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TPACK Based Differentiated Problem Posing to Enhance Entrepreneurial Digital Problem Solving

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ABSTRACT

This **study aims** to determine the effect of TPACK-based differentiated learning on high school students' problem-solving abilities and motivation. The study, **conducted** at Private Senior High School PAB 8 Saentis Sei Tuan, used a **quasi-experiment** method with two classes: the experimental class, which used the differentiated problem solving model based on TPACK, and the control class, which used the conventional school learning model without differentiation. The **results** of this study indicate that the average post-test score for student problem-solving abilities in the experimental class was higher than in the control class. Statistical testing using two-way ANOVA showed that the problem-solving skills of students taught with the TPACK-based differentiated learning model demonstrated a significant influence between the learning model and motivation on students' problem-solving skills, as well as an interaction between the TPACK based problem posing learning model and motivation in terms of problem-solving skills. These **findings** have practical implications for educators, providing evidence that the TPACK-based differentiated problem-posing learning model is more effective in improving students' problem solving abilities than the conventional learning model, with learning motivation also playing an essential role in enhancing student problem-solving skills.

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1. INTRODUCTION

The advancement of technology in the twenty first century requires educators to integrate Technological Pedagogical and Content Knowledge (TPACK) into the learning process to improve instruction effectiveness and student engagement [1]. This study integrates TPACK with differentiated instruction and problem-posing approaches to strengthen student problem-solving abilities and learning motivation, particularly in the context of physics education [2]. The approach aligns with global educational goals by encouraging Student Centered Learning that promotes analytical thinking and active participation [3]. Furthermore, this research directly supports Sustainable Development Goal 4, Quality Education, particularly the target that enhances relevant skills for youth, including technical, problem solving, and digital skills that are essential for future learning and workforce readiness [4]. Problem solving is a crucial twenty first century skill that requires students to analyze, reason, and apply concepts to realworld contexts [5]. However, observations at the studied school indicate that student achievement in problem solving remains low because conventional teaching methods do not optimally engage learners or integrate modern digital tools. The integration of TPACK based differentiated problem posing aims to address this challenge by encouraging active learning and supporting deeper conceptual understanding [6].

In addition to supporting Sustainable Development Goal 4, the integration of technology and innovative pedagogical strategies in this study also contributes to Sustainable Development Goal 9, Industry, Innovation, and Infrastructure, by promoting technological enhancement within the learning environment. By introducing innovative instructional models, this research reinforces the importance of digital readiness and technological competence as essential components of modern education. Moreover, by strengthening student entrepreneurial oriented problem solving abilities, this study aligns with Sustainable Development Goal 8 Decent Work and Economic Growth, which emphasizes the development of productive skills, creativity, and innovation to prepare learners for the rapidly growing digital economy.

The study aims to explore the effectiveness of TPACK based differentiated problem posing in improving student problem-solving abilities and motivation when compared to conventional learning approaches. The findings are expected to provide educators and institutions with insights into how technology enhanced, student centred learning models can improve learning outcomes while simultaneously supporting broader sustainable development goals.

The TPACK framework integrates three key components in education [7]. Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). TPACK shows how these three elements interact to create a more effective learning experience, taking into account the teaching context. In the diagram, you can see how Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Content Knowledge (TCK) intersect, with TPACK at the center of all these interactions [8]. Using TPACK, educators can better incorporate technology into teaching to enhance student learning and motivation [9].

2. LITERATURE REVIEW

2.1. Problem Posing Learning Model

The problem posing model, introduced by Paulo Freire, is a learning model that involves students formulating their own questions to deepen their understanding [10]. The key idea is to encourage active participation by asking students to create new problems, thereby making the learning process more engaging and motivating. This model has been proven to improve critical thinking skills and student participation in learning [11]. Students develop problem solving skills by organizing and solving the questions they create, which facilitates conceptual understanding [12, 13].

2.2. Differentiated Learning

Differentiated learning is an educational approach that adapts instruction to address the unique needs, interests, and readiness levels of students [14]. Using personalized support, differentiated learning aims to foster an inclusive learning environment that motivates active participation from all students. This model ensures that each learner receives the support they need, which enhances learning outcomes [15]. Key components of differentiated learning include setting clear objectives, conducting continuous assessments to monitor progress, and implementing effective classroom management strategies to meet diverse student needs [16].

In differentiated learning, students are not treated as a homogeneous group. Instead, their individual learning preferences and needs are considered when designing lessons and activities [17]. This approach encourages flexibility in teaching, allowing educators to modify content, processes, or learning environments to provide optimal learning opportunities [18, 19].

2.3. Technological Pedagogical Content Knowledge (TPACK)

TPACK is a framework that integrates three essential components: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). By combining these areas, TPACK provides a comprehensive model for educators to effectively integrate technology into the learning process [20]. This framework helps educators enhance their teaching practices by enabling them to choose the most appropriate technology tools to support pedagogical methods and content [21]. As technology continues to shape education, TPACK remains critical in ensuring that teachers can adapt to modern teaching methods, which are vital for engaging students in the 21st-century classroom [22, 23].

It emphasizes the importance of integrating these three components to create effective learning experiences in the 21st-century classroom [24]. Pedagogy focuses on teaching strategies, the application of differentiatThe relationship between pedagogy, content, and 21st-century technology in the context of teaching and learning [25]. 21st Century Technology includes using technology to enhance content exploration and provide greater support for student learning [5, 26]. The diagram also highlights how mastery of modern learning theories and the use of technology can improve classroom teaching quality, stressing that technology should be used wisely to support meaningful learning [27, 28].

2.4. Motivation to Learn

Learning motivation plays a fundamental role in influencing how students engage with academic tasks and pursue their educational goals. Motivated students are more likely to actively participate, overcome challenges, and persist through difficult tasks. Motivation is a psychological force that drives students to achieve success by helping them focus their efforts on learning objectives. In the context of education, motivation enhances students' ability to concentrate on tasks, apply their knowledge, and develop the skills necessary for academic achievement. A motivating learning environment encourages students to take ownership of their learning, fostering greater academic success [29, 30].

2.5. Problem Solving Ability

In the article, problem-solving ability is a core dependent variable assessed to understand the effectiveness of the TPACK-based differentiated problem-posing learning model [31]. This variable is structured around several dimensions of cognitive skills essential in understanding and solving complex problems, particularly in physics (the subject context of this study). Here is a breakdown of the development, theoretical foundation, measurement, and relevance of problem-solving as a variable in this study:

2.5.1. Definition and Conceptual Foundation of Problem-Solving Ability

This study defines problem-solving ability as the cognitive process by which students identify, analyze, and resolve complex issues through a structured approach. This ability is particularly important in science education, where students must apply theoretical knowledge to practical situations. As in other subjects, the problem-solving process in physics requires critical thinking, analytical reasoning, and logical sequencing of steps to arrive at a solution [32, 33]. The theoretical foundation for problem-solving in education aligns with Polya Problem Solving Model, which outlines four key steps for effective problem resolution:

- **Understanding the Problem**

  Recognizing and interpreting the problem, identifying key variables, and comprehending the given information.

- **Planning the Solution**

  Stratify the approach, select relevant concepts, and determine the formulas or methods to use.

- **Executing the Solution Plan**

  Implementing the chosen strategies, calculations, and steps to solve the problem.

- **Reviewing the Solution**

  Evaluating the solution's accuracy and logic, checking for errors, and reflecting on the process to understand it better.

This model emphasizes that problem solving is more than just finding an answer; it involves engaging with the problem more deeply, analyzing it, and validating the solution. The study uses this model to structure the assessments, focusing on the ability of the students to independently perform each step.

2.5.2. Importance of Problem-Solving Ability in the 21st-Century Learning Context

Problem solving skills are increasingly vital in 21st-century education, especially in STEM (Science, Technology, Engineering, and Mathematics) disciplines. As students encounter a world filled with complex issues, their ability to analyze, think critically, and devise solutions becomes essential [34, 35]. Physics, as taught in this study, involves problem-based learning where students' ability to apply theoretical knowledge makes problem-solving a critical skill.

- Apply scientific concepts (like heat and temperature) to analyze real-world phenomena.
- Develop systematic approaches for experimentation and calculation.
- Build a foundation for further scientific inquiry, where students can independently conduct experiments, analyze data, and draw conclusions.

The study emphasis on problem-solving ability aligns with educational frameworks such as Bloom's Taxonomy, which places problem-solving in higher-order cognitive processes that involve application, analysis, synthesis, and evaluation. The TPACK based learning model aims to shift students from rote memorization to meaningful, applied understanding by focusing on these higher-order skills [36].

2.5.3. Measurement of Problem-Solving Ability in the Study

In this study, problem-solving ability is quantitatively assessed through pretests and posttests, where student complete physics problems that reflect real-life applications of heat and temperature concepts. The assessment is broken down into the four stages defined by Polya's model, ensuring a comprehensive evaluation of student skills [37, 38]. The test items were validated to meet standard reliability and validity criteria, making them an appropriate tool for measuring changes in students' problem-solving abilities across the experimental (TPACK-based differentiated problem-posing model) and control (conventional model) groups. The pretest establishes baseline problem-solving capabilities, while the post-test, conducted after implementing the learning model, assesses progress and improvement in skills [39, 40]. Each aspect of problem-solving (understanding, planning, executing, and reviewing) is scored, and an overall score is calculated. Improvement is measured by comparing pretest and post-test scores, where a higher post-test score indicates enhanced problem-solving ability due to the learning intervention [41].

2.5.4. Indicators of Problem-Solving Ability and Their Relevance to Learning Outcomes

The indicators for measuring problem-solving ability are directly tied to the four stages of problem-solving and provide a comprehensive view of students' cognitive processes in physics. Improvement is measured by comparing pretest and post-test scores, where a higher post-test score indicates enhanced problem-solving ability due to the learning intervention [41].

This indicates the students' capacity to comprehend complex questions and identify relevant concepts. It reflects students' foundational knowledge and their ability to contextualize problems in physics.

- Planning the Solution: Shows student physics problems, an essential skill for developing systematic approaches to problem-solving.
- Executing the Solution Plan: This demonstrates students' practical skills, such as calculation, logical reasoning, and data manipulation.
- Reviewing the Solution: This activity reflects students' critical thinking and self-assessment skills necessary for validating answers and considering alternative approaches.

The study uses these indicators to determine whether the TPACK based model effectively supports each phase of the problem-solving process, especially compared to the conventional model [42, 43].

2.6. Hypothesis Development

In the study you provided, three hypotheses were developed to examine the effects of the TPACK based differentiated problem-posing model on high school student problem solving abilities and motivation. Let us delve into each hypothesis and the theoretical foundation behind them:

2.6.1. Hypothesis 1: The Effect of Learning Model on Problem-Solving Ability

There is a difference in problem-solving abilities between students taught using the TPACK-based differentiated problem-posing learning model and those taught using the conventional learning model [44]. This hypothesis assumes that integrating a TPACK-based (Technological, Pedagogical, and Content Knowledge) framework with a differentiated, problem-posing approach will result in superior outcomes for problem-solving skills compared to a traditional, non-differentiated model [45]. The TPACK framework emphasizes the use of technology as a tool to support pedagogy and subject content. By embedding problem-posing in this structure, students engage with the material more interactively, actively creating questions or problems that lead to deeper understanding. The theory here draws from the cognitive load theory, which suggests that learning environments structured around active engagement (such as problem-posing) reduce extraneous cognitive load, leading to improved learning outcomes [46, 47]. Problem-posing aligns with constructivist learning theory, which states that learners construct knowledge through active engagement rather than passive receipt.

2.6.2. Hypothesis 2: The Effect of Motivation on Problem-Solving Ability

There is a difference in problem solving abilities between students with high and low learning motivation. This hypothesis explores how intrinsic motivation influences problem-solving outcomes, suggesting that students with high motivation demonstrate more vital problem-solving abilities. Motivation is a well-established factor in educational psychology, where intrinsic motivation (driven by internal rewards, such as interest or enjoyment) is linked to higher engagement and perseverance in learning tasks [48]. Here, the hypothesis builds on the expectancy-value theory of motivation, which posits that student performance and effort are influenced by their expectations for success and the value they place on a task. This study measures motivation through indicators such as attention, relevance, confidence, and satisfaction, the ARCS (Attention, Relevance, Confidence, Satisfaction) Model of Motivation. The model asserts that each component supports engagement and persistence in learning, which, in turn, bolsters students' problem-solving skills. The hypothesis predicts that students with higher motivation will perform better in problem-solving tasks because they are more likely to engage fully, approach problems creatively, and persist through challenges.

2.6.3. Hypothesis 3: Interaction Between Learning Model and Motivation on Problem-Solving Ability

The TPACK-based differentiated problem-posing learning model interacts with students' motivation to affect problem-solving ability. The third hypothesis considers the combined effect of the learning model and motivation on students' problem-solving abilities, proposing that the interaction between these factors will further enhance learning outcomes. This hypothesis is rooted in the understanding that instructional design and motivation can synergistically influence cognitive engagement and performance. When instructional models align with students' motivational states, they amplify their willingness to participate and actively invest effort into problem-solving tasks.

3. RESEARCH METHOD

This research was conducted at Private Senior High School PAB 8 Saentis Sei Tuan, Kali Serayu Street, Hamlet 16, Saentis, Percut Sei Tuan District, Deli Serdang Regency. The research was conducted in the even semester of the 2023/2024 academic year. The sample of this research consisted of two classes, namely 30 students in class XI-1 as an experimental class that was taught using the TPACK-based problem posing differentiation learning model and 30 students in class XI-2 as a control class that was taught conventionally.

In this study, student problem-solving ability and learning motivation in physics were measured. The test was a written essay test consisting of 5 questions using skill indicators according to Polya and has been declared valid and reliable. The student learning motivation questionnaire consists of 20 statements based on four learning motivation indicators:

- Attention.
- Relevance.
- Confidence.
- Satisfaction.

The physics problem-solving ability test was given at the beginning and end of learning, while the motivation questionnaire was given at the beginning of learning. The material chosen in this study was temperature and heat. The data collection technique for learning motivation was carried out by distributing questionnaires. The scale form used in the study was a Likert scale with five alternative answers consisting of SS (Strongly Agree), S (Agree), RR (Undecided), TS (Disagree), and STS (Strongly Disagree). After getting the motivation score results, the value was categorized into high and low, as shown in the Table below:

Its dependent variable (Y) is students' problem-solving ability on the primary material of temperature and heat. In contrast, the moderator variable is students' learning motivation. Data analysis in this study used two-way ANOVA.

Table 1. Type sizes for final papers

Interval	Category
$X > \bar{X}$	High
$X < \bar{X}$	Low

Table 1 in this study the independent variable (X) uses TPACK-based differentiation problem-posing and conventional learning models. Before the data was analyzed, a data prerequisite test was carried out to determine normality and homogeneity. A two-way Analysis of Variance test was continued after the data was declared regular and homogeneous.

The categorization of students' motivation into the high and low groups enabled the researchers to analyze the interaction effect between motivation levels and learning treatment more precisely. This categorization is essential because motivation is often considered a psychological factor that can werw or weaken students' engagement in understanding complex physics concepts. By grouping students according to their motivation level, the analysis could reveal whether highly motivated students demonstrate significantly better improvements in problem-solving skills compared to those with lower motivation, especially when exposed to the same instructional methods.

4. RESULT AND DISCUSSION

4.1. Description of Students' Problem-Solving Abilities

Initial data collection of students' physics problem-solving abilities through a pretest of problem-solving abilities was carried out before learning by implementing TPACK-based problem posing differentiation learning. Data from the final test of physics problem-solving abilities based on problem-solving ability indicators: Understanding Problems, Planning Problem-Solving, Implementing, and Problem-Solving Plans and Re-Checking are presented in Table 2.

Table 2. Problem-Solving Ability Data

Indicator	Average Problem-Solving Score			Number of Students		Percentage
	Pre test	Post test	N-Gain	Complete (Score ≥ 75)	Not Complete (Score ≤ 75)	
Understanding the Problem	42.68	83.66	0.71	27	3	76.42
Planning the Solution	51.67	92.66	0.85			
Executing the Solution Plan	18	90.66	0.89			
Reviewing the Solution	3.68	65.33	0.64			
Average Score	31.5	83.07	0.78			

Based on Table 2 above, it can be seen that in Class XI Science at Private Senior High School PAB 8 Saentis Sei Tuan, which consists of 30 students, 27 students (90.00%) scored ≥ 75 on the physics problem-solving ability test for the topic of Heat and Temperature. In contrast, only three students (10.00%) did not pass, scoring < 75. Thus, it can be stated that the implementation of the TPACK-based differentiated problem-posing learning model is effective in physics learning.

The analysis results in Table 2 above show that the N-Gain score for the aspect of understanding the problem is 0.71, which falls into the high category; the aspect of planning the solution is 0.85, categorized as high; the aspect of executing the solution plan is 0.89, also in the high category; and the aspect of reviewing the solution is 0.64, which falls into the medium category.

Table 3. Student Learning Motivation Scores in Experimental and Control Class

Class	N	Min	Max	Mean
Control	30	57	85	68.06
Experimental	30	64	83	73.90

Table 3 compares learning motivation between the experimental and control classes. The learning motivation of students taught using the TPACK-based differentiated learning model is higher than that of students taught with the conventional learning model.

Table 4 presents the data on students' learning motivation (high, low) regarding their physics problem-solving ability. On the other hand, students with low motivation struggle more with these tasks, often lacking the drive to fully engage with the material or explore alternative problem solving strategies. These insights emphasize the importance of fostering intrinsic motivation in students to enhance their problem-solving skills and overall academic performance.

Table 4. Data on Problem-Solving Ability and Student Learning Motivation

Motivation	Statistic	Problem-Solving Ability	
		Experimental Class	Control Class
High (B1)	N	2	19
	$\bar{X}$	8.3	76.84
	.	6	
Low (B2)	N	1	11
	$\bar{X}$	8.2	68.18
	.	7	5
Average	N	8.3	73.67

Based on Table 4, it can be concluded that the group of students with high motivation who received the TPACK-based differentiated problem-posing learning model treatment, totaling 20 students with an average score of 83.62, is higher than the group of students with high motivation who received conventional treatment, totaling ten students with an average of 76.84. Furthermore, the group of students with low motivation who received the TPACK-based differentiated problem-posing learning model treatment, totaling ten students with an average score of 82.75, is higher than the group of students with low motivation who received conventional treatment, totaling 11 students with an average of 68.18. Hypothesis testing is conducted as follows:

4.1.1. Hypothesis 1

The hypothesis test to determine whether there is the problem solving ability of students in the TPACK-based differentiated problem posing learning model is higher than the problem solving ability of students in the conventional learning model at Private Senior High School PAB 8 Saentis Sei Tuan was conducted using a t-test, with the following results:

Table 5. Summary of One-Sided T-Test Hypothesis 1

Data	Average	t_{count}	t_{table}	Conclusion
Experiment Class	83.33	5.09	1.672	The problem-solving ability of experimental class students is higher than the control class.
Control Class	73.67	0		

Table 5 shows the results of the one-sided t-test for $\alpha = 0.05$ obtained $t_{count} = 5.090$ and $t_{table} = 1.672$. The calculation results show that $t_{count} > t_{table}$, which means H_0 is rejected and H_a is accepted. Therefore, it is concluded that the problem-solving ability of students in the TPACK based differentiated problem-posing learning model is higher than the problem-solving ability of students in the conventional learning model at Private Senior High School PAB 8 Saentis Sei Tuan.

4.1.2. Hypothesis 2

These results highlight the significant role that motivation plays in learning success. Students with greater motivation tend to be more engaged, persistent, and focused, which allows them to understand and process information more effectively. Conversely, students with low motivation often encounter difficulties in analyzing problems and maintaining concentration, leading to lower overstruggle to analyze problems and maintain concentration, resulting when analyzing problems and maintaining concentration. Their limited engagement can hinder their a to understand the material deeply, resulting in lower overall academic performance. These students may struggle to follow the steps required for problem solving, find it challenging to stay attentive, and show reduced confidence when completing learning tasks. To examine the influence of motivation on problem solving ability, a hypothesis test was conducted to determine whether students with high motivation performed better than those with low motivation at Private Senior High School PAB 8 Saentis Sei Tuan. The analysis used a t-test to compare the average scores of the two groups. The test results indicated that students with high motivation achieved significantly higher problem solving scores compared to students with low motivation, confirming that motivation is a key factor influencing students cognitive performance and learning outcomes. The hypothesis test to determine whether there is problem solving ability of students who have high motivation higher than students who have low motivation at Private Senior High School PAB 8 Saentis Sei Tuan was conducted using a t-test, with the following results:

Table 6. Summary of One-Sided T-Test Hypothesis 2

Data	Average	t_{count}	t_{table}	Conclusion
Highly Motivated Learners	75.05	7.5	1.672	The problem solving ability of highly motivated learners is higher than that of low-motivated learners.
Low Motivated Learners	66.47	92		

Table 6 shows the results of a one-sided t-test for $\alpha = 0.05$ obtained $t_{count} = 7.592$ and $t_{table} = 1.672$. The calculation results show that $t_{count} > t_{table}$, which means H_0 is rejected and H_a is accepted. Therefore, the conclusion is that the problem-solving ability of students with high motivation is higher than that of students with low motivation at Private Senior High School PAB 8 Saentis Sei Tuan.

4.1.3. Hypothesis 3

The hypothesis test to determine the interaction between the TPACK-based differentiated problem posing learning model, motivation, and students' problem solving ability was conducted using a two way analysis with a 2x3 ANOVA test. The ANOVA calculation results are shown in the Table 7.

The first hypothesis focused on the impact of the learning model on problem-solving abilities, comparing pretest and posttest scores. The second hypothesis analyzed the role of student motivation, while the third hypothesis examined how both the learning model and motivation combined to influence problem-solving outcomes [49]. The data revealed that the experimental class, using the TPACK based model, showed significant improvements compared to the control class, which used conventional learning methods.

Table 7. ANOVA Test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1929.275a	3	643.092	13.794	0
Intercept	330343.627	1	330343.627	7085.864	0
Learning Models	1552.999	1	1552.999	33.312	0
Learning Motivation	309.741	1	309.741	6.644	0.013
Learning Models Learning Motivation	206.481	1	206.481	4.429	0.04
Error	2610.725	56	46.62		
Total	374275	60			
Corrected Total	4540	59			
R Squared = 0.425 (Adjusted R Squared = 0.394)					

Based on the calculation results from Table 7, a significant value of 0.040 was obtained. This indicates that the test result (sig.) $<$ significance level, this H_0 is rejected, meaning there is an interaction in problem-solving ability between students with high and low learning motivation taught using the TPACK-based differentiated problem-posing learning model and the conventional model. The research results show that the average problem-solving ability of students in the experimental class, which received the TPACK-based differentiated problem-posing learning model treatment, is higher than the average score of the control group, which received the conventional learning model treatment, with an average score of 83.33 > 73.67. This characteristic enables students to solve various problems and have a structured approach to problem-solving.

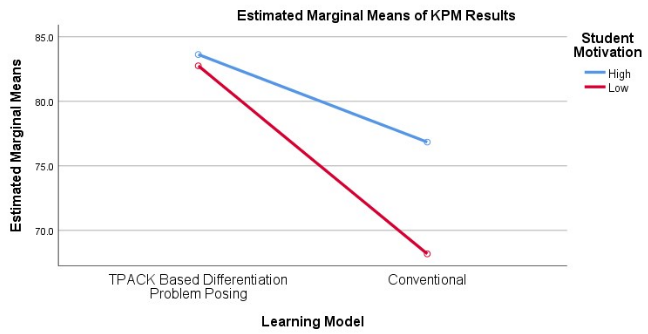

Figure 1. Interaction Between Learning Model Factor (A) and Motivation (B) on Students Problem Solving Ability

Based on figure 1 shows the interaction between the learning model and students' motivation in influencing their problem-solving ability. Students who received treatment through the TPACK based differentiated problem posing learning model achieved the highest average problem-solving ability score of 83.62 aclasshe lowest average score of 82.75. In contrast, students taught through the conventional learning model recorded the highest average score of 76.84 and the lowest average score of 68.18. This shows that the problem-solving ability of students in the experimental class is higher than that of the control class. These results are consistent with research indicating that the learning model strategy used has an impact on the development of students' critical thinking skills [50].

5. MANAGERIAL IMPLICATIONS

5.1. Implementation of TPACK-based Learning Models in Education

The results of this study suggest that integrating the TPACK-based differentiated problem-posing learning model significantly enhances students' problem-solving abilities. For educational institutions and administrators, this model provides a valuable framework for improving student engagement and learning outcomes. School can benefit from adopting this approach, especially in science and technology subjects like physics, where complex problem-solving skills are essential.

5.2. Enhancing Student Motivation through Tailored Learning Models

The study also highlights the importance of student motivation in achieving better learning outcomes. The TPACK-based learning model, by offering differentiated instruction, plays a crucial role in boosting students' intrinsic motivation. School administrators should focus on creating an environment that fosters motivation through engaging and challenging learning experiences. This can be achieved by incorporating technology, collaborative work, and active problem-solving activities that align with students' individual learning preferences.

5.3. Collaboration Between Educators and Technological Integration

As the study demonstrates, a strong relationship exists between learning models and the motivation to learn. For schools and universities aiming to stay competitive in a technology-driven educational landscape, fostering collaboration between educators and technology developers is essential. This collaboration can ensure that learning models like TPACK are not only effective but also continuously updated to meet the demands of modern education.

Furthermore, strategic collaboration between educational institutions, policymakers, and technology developers contributes to a more systemic and scalable implementation of TPACK-based approaches. Institutions benefit from co-designed solutions that align with curriculum standards, learning objectives, and institutional priorities. Policymakers can support this ecosystem by TPACK-based differentiated problem-posing learning model achieved the highest average problem-solving ability score of 83.62, while the class with the lowest average score becomes not merely an instructional enhancement but a foundational framework for transforming teaching and learning processes across various educational contexts.

6. CONCLUSION

The study concludes that the TPACK based differentiated problem posing learning model significantly enhances students problem solving abilities compared to conventional learning methods. The experimental class achieved higher average scores in problem solving tasks, especially in topics such as Heat and Temperature, showing that the integration of technology, pedagogy, and content knowledge creates a more effective and meaningful learning environment. These findings are consistent with research that highlights the value of active learning approaches such as problem posing in improving critical thinking and analytical skills.

Learning motivation was also shown to play an essential role in supporting student achievement. Students with high motivation performed better, engaged more deeply with the learning material, and demonstrated stronger persistence throughout the learning process. This aligns with intrinsic motivation theory, which explains that motivated learners interact more meaningfully with educational content and achieve higher levels of understanding. The results highlight the importance of providing an engaging and supportive learning environment to optimize student outcomes and strengthen complex cognitive skills.

In conclusion, the TPACK based differentiated problem posing learning model is an effective instructional strategy for improving both problem solving skills and learning motivation among high school students. By integrating technological, pedagogical, and content knowledge with differentiated instruction, this model promotes a more student centered and interactive learning experience. The study also contributes to SDG 4 Quality Education by enhancing digital, cognitive, and analytical competencies through innovative and technology supported learning practices. Additionally, by reinforcing critical thinking, problem solving, and foundational entrepreneurial skills, the study supports SDG 8 Decent Work and Economic Growth which emphasizes the development of relevant abilities for future employment, productivity, and participation in a technology driven society.

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6.2. Author Contributions

Conceptualization: DD; Methodology: SZ; Software: SM and SS; Validation: RH, SS and JT; Formal Analysis: DD and SZ; Investigation: SM; Resources: RH; Data Curation: JT; Writing Original Draft Preparation: DD and SZ; Writing Review and Editing: SM and RH; Visualization: JT and SS; All authors, DD, SZ, SM, RH, JT and SS, have read and agreed to the published version of the manuscript.

6.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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6.5. Declaration of Conflicting Interest

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