Effectiveness of the Implementation of an Innovative Problem-Based Learning (PBL) Model Based on TPACK to Enhance Student Engagement and Learning Outcomes in IPAS

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Abstract: This study aims to analyze the effectiveness of implementing an innovative Problem-Based Learning (PBL) model based on Technological Pedagogical and Content Knowledge (TPACK)—a model never used before—in an effort to increase both student engagement and learning outcomes in Natural and Social Sciences (IPAS) among fourth-grade students at SD Negeri Sentang. The study was conducted in the fourth-grade class of SD Negeri Sentang during the 2024/2025 academic year and employed a classroom action research (PTK) design. The population and sample consisted of 12 fourth-grade students (6 boys and 6 girls). The research instruments included observation sheets, field notes, and a test result assessment format for cognitive learning outcomes. Both quantitative and qualitative data were collected through observations, interviews, and documentation. Quantitative analysis was used to evaluate observation and test results, while qualitative analysis was employed to assess student interview data. This study was conducted as an effort to create a technology-integrated learning environment that enhances engagement—focusing on 21st-century skills (communicative, collaborative, critical thinking, collaboration)—and improves student learning outcomes. The findings indicate that the innovative PBL model based on TPACK significantly improved student engagement and learning outcomes, as evidenced by observations, interviews, and test results. The study recommends adopting the innovative PBL model that leverages technology to achieve better educational outcomes.

Keywords: IPAS; PBL; TPACK

Introduction

The 21st century is an era of global transformation. Globalization demands a progressive acceleration in the paradigm of education with the goal of improving its quality so that it can compete on a global scale and the ability to build, develop, and apply high-level thinking, problem-solving, and collaborative skills (Bashori, 2017; Maulana, 2021). In reality, education in Indonesia has not fully met public expectations (Azan et al., 2021; Fernandes et al., 2020). This phenomenon is marked by the low quality of graduates. From this, we can conclude that education in Indonesia still faces gaps that need to be addressed in order to enhance the quality of students who are competitive both regionally and globally (Azan et al., 2021; Pradiani et al., 2023). Therefore, education must function in accordance with its established goals.

Education itself is a process that involves teaching and learning to acquire and develop knowledge, skills, attitudes, and values in individuals. It holds a strategic position in the life and progress of humanity (Dacholfany, 2015; Ulfa et al., 2020; Yanti et al., 2022). Thus, education needs to design and create learning experiences that are innovative, challenging, engaging,

substantial, adaptive to the times, and in harmony with local wisdom (Ariani et al., 2022; Purwati et al., 2023). In this era of Industry 5.0, continuous educational innovations must be carried out to meet curriculum demands.

A curriculum is a set of plans and regulations used by schools or educational institutions to structure the teaching and learning process. It includes educational objectives, learning content, teaching methods or models, as well as the assessment of learning outcomes. The curriculum reflects the values, needs, and expectations of society towards education (Friska et al., 2023; Jeti et al., 2022; Mulder et al., 2019; Robinson et al., 2020). Curriculum reform is an inevitability that must be pursued so that the field of education can continue to exist and keep pace with the rapidly changing times (Chimbi et al., 2021; Damanhuri et al., 2013; de Paor, 2021; Suryadi et al., 2024). The current reform, shifting from the 2013 curriculum to the Merdeka curriculum, is an effort by the government to realize education that aligns with contemporary demands.

The design of the learning plan is expected not only to involve the selection of models, approaches, strategies, and innovative teaching methods that suit the needs of the students, but also to be integrated and complemented with relevant technology to support learning. With the continuous acceleration of change, technology plays a crucial role in balancing this pace. Research by Kusumaningtyas et al. (2020) shows that the selection of a problem-based learning (PBL) model, when combined with appropriate technology-based media, can greatly enhance the effectiveness of learning and provide more meaningful experiences for students. New technologies, particularly in the field of ICT, are playing an increasingly important role in education.

Based on observations conducted with the students of SD Negeri Sentang in the IPAS subject in January 2024, it was found that their levels of engagement and learning outcomes were not optimal. The following shows the range of engagement and learning outcomes for the fourth-grade students. The lack of student engagement was apparent during the learning process. This was caused by the learning model used which served as the framework for instruction not being aligned with the teaching methods applied. This is evidenced by the large number of students whose scores did not reach the Minimum Passing Criteria for the learning objectives (KKTP), which is 68.

Problem-based learning is an instructional model that assists students in identifying problems arising from real-life events, gathering information through self-determined strategies, and making decisions on problem resolution, which are then presented in the form of a performance demonstration. Integrating technology into this process can greatly help students explore a wider range of resources, enjoy a more engaging learning experience, become more technologically literate, and foster more meaningful collaboration, creativity, critical thinking, and communication.

Therefore, this study aims to analyze the implementation of a Problem-Based Learning model by integrating Technological Pedagogical and Content Knowledge (TPACK) to enhance both engagement and learning outcomes in IPAS (Natural and Social Sciences) among fourth-grade students at SD Negeri Sentang.

Method

This study was conducted in the fourth-grade class of SD Negeri Sentang during the 2024/2025 academic year. The research was carried out in stages, from the first cycle to the second cycle, after which improvements in outcomes were observed according to predetermined targets. Each cycle was divided into two meetings, followed by evaluations to measure the improvement in students' achievement of the minimum learning mastery. At the end of each cycle, reflection activities and planning for subsequent actions were conducted.

The study focused on assessing both the engagement levels and learning outcomes in the subject of Natural and Social Sciences. Student engagement was the primary focus of this research, as active learning is key to achieving optimal learning outcomes. Classroom action research aims to improve the quality of educational and instructional management in schools, enhance the professionalism and skills of educators and educational staff, promote professional collaboration among them, and ultimately improve the quality of classroom instructional practices.

The design of this classroom action research follows the model developed by Kemmis et al. (2014), which consists of four main components: planning, implementation, observation, and reflection.

In this study, the population and sample consisted of the fourth-grade students of SDN Sentang during the 2024/2025 academic year, totaling 12 students: 6 boys and 6 girls. The research instruments used were observation sheets, field notes, and a cognitive learning outcome test assessment format. In this action research, both quantitative and qualitative data were collected. Observations were conducted to gather data by monitoring ongoing activities and everything that occurred during the learning process. Field notes were maintained throughout the learning process to record what transpired during the implementation of this culturally responsive teaching approach, serving as qualitative data. Quantitative data in the form of

numerical scores obtained from evaluations after the instructional sessions, were analyzed using descriptive percentage techniques. Scores were analyzed based on student achievement, including the highest score, lowest score, total score, class average, and mastery level. The types of data used in this study included observations of the learning process, questionnaires, interview sheets, pre-test and post-test sheets, and photographs of learning activities.

The data collection techniques employed by the researcher were in line with the predetermined instruments, namely observation, interviews, and documentation. The data obtained in this study pertained to the implementation of the action—specifically, the process of applying a problem-based learning model based on TPACK to enhance engagement and learning outcomes in IPAS among fourth-grade students.

Table 1. Data Analysis Formula

Mastery Level (%)	Learning Outcome Category
0-34	Very low
35-54	Low
55-64	Medium
65-75	High
76-100	Very high

The data analysis techniques used involved both quantitative and qualitative approaches. Quantitative analysis was applied to evaluate the observation results and test outcomes, while qualitative analysis was used to assess the results of student interviews. The steps in qualitative data analysis included data reduction, data presentation, and drawing conclusions. For quantitative analysis, the average student engagement and average learning outcomes for each cycle were calculated. To determine the success of the classroom action research, the researcher established performance indicators: students scoring above the Minimum Mastery Criterion must reach ≥80%, with the IPAS Learning Objective Mastery Criterion for fourth grade being 69. Table 1 presents the data analysis formula.

Result and Discussion

Classroom action research using a Problem-Based Learning (PBL) model based on TPACK overall had a positive impact on increasing both engagement and learning outcomes in IPAS among fourth-grade students at SDN Sentang, as evidenced by data obtained from Cycle I through Cycle II. After implementing the intervention for two cycles, the research objectives—both process and outcome—were achieved. The presentation of process results consisted of three components: student activity, their learning outcomes, and interview results. Data collected during the teaching and learning process included observations of student activities, mastery of learning outcomes, and student interview results. The observed engagement, cognitive learning outcomes, and interview data were required to meet the predetermined targets following the intervention.

Below is a table showing the complete observation data from the classroom action research conducted from the pre-cycle through Cycle 3.

Table 2. Pre-Cycle Learning Engagement Observation Results for IPAS in Grade IV

Cycle	Average and Percentage of Observation Criteria			
	Communicative	Collaborative	Creative	Critical Thinking
Pre-cycle	2.6/65%	2.4/60%	2.7/ 67.5%	2.2/55%
Cycle 1	2.8/70%	2.7/67.5%	2.9/72.5%	2.6/65%
Cycle 2	3.4/85%	3.5/87.5%	3.5/87.5%	3.4/85%
Cycle 3	3.9/97.5%	3.9/87.5%	4/100%	3.8/95%

As observed in the table, student engagement increased across various criteria. In Cycle 1, the improvement was not very pronounced—especially in the area of critical thinking—because the students were not yet accustomed to the TPACK-based problem-based learning model. Engagement became significantly more apparent in Cycles 2 and 3. Students became increasingly active in communicating both within their groups and between groups. Collaborative behaviors among students began to emerge in the PBL process, both in exploring material from various sources and in collaborating to develop a product or solve problems. The creative aspect also saw a significant increase.

In Cycles 1 and 2, students started to appreciate a form of enjoyable creativity aligned with their interests. The completion of products and problem-solving tasks that resonated with their interests provided great motivation for limitless creativity while still remaining aligned with the learning objectives. Similarly, in terms of critical thinking, the high level of creativity in both product development and problem-solving stimulated the students' critical thinking, collaboration, and communication. Thus, the integration of these four aspects of engagement resulted in a learning process that was both enjoyable and meaningful, and it had a significant impact on learning outcomes.

Below is a table presenting the complete data on student learning outcomes from the pre-cycle through Cycle 3.

Table 3. IPAS Learning Outcomes for Grade IV

Action	Number and percentage of student learning outcomes	
	Completed	Not completed
Pre-Cycle	2 students /20%	10 students /83%
Cycle 1	5 students/ 41.6%	7 students/ 58%
Cycle 2	9 students/75%	3 students/25%
Cycle 3	11 students / 91.6%	1 student

Based on the students' learning outcomes obtained from the class action research tests, at the pre-test stage (pre-cycle) only 2 students (20%) out of a total of 12 achieved mastery. However, after the treatment was applied over 3 cycles, in cycle 3 the result was that 11 students (91.6%) obtained scores in the mastery category. This meets the predetermined mastery criterion of 80%. This is also evidenced by the diagram in cycle 3.
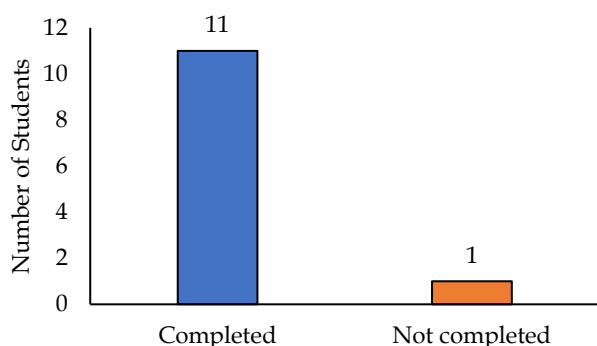

Figure 1. Learning outcomes in cycle 3

The learning outcomes further demonstrated that the percentage of students achieving mastery reached 12%, while those not achieving mastery amounted to only 1%. It is therefore concluded that the implementation of the innovative Problem Based Learning (PBL) model based on TPACK is effective in enhancing both student engagement and learning outcomes in science.

Interview results with several students revealed that when the PBL model based on TPACK was first implemented, students encountered a new experience; however, since they were not yet accustomed to it, their responses were relatively slow during the process, and the expected results were not achieved with only a few students being active and obtaining good test results. However, after several implementations, students became more familiar with the PBL model based on TPACK. As a result, during the learning process they became increasingly active in communicating both within their groups and with other groups, were able to collaborate in exploring and solving tasks and problems, expressed creativity in producing work and problem solving according to their interests, and, importantly, their critical thinking skills improved significantly. Such a learning process certainly provided meaningful learning experiences for the students and had a significant impact on their learning outcomes.

This research builds on previous studies—namely, the study by Ayunda et al. (2022) on the effect of the PBL model based on TPACK on enhancing students' higher-order thinking skills; a study by Ichsan et al. (2022) on the effect of the PBL model based on TPACK on science literacy skills in science learning for students from elementary to high school levels; and another study by Pratidina et al. (2023) on problem based learning (PBL) with the TPACK framework regarding high school students' mathematical problem-solving abilities.

This study can serve as a benchmark for using the PBL model based on TPACK to enhance student engagement and learning outcomes. The implications of this research can be recommended to teachers for implementation in learning processes that are not only context-based but also incorporate technology in line with contemporary demands. The PBL model based on TPACK prioritizes students' ability to think critically in solving problems by collaborating and communicating with both their own group members and members of other groups, thereby having an extraordinary impact on their creativity.

Conclusion

21st-century education faces the challenge of globalization, which demands quality improvements in order to compete internationally. In Indonesia, the education system still grapples with quality disparities, such as low levels of student engagement and learning outcomes. The curriculum needs to be updated and aligned with modern developments and technology. This study examines the implementation of the Problem Based Learning (PBL) model combined with Technological Pedagogical and Content Knowledge (TPACK) to enhance engagement and learning outcomes among fourth-grade students at SDN Sentang. The research results show that the TPACK-based PBL model is effective in improving student engagement and learning outcomes, as evidenced by increased scores and active student involvement throughout the learning cycles. The study suggests that applying the Problem Based Learning model can serve as an innovative strategy in the educational process to enhance the quality of education. Based on the collected data, it is evident that student engagement improved in various

aspects after the implementation of the TPACK-based Problem Based Learning model. In the first cycle, the increase in engagement was not very apparent, especially in terms of critical thinking. This was due to the students' unfamiliarity with a learning model that demands deeper thought and active problem solving. However, in the second and third cycles, student engagement increased significantly. They became more active in communicating, both within their groups and with other groups, and demonstrated progressively better collaboration in every stage of the learning process. Their ability to explore material from various sources and to collaborate in producing work or solving problems also grew. The learning outcomes obtained from the class action research tests showed a clear improvement. At the pre-cycle stage, only 2 out of 12 students (20%) achieved mastery. After the intervention over three cycles, there was a significant improvement, with 11 students (91.6%) reaching mastery in the third cycle. This increase meets the minimal mastery criterion of 80%. The data is further supported by a diagram of the learning outcomes in the third cycle, which shows a more optimal achievement compared to previous cycles. Thus, it can be concluded that the implementation of the TPACK-based Problem Based Learning model has a positive impact on both the engagement and learning outcomes of fourth-grade students in the science subject (IPAS).

Conflicts of Interest
The authors declare that there is no conflict of interest in the publication of this article.

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