanced Diet".

PBL transforms the teacher's role from the sole source of knowledge to a facilitator of learning. Teachers guide students through collaborative inquiries and real-world problem-solving tasks, which can significantly enhance students' critical thinking and problem-solving abilities. This approach makes learning more relevant and engaging, encouraging exploration and discovery.

Adopting PBL also teachers to innovate and experiment with new teaching strategies, contributing to their professional growth. They can develop skills in facilitating student-centred learning, managing collaborative projects, and integrating real-world problem-solving into the curriculum, staying current with educational best practices.

Students

The study's findings have profound implications for students. PBL encourages them to take ownership of their learning, transforming them from passive recipients to active participants. This active engagement fosters responsibility and autonomy in their educational pursuits and promotes independent learning habits.

PBL requires students to engage in critical analysis, evaluate multiple solutions, and make informed decisions. This process develops critical thinking skills, enabling students to approach complex problems with confidence. The real-world scenarios in PBL make learning more relevant and enhance knowledge retention and application.

Moreover, the collaborative nature of PBL enhances social and communication skills. Working in teams, students articulate ideas, listen to diverse viewpoints, and negotiate consensus, which are essential skills for both academic and professional success. PBL fosters effective teamwork and leadership abilities, and provides experience in managing group dynamics and resolving conflict.

CONCLUSION

This research demonstrated that PBL effectively enhances Form Two students' academic performance in the "Balanced Diet" subtopic. Unlike traditional teaching methods, PBL encourages active engagement in the learning process, and fosters critical thinking, problem-solving skills, social and communication skills, and deeper subject understanding. The findings also suggested that implementing PBL in secondary school science curriculum can address some of the challenges associated with traditional teaching methods. By promoting student-centred learning and collaborative problem-solving, PBL not only improves academic performance but also prepares students with essential 21st century skills.

Further research is recommended to explore the long-term effects of PBL on students' academic performance across different subjects and educational levels. Investigating the impact of PBL on diverse student populations and in various educational contexts can provide a more comprehensive understanding of its effectiveness and inform broader curriculum reforms. Overall, this study underscores the importance of innovative teaching methods like PBL in enhancing the quality of education and equipping students with the skills needed for future success.

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