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Problem-Based Learning Model Using Geogebra Application: Students Motivation to Learn Translation Material of High School

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ABSTRACT

This study aims to describe the application of the Problem-Based Learning (PBL) model with the help of the GeoGebra application to increase students' learning motivation for geometric transformation material, especially translation. This study is a form of classroom action research carried out in two cycles in class XI E of High School 4 Palu involving 35 students. Each cycle consists of planning, implementation, observation, and reflection steps. In cycle I, the material is related to translation to points, while in cycle II, it is related to translation to lines. Data were collected through a learning motivation questionnaire and observation sheets, which were analyzed descriptively. The results indicated that students' learning motivation increased from cycle I to cycle II. In cycle I, only 6 students (17.1%) were included in the strong motivation category, while 11 students (31.5%) were included in the low category. After the improvement in Cycle II, the number of highly motivated students increased to 15 (42.8%), while those in the low group decreased to only 2 (5.8%). Observational data shows increased student engagement and enjoyment in learning. Consequently, the implementation of the GeoGebra-assisted PBL paradigm has proven successful in increasing motivation in mathematics learning.

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1. INTRODUCTION

Mathematics is a fundamental discipline in education that contributes significantly to the development of logical, systematic, and critical thinking skills (Dolapcioglu & Doğanay, 2022; Boadu & Bonyah, 2024). In practice, students often perceive mathematics as challenging and boring (Schoenfeld, 2022). This negative perception is due to traditional learning styles that are largely one-way and use little visual media, thus hindering concrete conceptual understanding.

Learning motivation is a crucial aspect that significantly influences student performance in understanding subject matter (Albrecht & Karabenick, 2018; Jia & Tu, 2024). Inadequate learning motivation often results in reduced student engagement in

the educational process and poor academic performance (Cavilla, 2017). This problem is particularly evident in mathematics education, where geometric transformations, particularly translations, are abstract and lack contextual relevance to students' everyday experiences.

Learning motivation is shaped by two main components: internal factors, including a sense of success and future expectations, and external factors, such as rewards and a supportive learning environment (Loh, 2019). The integration of intrinsic and extrinsic motivation can significantly improve student learning outcomes (Waheed et al., 2016; Zaccone & Pedrini, 2019). Kurniawan et al. (2023) showed that these two types of motivation contributed 50.6% to students' mathematics learning achievement. To address this lack of motivation, innovative educational strategies such as Problem-Based Learning (PBL) are considered advantageous because they focus on solving real-world problems related to students' lives (Harun et al., 2012; LaForce et al., 2017).

Several recent studies have indicated that the use of Problem-Based Learning (PBL) approaches, supported by technologies such as GeoGebra, is beneficial in improving the quality of mathematics education. Puspasari et al. (2023) observed that the implementation of Problem-Based Learning (PBL) facilitated by GeoGebra increased student learning motivation by 16.55 points and increased graduation rates by 15% in high school. Wulandari and Misu (2023) documented a significant increase in students' mathematical problem-solving skills after using PBL and GeoGebra methodology. GeoGebra, as a mathematical visualization tool, offers an interactive learning experience that allows students to explore geometric topics such as translation in a more dynamic and realistic way (Dahal et al., 2022).

A preliminary study conducted by the researchers showed that mathematics learning in grade XI E of High School 4 Palu demonstrated low student motivation towards translation material. Observational data showed that students were passive in asking questions and discussing, resulting in decreased student enthusiasm during the learning process. Unengaging conventional learning methods and a lack of interactive media exacerbate this situation. One factor contributing to low learning motivation is student passivity during classroom learning, caused by a lack of diversity in pedagogical methods and resources used by educators (Li & Xue, 2023; Schweder & Raufelder, 2024).

Therefore, innovative learning is crucial for establishing a reciprocal interaction model between educators and students, allowing students to actively explore knowledge and articulate ideas during the problem-solving process. The Problem-Based Learning (PBL) approach, along with interactive media such as GeoGebra, is considered capable of addressing these challenges. This study aims to explain the application of the Problem-Based Learning (PBL) model, facilitated by the GeoGebra application, to improve the learning motivation of grade XI E students at high school 4 Palu on translation material.

2. METHOD

This type of research is Classroom Action Research (CAR), with the aim of improving and enhancing the quality of the learning process directly in the classroom. This research uses the model for classroom action research developed by Kemmis and McTaggart, which has four main components in each cycle: planning, action, observation, and reflection. These four components form a cycle that can then continue to the next cycle in a spiral. This research was conducted in two cycles, each consisting of one meeting. The research cycle used is presented below in Figure 1.

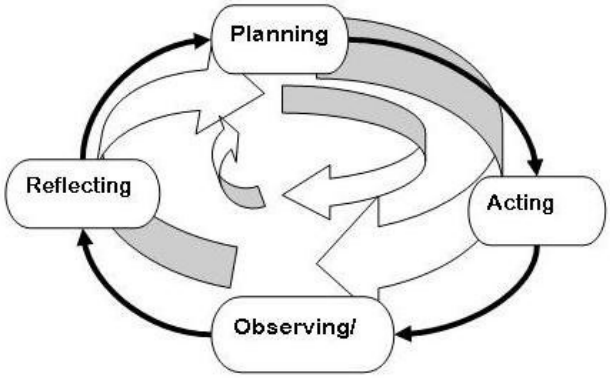

Figure 1. Kemmis and McTaggart's Classroom Action Research Cycle

This study involved 35 11th-grade E students at High School 4 Palu. In Cycle I, the material used was point translation, while in Cycle II, the material was line translation. Both cycles used a problem-based learning approach with the GeoGebra application as the primary medium.

The instruments used were a learning motivation questionnaire and a motivation observation sheet. The motivation questionnaire consisted of 25 statements with a 4-point Likert scale covering four main indicators: attention, relevance, confidence, and fulfillment. The observation sheet evaluated six dimensions: enthusiasm, seriousness, cooperation, engagement, conversation, and curiosity.

The questionnaire and observation data collected were examined descriptively to assess improvements in students' motivation categories from Cycle I to Cycle II. This study used a learning motivation questionnaire consisting of 25 questions, using a four-point Likert scale: Strongly Agree (S), Agree (A), Disagree (D), and Strongly Disagree (SD), resulting in a total score between 25 and 100. Based on these results, student motivation was categorized into five levels: very high (100), high (91–99), moderate (81–90), low (71–80), and very low (<71). Simultaneously, observational data were evaluated based on scores on six main variables used to measure student engagement, enjoyment of learning, and participation in the educational process.

The instruments used in this study were:

A closed-ended learning motivation questionnaire with 25 statements. The questionnaire covered four aspects of learning motivation indicators:

1. Student attention to learning.
2. Level of relevance of learning to student needs
3. Level of student confidence in their learning abilities

4. Level of student satisfaction with the learning process

Each statement is answered using a four-level Likert scale:

Strongly Agree (SS), Agree (S), Disagree (DS), and Strongly Disagree (STS). Scoring is adjusted for positive and negative statements.

For the observation sheet instrument, the aspects assessed are:

1 = Demonstrates enthusiasm for learning
2 = Demonstrates seriousness in thinking
3 = Demonstrates cooperation in groups
4 = Demonstrates active participation in class
5 = Demonstrates sharing in discussions
6 = Demonstrates curiosity by asking questions.

3. RESULTS AND DISCUSSION

Results

This research was conducted in two stages. Each cycle was designed to improve students' understanding of translation material and increase their learning motivation through the integration of Problem-Based Learning (PBL) and GeoGebra visual media. Data on learning motivation were collected using a questionnaire administered at the end of each cycle. The results were analyzed and categorized into three classifications: high, medium, and low.

Cycle I: Translation with Points

In Cycle I, students learned about translation with points. Although the GeoGebra application was used, the implementation remained simple: students only manipulated single points on the coordinate plane. Learning focused on understanding translation rules in vector form and visually observing changes in point positions.

The questionnaire results showed:

a. 6 students (17.1%) were in the high motivation category,
b. 18 students (51.4%) were in the medium motivation category,
c. 11 students (31.5%) were in the low motivation category.

These results suggest that the suboptimal use of GeoGebra and the overly simplistic materials have not been able to optimize students' learning enthusiasm. Learning in Cycle I was still initially exploratory and did not provide adequate cognitive challenges. This is reinforced by observational data, which showed that students were not fully active in discussions and asking questions. Active participation was only evident in a few students with a strong interest in technology, while the majority remained passive. Overall, the average observation score was in the "sufficient" category.

Cycle II: Translation of Lines

Refinements were made in Cycle II by changing the material to translation of lines. Students were asked to solve problem-based problems, such as determining the shadow

of a line through translation with a given vector. They used GeoGebra to draw, move, and analyze the lines before and after the translation.

The results of the questionnaire in Cycle II showed significant changes:

a. 15 students (42.8%) were in the high motivation category,

b. 18 students (51.4%) were in the medium motivation category,

c. Only 2 students (5.8%) were in the low motivation category.

Observations showed an increase in student engagement, enthusiasm for learning, and curiosity. The average observation score rose to the "good" category.

The increase in learning motivation occurred because students were more engaged when the geometric objects used were more complex and meaningful. They felt challenged to understand patterns, work collaboratively in groups, and verify their answers visually. GeoGebra, in this case, served not only as a tool but also as an interactive medium that stimulated curiosity and active engagement. The following presents a comparison of the results of learning motivation between cycle I and cycle II in Table 1.

Table 1. Comparison of learning motivation results between cycle I and cycle II

Category	**Percentage of Cycle I**	**Percentage of Cycle II**
High	17,1%	42,8%
Medium	51,4%	51,4%
Low	31,5%	5,8%
Total	100%	100%

The 25.7% increase in the high motivation category demonstrates that the PBL approach with visual media is effective in creating a more meaningful learning environment. Furthermore, the decrease in the number of students in the low motivation category also indicates that problem-based learning and technology media increase self-confidence and enthusiasm for learning mathematics.

Discussion

This study aims to explain the application of the Problem-Based Learning (PBL) model facilitated by the GeoGebra application to improve the learning motivation of 11th-grade students at High School 4 Palu on translation. The results showed that student learning motivation increased from cycle I to cycle II. This conclusion aligns with the statement of Shin and Bolkan (2021) that learning motivation increases when educational experiences are engaging, dynamic, and intellectually stimulating. This strategy becomes increasingly relevant in mathematics education when integrated with interactive technology. Recent research by Ji and Zheng (2025) demonstrated that interactive learning through two-way engagement significantly improves student motivation and academic performance.

Furthermore, a literature review by Yohannes and Chen (2023) demonstrated that using GeoGebra as a visual tool significantly increases student self-efficacy and aids understanding of abstract topics, making them more tangible. GeoGebra has been shown to significantly improve students' creativity, conceptual understanding, and problem-solving skills (Nurfadilah & Suhendar, 2022; Handayani et al., 2022). These results

strengthen the research conclusions of Hohenwarter and Jones (2007) that GeoGebra plays an important role as a link between visual and symbolic representation in mathematics education, thereby increasing student motivation and involvement in learning activities.

Practical Implications:

1. Improving Student Motivation: This research provides an example of the effective application of a problem-based learning model using the GeoGebra application to increase student motivation in learning translation material in high school.
2. Developing Learning Models: The results of this research can be used as a reference for developing more innovative and effective learning models to increase student motivation in learning mathematics.
3. Utilizing Technology: This research provides an example of the use of technology, such as the GeoGebra application, in mathematics learning to increase student motivation.

Theoretical Implications:

1. Developing Mathematics Learning Theory: This research can contribute to the development of more effective mathematics learning theories that increase student motivation.
2. Implementing a Problem-Based Learning Model: The results of this research provide an example of the effective application of a problem-based learning model in mathematics education to increase student motivation.
3. Improving Conceptual Understanding: This research can help improve students' understanding of mathematical concepts through the implementation of a problem-based learning model using the GeoGebra application.

4. CONCLUSION

Findings from classroom action research conducted over two learning cycles using the Problem-Based Learning model, complemented by the GeoGebra application, indicate that this strategy effectively increases student motivation in learning geometric transformations, particularly translation. In Cycle I, the learning emphasis was on translating material into points. Although GeoGebra was used as an educational tool, student motivation remained mostly moderate to low. This was due to the simplicity of the material and the less-than-optimal media used to encourage active student engagement. Improvements were implemented in Cycle II by using more contextual translation material for lines. GeoGebra was used in a more exploratory manner, allowing students to engage directly with visual and dynamic learning objects. As a result, there was a substantial increase in the high learning motivation category and a significant decrease in the low category. Questionnaires and observations indicated that this method produced positive results, increasing the number of highly motivated students while reducing the number of poorly motivated students. This strategy encouraged critical thinking, collaboration, and active engagement in the learning process among students.

Consequently, the problem-based learning model effectively encourages critical thinking, active discussion, and problem-solving in mathematics education. Utilizing GeoGebra as an interactive visual medium enhances students' understanding of geometric transformation concepts while fostering enthusiasm and a desire to learn. The integration of PBL and GeoGebra methodologies is most effective when used for subjects that require both visual and intellectual abilities, such as line translation.

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