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The Implementation of the STAD Learning Model Assisted by PowToon on Solid Geometry to Improve the Learning Outcomes of Eighth-Grade Students

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ABSTRACT

This study aimed to address eighth-grade students' low conceptual understanding and problem-solving skills in learning flat-sided solid figures by applying the STAD learning model assisted by Powtoon. A quasi-experimental method with a Nonequivalent Control Group Design was employed, with samples selected using cluster sampling from SMP Muhammadiyah 01 Medan. Research instruments consisted of pretest and posttest essay questions. The results showed that the experimental class obtained a higher mean N-Gain score of 0.65 (medium category) than 0.38 (medium category) in the control class. The independent samples t-test revealed that the difference was statistically significant ($t = 3.142$, $df = 48$, $p = 0.003 < 0.05$, t-table = 2.011). These findings indicate that implementing the STAD model, assisted by Powtoon, effectively enhanced students' conceptual understanding and mathematical problem-solving skills. Moreover, it suggests that cooperative learning supported by interactive animations can serve as an effective alternative to foster more active, collaborative, and meaningful mathematics learning in secondary schools.

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1. INTRODUCTION

Education is a systematic process of teaching and training aimed at shaping character and enhancing knowledge. Ki Hajar Dewantara emphasized that education encompasses the development of ethics, intellect, and physical health. Education does not merely focus on intellectual aspects but also seeks to cultivate morality and ethics as the foundation of social life. According to Law Number 20 of 2003, education aims to create a conducive learning environment that enables individuals to develop optimally in spiritual, intellectual, personal, and practical competencies [1]. In addition, 21st-century education must equip students with mathematical literacy and critical thinking skills, which can be enhanced through interactive digital learning modules [2].

Mathematics is an important subject in education for the development of human resources; however, many students consider it difficult and complex, resulting in low motivation to learn. This negative perception often becomes a learning obstacle, causing anxiety and making students reluctant to study it [3]. Mathematics learning involves interacting with various components to develop students' problem-solving thinking skills, enabling them to understand concepts deeply rather than merely memorizing formulas [4].

However, educational challenges in Indonesia are related to students' low learning outcomes and the dominance of teacher-centered practices. Students tend to be passive, merely receiving information without fully understanding the concepts, which leads to poor conceptual understanding and weak mathematical problem-solving skills [5]. Psychological factors such as motivation and stress also affect students' creative thinking and problem-solving abilities [6]. In fact, learning outcomes are an important indicator in the educational process, encompassing cognitive, affective, and psychomotor domains [7]. Student learning outcomes may be influenced by internal factors (such as motivation, interest, and readiness to learn) as well as external factors (such as teachers, instructional methods, learning media, and the learning environment) [8].

In mathematics learning, conceptual understanding reflects students' ability to apply definitions, concepts, relationships, and multiple mathematical representations more deeply [9]. Moreover, in the 21st century, students are expected to master various competencies, one of the most crucial being problem-solving skills, which are essential for critical, systematic, and creative thinking in addressing real-world problems [10]. Nevertheless, students' mathematical problem-solving ability remains relatively low, particularly in solving contextual word problems [11]. Therefore, mathematics instruction should emphasize rote memorization of formulas and foster meaningful learning experiences that build understanding and develop critical thinking skills.

One promising approach to improving the quality of mathematics learning is cooperative learning. The Student Teams Achievement Division (STAD) model, as one of the cooperative learning types, emphasizes heterogeneous group work, collaborative discussion, and shared responsibility in mastering the subject matter [12]. This model aligns with Vygotsky's Zone of Proximal Development (ZPD) theory, which highlights the importance of social interaction and scaffolding in fostering students' cognitive development [13].

In addition to learning models, instructional media also play a vital role in bridging abstract mathematical concepts to make them more accessible. One relevant digital medium is PowToon, which suits the characteristics of the digital-native generation that requires visual, interactive, and engaging learning experiences. PowToon has enhanced students' attention, motivation, and conceptual understanding [14].

Previous studies have shown that the STAD model can significantly improve students' mathematics learning outcomes [15]. Some studies also indicate that the STAD learning model affects the learning outcomes of elementary school students [16]. Several studies have combined the STAD model with PowToon, for example, in science learning on environmental pollution topics [17]. However, research specifically integrating STAD with PowToon in mathematics learning remains limited, particularly on three-dimensional solid geometry in junior high schools. Therefore, this study provides novelty by examining the effectiveness of integrating STAD with PowToon to enhance students' conceptual understanding and mathematical problem-solving skills.

Based on the foregoing, this study aims to examine the effectiveness of implementing the STAD learning model assisted by PowToon in enhancing eighth-grade students' conceptual understanding and mathematical problem-solving skills in the topic of three-dimensional solid geometry. The study is expected to provide practical contributions for teachers in adopting innovative teaching strategies, help students strengthen their mathematical competencies, and serve as a reference for future research in mathematics education.

2. METHOD

This study employed a quasi-experimental method with a Nonequivalent Control Group Design to investigate the effect of the STAD learning model assisted by Powtoon on eighth-grade students' learning outcomes in solid geometry. The sample consisted of 50 students from SMP Muhammadiyah 01 Medan, divided into 25 students in the experimental class and 25 in the control class, selected using cluster sampling [18].

In the experimental group, Powtoon was integrated into four sessions (2×40 minutes each) as animated media to present concepts, demonstrate problem-solving steps, and provide practice examples, while the control group received conventional instruction. This design was chosen because the school had already formed intact classes, making individual randomization impractical.

The research instrument comprised a pretest and posttest of five essay questions validated for reliability, difficulty level, and discrimination power (see Appendix A). Data analysis included tests of normality, homogeneity, and an independent *t*-test, along with an N-Gain analysis to measure the effectiveness of the treatment [19].

3. RESULTS AND DISCUSSION

3.1. Results

This study was conducted at SMP Muhammadiyah 01 Medan, with data collected from experimental and control classes through essay tests consisting of five items. Before analysis, the instrument was tested for validity, reliability, difficulty level, discrimination power, data normality, and homogeneity.

Descriptive Statistical Analysis

a. Test Validity

All five items were declared valid based on the product-moment correlation at a 5% significance level, and thus were used in this study.

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b. Test Reliability

All five items were declared valid based on the product-moment correlation at a 5% significance level, and thus were used in this study.

c. Difficulty Level

Item analysis showed variation: item 1 (easy), items 2 and 5 (moderate), item 3 (moderate–difficult), and item 4 (difficult). This distribution ensured comprehensive measurement of students' abilities.

d. Discrimination Power

All items had good discrimination indices, ranging from 0.58 to 0.83, confirming their ability to distinguish between high- and low-achieving students.

e. Normality Test

The Shapiro–Wilk test indicated normally distributed data (Sig. > 0.05 for all pretest and posttest scores).

f. Homogeneity Test

Levene's test results showed equal variances between groups (Sig. > 0.05), confirming data homogeneity.

Thus, the instrument was declared valid, reliable, and appropriate for assessing this study's conceptual understanding and problem-solving skills.

g. T-Test

Based on the normality and homogeneity tests, the data met the assumptions for parametric testing. Therefore, hypothesis testing was conducted using the t-test at a 0.05 significance level.

1. Hypothesis Test 1

   Ha: Implementing the STAD learning model assisted by Powtoon can improve the conceptual understanding of eighth-grade students. The results can be seen in Table 1.

Table 1. Paired *t*-Test (Pretest vs. Posttest Experimental Class)

Test Statistics	Value
Mean Pretest	66.80
Mean Posttest	85.20
Average Difference	18.40
The value of t (calculated t)	8.124
df (degree of freedom)	24
Sig. (2-tailed)	0.000
Cohen's d	1.62

These results indicate a significant improvement in students' conceptual understanding after the implementation of STAD assisted by Powtoon, with a considerable effect size.

2. Hypothesis Test 2
Ha: Implementing the STAD learning model assisted by Powtoon can significantly improve the mathematical problem-solving skills of eighth-grade students. The results are presented in Table 2

Table 2. Independent *t*-Test (Posttest, Experimental vs Control)

Test Statistics	Experimental Value	Control Value
Mean Posttest Problem Solving	52.00	44.80
Average Difference	7.20	
The value of t (calculated t)	3.524	
Df	48	
Sig. (2-tailed)	0.001	
Cohen's d	1.00	

The experimental class outperformed the control class in problem-solving skills, with a large effect size. This confirms that STAD assisted by Powtoon is statistically significant and educationally meaningful in enhancing mathematical problem-solving.

h. **N-Gain Test**

The N-Gain analysis measured students' learning improvement between the pretest and posttest. The results are presented in Table 3.

Table 3. N-Gain Test Results (Experimental vs Control)

Group	Average N-Gain	Category	Number of Students	Description
Experimental	0,65	Medium	25	Effective in improving outcomes
Control	0,38	Medium	25	Less optimal

Table 4. Independen *t*-Test on N-Gain

Group	Mean N-Gain	t Calculated	df	Sig. (2-tailed)	t Critical	Cohen's d	Decision
Experimental vs Control	0.65 vs 0.38	3.142	48	0.003	2.011	0.89 (large)	H_0 rejected ✅

The experimental class achieved a significantly higher N-Gain than the control class, with a large effect size. This indicates that the STAD model, assisted by Powtoon, effectively improved students' conceptual understanding and problem-solving skills in three-dimensional geometry, making it a more optimal approach than conventional instruction.

Data Collection Technique

1. Experimental Class

a. Applying the STAD learning model assisted by Powtoon on three-dimensional geometry improved the conceptual understanding of eighth-grade students.

Implementing the STAD learning model assisted by Powtoon significantly improved students' conceptual understanding and problem-solving skills in three-dimensional geometry.

These findings confirm that using the STAD model supported by Powtoon successfully improved students' conceptual understanding, particularly in three-dimensional geometry. The substantial increase in scores demonstrates that interactive and collaborative instructional methods such as STAD can foster active student engagement and a deeper comprehension of the subject matter.

Table 5. Classification of Conceptual Understanding (Pretest and Posttest, Experimental Class)

No	Assessment Category	Interval	Number of Students	Percentage
1	Very High	82,00 – 100,00	0	0%
2	High	72,00 – 81,00	0	0%
3	Moderate	63,00 – 71,00	0	0%
4	Low	41,00 – 62,00	0	0%
5	Very Low	00,00 – 40,00	25	100%
	Total		25	100%

Table 5. Based on the pretest results, all students (100%) were classified in the *very low* category. However, this condition still provides important baseline information, indicating that students required instructional support to enhance their conceptual understanding.

b. Applying the STAD model, assisted by Powtoon, enhanced students' mathematical problem-solving ability.

Table 6. Classification of Problem-Solving (Pretest and Posttest, Experimental Class)

No	Assessment Category	Interval	Number of Students	Percentage
1	Very High	82,00 – 100,00	0	0%
2	High	72,00 – 81,00	0	0%
3	Moderate	63,00 – 71,00	18	72%
4	Low	41,00 – 62,00	7	28%
5	Very Low	00,00 – 40,00	25	100%
	Total		25	100%

Out of 25 students observed, the average pretest score was 33.6, which increased to 54.4 in the posttest, reflecting an overall improvement of approximately 28%. This indicates a positive development in students' mathematical problem-solving skills following the intervention.

The posttest results showed that 72% of students were classified in the Low category, while 28% remained in the Very Low category. This indicates that implementing the STAD model assisted by Powtoon improved students' mathematical problem-solving abilities, moving most students from Very Low to Low. Although the progress did not reach higher categories, the results demonstrate the model's effectiveness in enhancing students' skills.

Furthermore, a comparison of students' problem-solving skills before (pretest) and after (posttest) the intervention is illustrated in Figure 1.

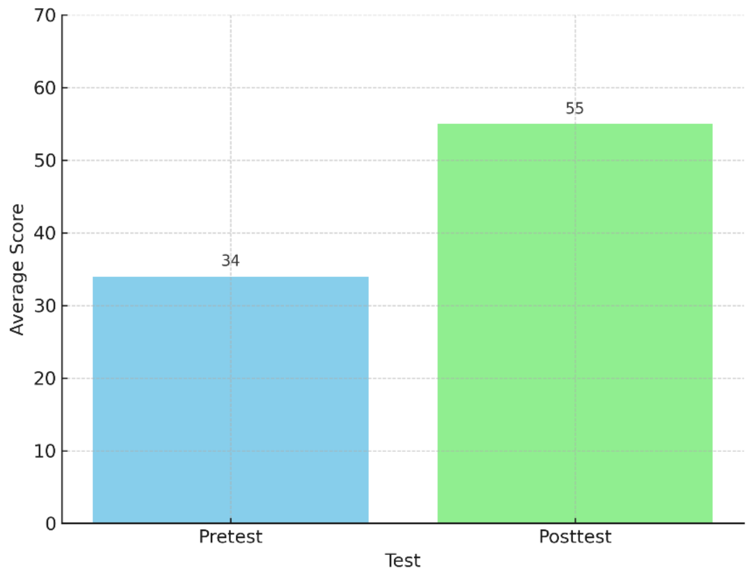

Figure 1. Students' Problem-Solving Skills Before STAD-Powtoon Intervention (Experimental Class)

The pretest results indicate that all students were classified in the "Very Low" category, representing 100% of the class. This highlights that students initially had very limited problem-solving skills in solid geometry. The homogeneity of low scores underscores the need for instructional interventions, such as the STAD model assisted by Powtoon, to improve students' conceptual understanding and problem-solving abilities.

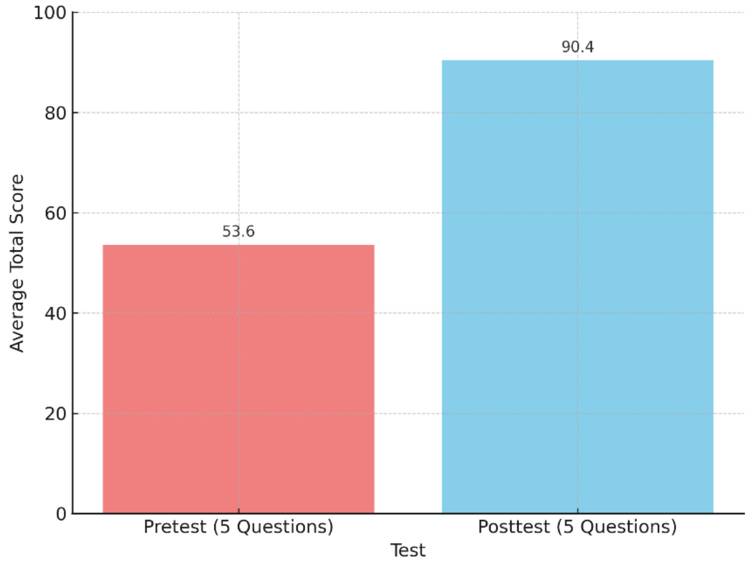

Figure 2. Students' Problem-Solving Skills After STAD-Powtoon Intervention (Experimental Class)

The posttest results reveal a significant improvement in students' problem-solving abilities. Following the intervention, the majority of students (72%) moved to the "Low" category, while 28% remained in the "Very Low" category. This indicates that the STAD model, assisted by Powtoon, effectively enhanced students' skills, even though most students had not yet reached higher performance levels.

2. Control Class

a. Implementation of Conventional Learning on Solid Geometry for Eighth-Grade Students

Based on pretest and posttest results in the control class taught using conventional methods, the average score increased from 16 to 24.8, representing a 40% improvement. However, this gain was inconsistent and remained relatively low. Many students showed no progress, most maintained their initial scores, and only a small number demonstrated notable improvement, such as moving from very low scores (including zero) to 40.

Conventional teaching methods did not foster a comprehensive understanding of solid geometry concepts. These results highlight the necessity of adopting innovative learning models and media, such as the STAD model assisted by Powtoon, to improve student learning outcomes significantly.

Table 7. Classification of Conceptual Understanding (Pretest and Posttest, Experimental Class)

No	Assessment Category	Interval	Number of Students	Percentage
1	Very High	82,00 – 100,00	0	0%
2	High	72,00 – 81,00	0	0%
3	Moderate	63,00 – 71,00	0	0%
4	Low	41,00 – 62,00	0	0%
5	Very Low	00,00 – 40,00	25	100%
	Total		25	100%

These results indicate that conventional instruction has not improved students' conceptual understanding of solid geometry, primarily because this approach does not sufficiently engage students in active learning. A similar pattern was also observed in the experimental class, which did not show notable improvement in conceptual understanding indicators, although this was assessed using only two items. These findings underscore the necessity of innovative and interactive instructional approaches to genuinely enhance students' conceptual comprehension genuinely.

The graphical representation of students' conceptual understanding in the control class, both before (pretest) and after (posttest) instruction, is presented in Figure 3.

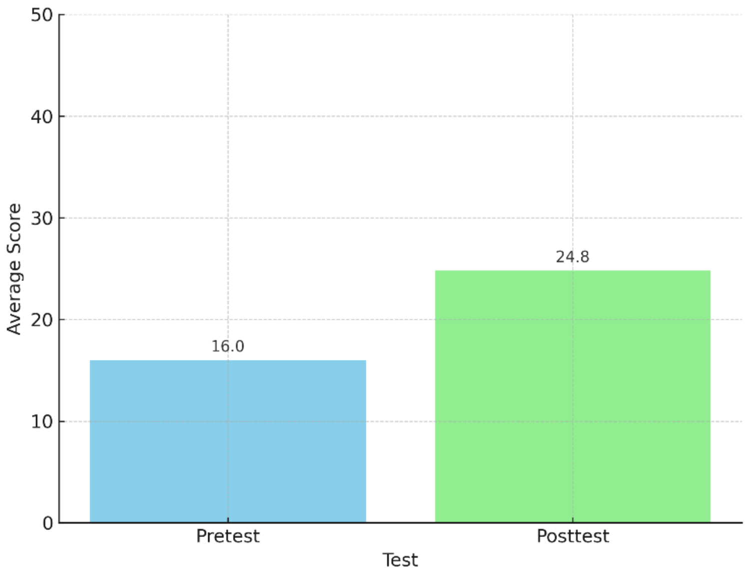

Figure 3. Diagram of Pretest and Posttest Results of Students' Conceptual Understanding in the Control Class

This diagram reinforces the finding that there was no significant improvement in students' conceptual understanding in the control class.

b. The Application of the STAD Model Assisted by Powtoon in Enhancing Students' Mathematical Problem-Solving Ability

The mathematical problem-solving ability of Grade VIII students taught using conventional methods showed limited improvement. The average pretest score of 24.8 increased to 28.8 in the posttest, representing a modest gain of 4 points (approximately 20%). Most students maintained their initial scores, with only a few demonstrating notable progress. These results indicate that conventional instruction alone is insufficient to enhance students' problem-solving skills, highlighting the need for innovative and interactive learning approaches, such as the STAD model assisted by Powtoon, to achieve meaningful improvements.

Table 8. Classification of Problem-Solving (Pretest and Posttest, Experimental Class)

No	Assessment Category	Interval	Number of Students	Percentage
1	Very High	82, 00 – 100, 00	0	0%
2	High	72, 00 – 81, 00	0	0%
3	Moderate	63, 00 – 71, 00	0	0%
4	Low	41, 00 – 62, 00	0	0%
5	Very Low	00, 00 – 40,00	25	100%
	Total		25	100%

From a total of 25 students in the control class, all (100%) indicated no improvement in category levels from pretest to posttest. These results show that conventional instruction did not enhance students' mathematical problem-solving skills. In contrast, the STAD model, assisted by Powtoon in the experimental class, successfully promoted progress in achievement categories. This underscores the need for innovative instructional approaches to help students advance from very low performance levels to higher categories in line with the learning objectives.

The graphical representation of students' mathematical problem-solving ability in the control class, both before (pretest) and after (posttest) instruction, is presented in Figure 4.

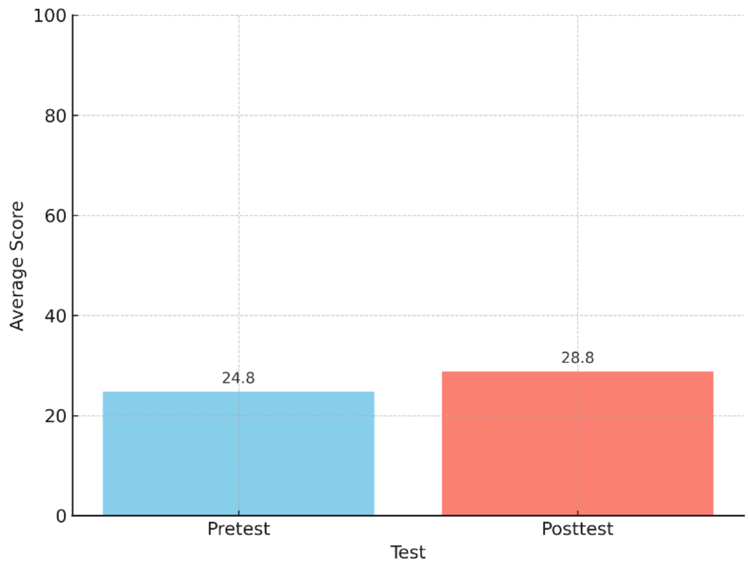

Figure 4. Diagram of Pretest and Posttest Results of Students' Problem-Solving Ability in the Control Class

As shown in Figure 4, the average pretest score in the control class increased slightly from 24.8 to 28.8 on the posttest, reflecting a minimal gain of approximately 4 points. Most students remained in the Very Low category, indicating that conventional teaching methods had a limited impact on improving students' mathematical problem-solving skills. These results underscore the need for innovative learning approaches, such as the STAD model assisted by Powtoon, to substantially improve learning outcomes.

3.2. Discussion

The Implementation of the STAD Model Assisted by Powtoon in Enhancing Students' Conceptual Understanding

Using the STAD model supported by Powtoon effectively enhances students' conceptual understanding, as evidenced by the significant increase in posttest scores from an initially very low baseline. Through small group collaboration, students could support one another in comprehending the material, while Powtoon provided engaging visualizations of abstract concepts, making learning more active and meaningful. These findings align with Vygotsky's theory, which emphasizes the role of scaffolding in group discussions, enabling students to attain higher levels of understanding within their Zone of Proximal Development with the support of peers and teachers[20]. Similar results also found that interactive media in cooperative learning significantly improved conceptual understanding in mathematics [21], and also demonstrated that audiovisual aids enhanced students' comprehension in abstract topics [22]. However, compared to research by Erlina that used static visual aids, the dynamic animation in Powtoon appears to increase engagement and retention more effectively [23].

Teachers can implement STAD with Powtoon by allocating 30–40 minutes per session, forming heterogeneous groups, and guiding discussions actively. This approach allows abstract concepts to be visualized concretely and promotes collaborative learning strategies.

The Implementation of the STAD Model Assisted by Powtoon in Enhancing Students' Mathematical Problem-Solving Ability

The STAD model and Powtoon improved students' mathematical problem-solving skills, as shown by increased scores from pretest to posttest. Students initially categorized as low achievers made progress, although some remained in the low category. This limited improvement may be attributed to the short duration of the intervention, varying initial abilities among students, and the relative difficulty of the tasks. Cooperative work in heterogeneous groups and collective discussions encouraged critical thinking and strategy development, while Powtoon animations helped students grasp concepts systematically rather than relying solely on memorization. These results are consistent with Vygotsky's theory, emphasizing social interaction in developing higher-order thinking skills [20]. Similar findings were reported by Wahuyuni [24] and Widya [25], who highlighted that interactive cooperative learning improved problem-solving in middle school mathematics.

Teachers can realistically apply STAD with Powtoon by planning short, focused sessions, actively facilitating group discussions, and using animations to illustrate complex problems.

This study was limited by a short intervention period, a single school setting, and a small sample size. Future research should extend the duration, include multiple schools, and explore comparisons with other active learning models to validate and generalize these findings.

4. CONCLUSION

Implementing the STAD learning model assisted by Powtoon demonstrates potential in enhancing students' engagement and understanding of mathematical concepts. This approach highlights the benefits of integrating interactive digital media into learning, promoting collaborative and active learning experiences. Although this study was limited to one school and a single topic in solid geometry, it provides valuable insights for educators seeking innovative teaching strategies. Future research is recommended to explore the application of STAD with digital media across different mathematical topics, longer-term implementations, and varied educational settings. Overall, this study contributes to the broader discourse on digital media integration in education, offering a model for curriculum development that supports more interactive and meaningful learning experiences.

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