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Students understanding of mathematical concepts: A study based on the integrative learning model

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Abstract

This research aims to test the effect of the integrative learning model on students' understanding of mathematical concepts. The population of this study was all students in class VIII of SMP Negeri 11 Kendari spread across 3 classes. The sample determination in this research was carried out using a simple random technique so that 2 classes were obtained: class VIII1 as the experimental class where the integrative learning model was applied and class VIII2 as the control class where the problem-based learning model. The research design uses a Posttest Only Control Group Design. Research data was collected through instruments in the form of tests of understanding mathematical concepts through description questions and observation sheets. Data analysis techniques use descriptive and inferential statistics via the t-test at $\alpha = 0.05$. This research concludes that the integrative learning model influences the understanding of mathematical concepts in class VIII students at SMP Negeri 11 Kendari. Students' understanding of mathematical concepts taught with the integrative learning model is better and higher than with the problem-based learning model.

Keywords: Integrative learning; Student Understanding; Mathematical concepts; Problem-based learning.

1. Introduction

Mathematics is a subject studied from elementary school to university. This is how important mathematics is in learning. Understanding concepts is one aspect that students must master in the field of mathematics apart from problem-solving reasoning and communication. Students' ability to determine solutions to mathematical problems related to mastery or understanding of the concept of a subject is a problem in teaching mathematics. Students who do not understand basic mathematical concepts have difficulty working on various mathematical problems [1]. This problem arises because most students think that mathematics subjects are difficult to understand and students lack attention in receiving lessons[2], [3].

Understanding mathematical concepts is the earliest ability students must have in learning mathematics, as a foundation that must be solid in learning mathematics to achieve other abilities [4], [5]. Understanding concepts is the most basic stage that must be achieved by students so that it is easier to continue their level of understanding of mathematics to the next stage [6], [7]. Understanding mathematical concepts is the integrity of concepts that exist in mathematics with operations and relationships and can be measured using instrumental and relational categories [8]. Concept understanding is a student's ability to grasp concepts, operations, and relationships in mathematics [9], [10], the level of connection between an idea, procedure, or mathematical fact that is thoroughly understood and can be used to classify a group of objects [11]. Concept understanding is a person's ability to master a concept being studied and be able to re-express a concept in a language that is easy to understand [12]. Concept understanding is divided into two types, namely instrumental understanding and relational understanding. Instrumental understanding is defined as understanding mutually exclusive concepts and only memorizing simple calculation formulas. In this case, one only

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understands the sequence of working the algorithm. In contrast, relational understanding contains schemas and structures that can be used to solve broader and more meaningful problems [5], [13].

Understanding mathematical concepts is the ability of students to master the material by restating a concept and understanding obtained from learning which is seen through the ability to synchronize, think, and act shown by students in understanding the definition, special characteristics, essence, and essence/content of the material. mathematics and the ability to select and use procedures efficiently and precisely so that they can apply these concepts in everyday life, with indicators that students can: (1) restate a concept, (2) classify objects according to certain properties by the concept, (3) giving examples and non-examples of concepts, (4) developing necessary or sufficient conditions for a concept, (5) using, utilizing, and selecting certain procedures or operations, (6) presenting concepts in various forms of mathematical representation, and (7) applying concepts or problem-solving [14].

Students who master the concept can identify and work on new, more diverse problems [15]. Understanding a concept is very important because if students master the concept, students will easily develop reasoning abilities and have no difficulty understanding mathematical problems that require reasoning or non-routine questions [16]. Therefore, teachers need to design learning that can increase students' conceptual understanding of the material. A strong understanding of concepts also provides a solid foundation for students to expand the scope of their thinking [17]. Thus, they can adapt the concepts they have learned to real-world situations or different contexts. For example, in mathematics, a deep understanding of concepts such as ratios, proportions, or patterns can help students in solving more complex problems, such as applications in physics or economics [18]. Along with that, teachers also need to provide challenges that are appropriate to student's level of understanding to encourage them to think more creatively and analytically, thereby increasing their ability to solve more diverse problems. Thus, learning is not just about mastering concepts, but also about how to apply them flexibly in various contexts [19].

However, in reality, students' understanding of mathematical concepts is still low based on various studies, among others [16], [20]. This is also one of the problems faced at SMP Negeri 11 Kendari. In an interview with the class VIII mathematics teacher at SMP Negeri 11 Kendari, the researcher obtained information that in the learning process a learning model had been implemented that was the learning model recommended in the 2013 curriculum. However, the implementation was not optimal so students' ability to understand a mathematical concept was still limited. low. Students' lack of ability to understand mathematical concepts can be seen from students who are unable to work on the practice questions given by the teacher and at the end of the lesson students find it difficult to re-describe the material they have learned; students are not able to explain the similarities and differences of the material they have learned. has been studied. This happens because students tend to memorize a concept and not understand it. Students also still have difficulty in meeting mathematical concepts with everyday life, as a result, students have difficulty solving mathematical story problems that relate to everyday life. This is reinforced by the average daily test score for students in class VIII1 is 58.31, class VIII2 is 59.76 and class VIII3 is 55.36.

One of the causes of students' low understanding of mathematical concepts is the learning model applied by teachers. The learning model applied by mathematics teachers at SMP Negeri 11 Kendari is the problem-based learning (PBL) model. PBL is a collection of teaching models that use problems as a focus to develop problem-solving, material, and self-regulation skills [21], [22]. The PBL model is an active learning model that allows students to learn and hone problem-solving skills, develop competencies with academic content standards, and realize the relevance of applying learning according to the content for practical purposes [23], [24]. PBL is a learning model that presents contextual problems that can stimulate students to learn and produce ideas or hypotheses to be explored in an effort to understand relationships in the domain or to provide solutions to problems [25], [26]. This shows that in problem-based learning, students learn by doing, not by listening to the teacher teach or being asked to read and memorize. Teachers must therefore think about problem-based assignments and consider carefully what the outcomes of student learning are. PBL has three characteristics, namely: (1) lessons focus on problem-solving, (2) responsibility for solving problems rests with students, and (3) teachers support the process when students work on problems [27], [28]. However, the PBL model has not been able to improve students' ability to understand mathematical concepts.

One learning model that can be applied to improve students' understanding of mathematical concepts is the integrative learning model [29], [30]. The integrative model is ideal for teaching knowledge concepts because the aim of this model is to foster students' conceptual understanding of the content studied based on facts, concepts, and generalizations [31]. Learners begin to learn factual knowledge and then continue to use that knowledge to make greater connections between facts and concepts and ultimately make inferences about information about previously learned content. The syntax of the integrative learning model is explained in Table 1 [22].

Table 1 Integrative learning model syntax.

Phases of the integrative learning model	The role of the teacher	The role of students
Describe, compare and look for patterns	The teacher asks students to describe, compare, and look for patterns in the content that students examine. The teacher guides students through this phase by creating (or having students create) graphic organizers to enhance students' understanding of the information and recordings.	Students analyze content by explaining, comparing and looking for patterns in the content studied. They (or teachers) enter data/information into graphic organizers developed by teachers or students or developed jointly by teachers and students. (note: either the teacher or students record the data in a graphic organizer)
Explain the similarities and differences	The teacher asks students to explain the similarities and differences	Learners explain similarities and differences in the content studied and support their ideas using data from graphic organizers
Generate hypotheses from different circumstances	The teacher asks students to make hypotheses based on different conditions	Learners form hypotheses about possible outcomes related to the content being studied and based on different conditions
Generalize to form broad relationships	The teacher asks students to generalize their conclusions	Learners generalize their understanding to demonstrate understanding of the broad relationships between the content studied

Based on the description that has been explained, this research aims to determine the effect of the integrative learning model on students' understanding of mathematical concepts.

2. Material and methods

This research is a quasi-experiment carried out in class VIII of SMP Negeri 11 Kendari, Indonesia, which consists of three parallel classes. The sample in this study was class VIII1 as the experimental class and VIII2 as the control class which was determined by simple random. The number of students in the experimental class and control class was 30 students each. In the experimental class, an integrative learning model was applied, while in the control class, the PBL model was applied. The variables used in this research consist of the dependent variable and the independent variable. The dependent variable is understanding of mathematical concepts (Y) and the independent variable is the learning model (X). The dependent variable Y is divided into two parts, namely Y1 is students' understanding of mathematical concepts taught using the integrative model and Y2 is students' understanding of mathematical concepts taught using the PBL model. Variable X is also divided into two parts, namely integrative learning model (X1) and PBL (X2). The design used in this research was Posttest Only Control Group Design.

The instrument used to collect data on students' understanding of mathematical concepts is a test in the form of a description of six questions that have been validated, while the instrument used to observe the implementation of learning using both the integrative model and the PBL model uses an observation sheet. The data obtained was analyzed using descriptive and inferential statistics. The statistic used to test the hypothesis is the one-way t-test.

The research procedure was carried out in stages: (1) applying the integrative learning model to the experimental class for six meetings, (2) applying the PBL model to the control class for six meetings, (3) giving post-tests to the experimental class and control class, and (4) analyzing research data.

3. Results

The results of the descriptive analysis of students' understanding of mathematical concepts after learning with the integrative model and PBL are explained in table 2.

Table 2 Students' Understanding of Mathematical Concepts

Statistics	Experimental Class (Y1)	Control Class (Y2)
The number of students	30	30
Average	67.92	59.17
Std. Dev	13.05	12.59
variance	170.18	158.53
Minimum	41.66	20.83
Maximum	83.33	83.33

Based on Table 2, it is found that the average understanding of students' mathematical concepts taught using the integrative model in the experimental class is 67.92 with a standard deviation of 13.05 a minimum value of 41.66, and a maximum value of 83.33. The average understanding of mathematical concepts taught using the PBL model is 59.17 with a standard deviation of 12.59, a minimum value of 20.83, and a maximum of 83.33. This shows that the ability to understand mathematical concepts taught using the integrative learning model is higher than understanding concepts taught using the PBL model.

Students' understanding of mathematical concepts based on high, medium, and low categories taught using the integrative learning model and PBL is explained in Table 3.

Table 3 Categories of students' understanding of mathematical concepts after being taught using the Integrative Learning Model and PBL

Category	Integrative Learning Model		PBL Model	
	Frequency	Percentage (%)	Frequency	Percentage (%)
High	16	53.33	5	16.67
Medium	8	26.67	15	50
Low	6	20	10	33.33
Total	30	100	30	100

Based on Table 3, it can be seen that students' understanding of mathematical concepts taught using the integrative learning model is in the high category at 53.33%, in the medium category at 26.67%, and in the low category at 20%. Understanding of mathematical concepts of students taught using the PBL model is in the high category as much as 16.67%, as much as 50% in the medium category, and in the low category as much as 33.33%. The results show that students' understanding of mathematical concepts taught with the integrative learning model is better than PBL.

The hypothesis that will be tested in this study is "students' understanding of mathematical concepts taught with the integrative learning model is higher than with the PBL model", with the hypothesis formulation being H_0: $\mu_1 \leq \mu_2$ vs H_1: $\mu_1 > \mu_2$. H_0 means there is no difference between students' understanding of mathematical concepts taught using the integrative learning model and the PBL model. H_1 means that students' understanding of mathematical concepts taught using the integrative learning model is higher than the PBL model. The analysis used to test this hypothesis is the t-test. Before using the t-test, two conditions must be tested, namely data normality and data homogeneity.

The Kolmogorov-Smirnov test was used to test the normality of variable data for students' understanding of mathematical concepts taught using the integrative learning model and PBL. The hypothesis to be tested is H0 The data is normally distributed and H1 the data is not normally distributed, with the test criteria accepting H0 if the sig (2-tailed) value is greater than α=0.05, otherwise H0 is rejected. The results of the data normality test for the variable understanding of mathematical concepts taught using the integrative learning model obtained sig. (2-tailed) is 0.411 and the variable data for students' mathematical understanding taught using the PBL model is 0.5978. These results show that the sig data value is greater than α=0.05. This means that the data for both variables is normally distributed.

The homogeneity of variance test is used to determine whether the variance of the two groups of data on students' understanding of mathematical concepts taught using the integrative model and PBL is homogeneous or not. The statistic used to test data homogeneity is the Levene test. The hypothesis to be tested is H0 which states that both groups of data have homogeneous variances and H1 states that both groups have inhomogeneous variances. The testing criteria is to accept H0 if the sig (2-tailed) value is greater than α=0.05, otherwise H0 is rejected. The results of the homogeneity of variance test analysis obtained a value of Sig = 0.580 which is greater than α = 0.05. This means that both data have homogeneous variance.

Based on the results of testing data normality and data homogeneity, the statistical test used to test the hypothesis is the t-test. The hypothesis that will be tested is that students' understanding of mathematical concepts taught with the integrative learning model is higher than with the PBL model. The test results obtained a value of sig.=0.005 which is smaller than α=0.05. This means that H0 is rejected or students' understanding of mathematical concepts taught with the integrative learning model is higher than with the PBL model.

4. Discussion

Learning activities with an integrative learning model in the experimental class begin with the preliminary stage, namely greeting, checking whereabouts, providing apperception, providing motivation, conveying learning objectives and learning steps to students. Then the teacher asks the students to read a mathematics textbook on straight line equations, then the teacher directs the students' attention to the pictures in the textbook and asks the students to look for similarities and differences in the pictures given. Next, participants were asked to explain the similarities and differences between the images. After students describe the similarities and differences in the images, the teacher then provides learning materials and gives students the opportunity to ask questions about the images they have previously observed. In the next stage, the teacher distributes the LAS (Learner Activity Sheets) to students and then asks students to observe the questions on the LAS, then students are asked to write down the information obtained on the LAS, provide individual assistance by directing the work on the LAS. At this stage, the teacher's role is to direct and guide students through explanations or questions that lead to solving problems if there are students who ask questions. After completing the problems from the LAS according to the specified time, several students are selected to communicate the results of their work and then respond to them by their classmates. The teacher plays the role of directing the discussion, correcting students if there are wrong answers, and helping students draw the correct conclusions from the results of problem-solving created by students. At the end of the meeting, the teacher who guides the participants brings conclusions to the material they have studied and gives assignments. The preparation of the stages in this learning emphasizes students being able to solve a problem with their own ideas so that the lesson material can be easily remembered by students and not easily forgotten and can train and improve students' understanding of mathematical concepts.

Based on the results of descriptive analysis of the data obtained on students' understanding of mathematical concepts, the average score of the experimental class was higher than the average score of the control class. Based on the average score, the understanding of mathematical concepts of experimental class students is higher than the understanding of mathematical concepts of control class students. This indicates that from the average value indicator, the integrative learning model is able to have a positive influence in increasing students' understanding of mathematical concepts when compared to the PBL model. From the indicator of data diversity (variance), the experimental class students' understanding of mathematical concepts data had a larger variance compared to the control class post-test data. The variance values of the two groups show that the experimental class students' understanding of mathematical concepts is more varied than the control class.

Learning in the experimental class was better than the control class, although there were several obstacles that hindered it, for example there were students who chose to remain silent when asked or did not want to give an opinion. Because teachers use an integrative learning model that is not teacher-centered, students are required to be active in undergoing the learning process of searching and finding. The learning model applied in the control class is also a learning model that organizes it to activate student activities, but there are several weaknesses. This is the reason why students in the experimental class understand mathematical concepts better than students in the control class who are taught using the PBL model.

The results of the inferential analysis show that students' understanding of mathematical concepts taught using the integrative learning model is higher than students' understanding of mathematical concepts taught using the PBL model. If linked to the results of descriptive analysis in terms of averages and categorization, it can be concluded that the integrative learning model has a significant influence on the understanding of mathematical concepts of class VIII students at SMP Negeri 11 Kendari. This is in accordance with the theory of [8] that the integrative learning model

provides students with the opportunity to build their own understanding of the topics they are studying rather than simply recording lessons in a form that has been arranged systematically. Apart from that, based on previous research conducted by [31], it was concluded that the integrative learning model can improve students' ability to understand mathematical concepts. Research conducted by [30] concluded that the application of the integrative learning model was more influential than the application of the conventional learning model on students' mathematical communication skills in statistics material in class IX students at SMP Negeri 8 Kendari

The integrative learning model encourages students to think in groups and individually, participate actively in learning, and be able to solve problems and draw the right conclusion/solution to a problem. In this way, participants are trained to be more skilled in solving a problem or drawing appropriate conclusions/solutions. The facts obtained in this research are that there is an influence of the use of integrative learning models on students' understanding of mathematical concepts or that the use of integrative learning models is better than the use of PBL models on students' understanding of mathematical concepts.

5. Conclusion

Based on the research results and discussion in this study, it can be concluded that the average understanding of mathematical concepts for students taught using the integrative learning model is higher and better than the PBL model. The application of the integrative learning model influences the understanding of mathematical concepts in class VIII students at SMP Negeri 11 Kendari.

From the results of this research, it is recommended that mathematics teachers and other researchers use the Integrative learning model in mathematics learning to optimize students' understanding of mathematical concepts.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have declared no conflict of interest in relation to this article.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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