**The Effect Of Problem-Based Adaptive Learning On Students' Mathematical Concept Understanding Ability**

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**Abstract**

Does traditional classroom instruction produce significantly different outcomes in students’ understanding of mathematical concepts when compared to adaptive problem-based learning? This study aims to achieve this objective. The activities were conducted at SMA Negeri 1 Pantai Labu. The study population consisted of four hundred and fifty ninth grade students (n=150). The study used a stratified sampling technique. One group of the sample used Problem-Based Adaptive Learning (PBAL) along with a more conventional learning methodology, while the other group used an alternative approach. The first group consisted of thirty students. The conceptual understanding and semi-experimental research methodology was used. Data processing techniques in Excel and IBM SPSS Statistics 30, including t-test for independent samples and homogeneity test. Data analysis, with a significance level of 0.12>0.05, revealed significant differences between students involved in adaptive problem-based learning and those who received conventional instruction. This indicates that H1 is accepted and H0 is rejected. The study suggests that adaptive problem-based learning can serve as an effective instrument for high school mathematics educators who aim to increase student motivation.

***Keywords:*** *Adaptive Learning and Understanding Mathematical Concepts.*

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**INTRODUCTION**

Education is an important aspect in an individual's life and greatly influences daily activities, especially in society (Fau et al., 2023). Analysis of the progress of knowledge and technology, professional search, religious progress, education, and aspects of human life (Sadewo et al., 2022). Formal education is a means to increase students' knowledge. In accordance with the provisions of Law Number 20 Article 1 Paragraph (11) and (13), structured and integrated education includes basic education, secondary education, and higher education. (Denmark, Krone, 2022)

Students' understanding of mathematical concepts poses a significant challenge in Indonesian mathematics education (Putri Khairani et al., 2021). Mire (2022) argues that mathematics was originally developed to solve problems in human life. Thus, mathematics was developed to meet human needs. Gauss as quoted by Evoulina (2024) stated that mathematics is the foundation of science, while accounting theory is part of mathematics. Currently, various fields of science have developed rapidly thanks to mathematics. This is because mathematics is a fundamental science that everyone should have (Permatasari, 2021).

The fundamental aspect of mathematics education that students must achieve is conceptual understanding (Aledya, 2019). With a deep conceptual understanding, students are better able to solve problems because they can relate and apply the concepts that have been learned. Conversely, if students' understanding of a concept is limited, students will have difficulty in choosing and using certain procedures to apply concepts and problem-solving algorithms (Suendarti, 2021). The National Council of Mathematics Teachers argues that students must acquire mathematical knowledge with understanding, actively building new insights from existing experiences and knowledge (Tukly et al., 2022). Conceptual understanding serves as a foundation for advancing to higher-level topics in mathematics education (Komariyah et al., 2018). Students' progress to the next level in mathematics education is made possible by an understanding of basic concepts (Natalia, 2021). The justification for this is that mathematics is a discipline that is inherently connected to other domains. and has no definite rules or boundaries. This indicates a correlation between the two concepts (Rizki et al., 2020). In line with the objectives of mathematics education that have been set, students are expected to be able to understand a mathematical concept to apply its principles effectively in problem solving.

However, the following statement shows that students' understanding of mathematical concepts is inadequate; Research on this understanding shows that students' learning capacity is below 50%, and their level of active engagement with the subject matter is also inadequate. Based on observations of a mathematics teacher at a high school in Pantai Labu, there are several factors that influence students' low understanding of mathematical concepts, namely students' perceptions that mathematics lessons are very difficult, lack of appeal to the material, and minimal variation in the use of learning models.

The term “adaptive learning system” refers to an educational framework that adapts its operation to the unique abilities of individual learners (Wicaksana, 2020). Steichen et al. (2012) defines an adaptive learning system as an educational framework that adapts its approach to each learner according to their previous experiences, characteristics, and behaviors. Adaptive learning systems adjust their teaching strategies to meet the unique needs of each student, encouraging the achievement of their maximum potential in the educational environment. Brusilovsky (2007) outlined several factors that influence user modeling, including knowledge, interests, background, individual traits, work context, skills, and goals and tasks. Adaptive problem-based learning is a teaching method that is increasingly used to improve students' understanding of mathematics. Adaptive problem-based learning aims to adapt instruction to the unique needs of each student and encourage active participation from students during the learning process (Pujiriyanto et al., 2022).

Difficulties with problem-based learning Earlier studies on mathematics education aimed to improve students' conceptual understanding of the subject. One example of prior research is a study that Fitrah conducted in 2017. The researchers had only just begun to formulate a methodology that would completely incorporate adaptive learning. This study set out to determine how problem-based learning affected students' performance in the classroom. Mathematical comprehension is the end goal of adaptive learning.

This research has the potential to significantly improve students' understanding of mathematical concepts. There is a gap in the current literature that this study intends to fill by exploring the effects of problem-based learning on students' comprehensive understanding of mathematical concepts. Adaptive problem-based learning was one of the more conventional ways of instructing pupils in mathematical problem-solving. How problem-based learning influences students' understanding of mathematical ideas needs to be thoroughly investigated.

**METHOD**

This study focuses on Grade X students at SMA Negeri 1 Pantai Labu in North Sumatra Province. The school is located on Jalan Ramunia 1, Perkebunan Ramunia Village, Pantai Labu District, Deli Serdang Regency, among other locations. The implementation of the study will be carried out in the second half of the 2024–2025 academic year. The 2023–2024 academic year will show the direct impact of Problem-Based Adaptive Learning on the understanding of mathematical concepts among Grade X students at SMA Negeri 1 Pantai Labu in Deli Serdang Regency. Therefore, the research methodology used in this study is a quantitative quasi-experimental design. All grade X students at SMA Negeri 1 Pantai Labu are the study population. This study uses a stratified sampling method. Thirty students will be involved in Problem-Based Adaptive Learning, while the other thirty will use the conventional method.

This design can be described as follows:

Table 1 Research Design

|  |  |  |
| --- | --- | --- |
| **Group** | **Treatment** | **Post Test** |
| **Experiment(R)** | **X** | **O1** |
| **Control (R)** | **-** | **O2** |

Information :

|  |  |
| --- | --- |
| R = | The experimental group and control group of class X students at SMA Negeri 1 Pantai Labu were taken using the total sampling technique. |
| X = | Learning that involves learning through the Problem-Based Adaptive Learning model in the experimental group. |
| O1 = | The posttest results of the experimental group after receiving learning through the Problem-Based Learning model. |
| O2 = | The posttest results of the control group that received conventional learning using the direct learning model. |

The technique used is a test, which is based on exam questions. The assumption used is the capacity to understand conceptual relationships related to the subject matter being taught. Understanding a concept depends on the student's ability to articulate its meaning.

**1. Analysis of the Validity of the Question Instrument**

The validity of an instrument is indicated by its sensitivity to the target variable. The validity of the instrument in this study was tested using product moment correlation, as shown below:

Information :

: product moment correlation coefficient

x : score for each question/item

y : total score

n : number of respondents The validity testing criterion is that each item is valid ifobtained from the critical value of r product moment.(Indra Jaya, 2018)

The next step is to calculate using the t-test formula to get the calculated t value, with the formula:

The number of subjects is denoted by n, and the correlation coefficient is denoted by r. The next step is to compare certain levels of confidence (a) using tcount and ttable. The correlation index is valid if and only if tcount is ttable; if ttable for some levels of confidence (a), then the index is invalid.

**2. Reliability**

Evaluation of reliability coefficient using KR-21 technique. For dichotomous instruments, such as true-false, where the possible values ​​are 1 and 0, the KR21 formula can be used. The KR 21 procedure is used to conduct reliability assessment.(Widodo et al., 2023)

Information :

= instrument reliability

= number of questions

= mean/average score

= total variance

To calculate the total variance, the formula used is

Information :

*X*= Score

*N*= Number of respondents

= Total Variance

**Table 3.2 Test Reliability Categories**

|  |  |  |
| --- | --- | --- |
| **No** | **Interval** | **Category** |
| 1 |  | very high reliability |
| 2 |  | high reliability |
| 3 |  | moderate reliability |
| 4 |  | low reliability |
| 5 |  | very low reliability |

Data analysis This study assessed students’ mathematical problem-solving skills after participating in adaptive problem-based learning through descriptive data analysis. Inferential statistics is a subfield of statistics that extrapolates the results of statistical sample analysis to the entire population. Statistical tests, including normality tests and homogeneity tests, are conducted to verify that the variables being compared show similarities across groups. This is the initial stage of the procedure. Data from the sample are used to compare the means of the two groups through a t-test.

**RESULTS AND DISCUSSION**

The researcher will use IBM SPSS Statistics 30 to describe the research data for each variable. In summarizing the research findings for each variable, the following presentation will follow a systematic order:

**Table 4.4 Results of Descriptive Statistical Tests**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| N | | Range | Minimum | Maximum | Mean | Std. Deviation |
| Post-Test Control | 30 | 13 | 78 | 91 | 84.47 | 3.910 |
| Post-Test Experiment | 30 | 8 | 85 | 93 | 89.40 | 2,513 |
| Valid N (listwise) | 30 |  |  |  |  |  |

*Source: SPSS 30 output*

**C. PREREQUISITES TEST RESULTS**

**a. Results of the Normality Test of Students' Mathematical Concept Understanding**

Students' Mathematical Concept Understanding was analyzed by comparing the posttest scores in the control class and the experimental class. To determine students' Mathematical Concept Understanding, the following statistical test was conducted.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4.5 Normality Test Results** | | | | | | | | | | | | | |
|  | | | class | | | Kolmogorov-Smirnova | | |  | | Shapiro Wilk | | |
|  | | | Statistics | | | df | Sig. | Statistics | df | |  | Sig. |
| Mathematical Concept Understanding Test | | post-test control (conventional) | | | .107 | | 30 | .200\* | .955 |  | 30 |  | .223 |
| Post-Test Experiment (Problem-Based Adaptive Learning) | | | .128 | | 30 | .200\* | .937 |  | 30 |  | .074 |

Based on the table above, it is known that the significance value of the normality test for all data in both the Kolmogorov-Smirnov and Shapiro Wilk tests is > 0.05, which means that the data is normally distributed.

**b. Results of the Homogeneity Test of Students' Mathematical Concept Understanding**

The results of the homogeneity test using SPSS 30 are as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 4.6 Homogeneity Test Results** | | | | |
|  | | Levene Statistics | df1 | df2 |  | sig |
| Mathematical Concept Understanding Test | Based on Mean | 6,752 | 1 | 58 |  | .012 | |
| Based on Median | 6,620 | 1 | 58 |  | .013 | |
| Based on Median and with adjusted df | 6,620 | 1 | 53,098 |  | .013 | |
| Based on trimmed mean | 6,769 | 1 | 58 |  | .012 | |

**C. Hypothesis Test Results**

1. T-Test (Partial)

The purpose of the T-test is to determine the individual regression coefficients. This test will provide a value𝐻0 (there is no influence of mathematical competence or self-concept on students' mathematics learning outcomes) or𝐻1 (the influence of self-concept or mathematical competence on students' mathematics learning outcomes). This is based on the decision-making process.

a). Values ​​and values𝑆𝑖𝑔< 0.05 then𝐻1accepted,𝐻0rejected. There is a significant positive influence.

b). Values ​​and values𝑆𝑖𝑔> 0.05 then𝐻1rejected,𝐻0accepted. There is no significant positive effect.

**Table 4.7 T-Test Data Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Independent Samples Test** | | | | |
|  | | Levene's Test for Equality of Variances | | t-test for Equality of Means |
| F | Sig. | t |
|
| Students' Mathematical Concept Understanding Test | Equal variances assumed | 6,752 | .012 | -5.813 |
| Equal variances not assumed |  |  | -5.813 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Independent Samples Test** | | | | |
|  | | t-test for Equality of Means | | |
| df | Significance | |
| One-Sided p | Two-Sided p |
| Students' Mathematical Concept Understanding Test | Equal variances assumed | 58 | <.001 | <.001 |
| Equal variances not assumed | 49,467 | <.001 | <.001 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Independent Samples Test** | | | |
|  | | t-test for Equality of Means | |
| Mean Difference | Std. Error Difference |
|
| Students' Mathematical Concept Understanding Test | Equal variances assumed | -4.933 | .849 |
| Equal variances not assumed | -4.933 | .849 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Independent Samples Test** | | | |
|  | | t-test for Equality of Means | |
| 95% Confidence Interval of the Difference | |
| Lower | Upper |
| Students' Mathematical Concept Understanding Test | Equal variances assumed | -6.632 | -3.234 |
| Equal variances not assumed | -6.638 | -3.228 |

**E. DISCUSSION**

Students in tenth grade at SMA Negeri 1 Pantai Labu showed marked improvement in their trigonometry comprehension after engaging in an adaptive problem-based learning program, according to the findings. The data comes from a mathematical test that 61 students from SMA Negeri 1 Pantai Labu took in their eleventh year. Results from a partial T-test showed that in grade X at SMA Negeri 1 Pantai Labu, students' comprehension of mathematical ideas was negatively impacted by the adaptive learning variable (X). There is a statistical significance level of 0.012, just below the 0.05 threshold, and the t-value is 5.183, which is greater than the tabulated t-value. In order to improve students' understanding of mathematical concepts, adaptive learning methodologies gradually introduce more difficult problems.

The findings show that using adaptive problem-based learning strategies helps students understand mathematical ideas better. Improved mathematical comprehension can result from the classroom's systematic use of adaptive problem-based learning.

**CONCLUSION**

The results of the research and analysis show that mathematical concepts are influenced by problem-based adaptive learning in class X of SMA Negeri 1 Pantai Labu in the 2024/2025 academic year.

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