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Implementation of Scientific Approach in Reducing Student Misconceptions on Energy Matter

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The purpose of this study was to determine the effect of applying scientific approaches to reduce student misconceptions. The subjects of this study were students of Noemuti State High School with a sample size of 58 students obtained through purposive sampling techniques, which were then divided into 2 groups, namely the experimental group and the control group. This research itself is a quasi-experimental research with a Nonequivalent Control Group Design research design. Misconception data was obtained by giving a test in the form of a multiple-choice test of 25 questions with 5 answer choices with the help of CRI. The results showed that the percentage of misconceptions during the pre-test was almost the same between the experimental and control groups, namely 46.05% and 45.25%. Meanwhile, after being given treatment to the experimental group and carrying out a post-test, there was a difference in the percentage of student misconceptions between the experimental and control groups, namely 20.69% for the experimental class and 34.90% for the control group. Furthermore, from the results of data analysis using the t-test, the sig value of the research data was obtained from 0.00 < 0.05. This shows that there is an influence of scientific approaches on reducing student misconceptions where. By using a scientific approach, the reduction of student misconceptions is better than without using a scientific approach.

1. Introduction

One of the important objectives of the science learning process in the classroom is to help students improve their understanding of science concepts (conceptual understanding in science). The definition of Concept Understanding has been put forward by several experts according to their respective points of view Dinata (2019), Krieger (2012), and Septiani &; Pujiastuti (2020) defines concept understanding as a skill that individuals have to master a particular concept. Meanwhile, Hounsell (1997) defines Concept Understanding as an individual's ability to understand something holistically and thoroughly. Meanwhile, when viewed from psychological studies, understanding concepts is the result of mental processes that are able to make meaningful connections about facts and ideas that were previously separated or have stand-alone meanings (Halford, 1993; Johnson-Laird, 1983; Kusuma & Baskara, 2022; Tarmidzi, 2019). A person with a good understanding of concepts is able to make and understand the relationship of these facts and describe them in words (Auliya, 2016; Perkins, 2006).

In more detail, understanding the concept of Science is defined as the ability of students to organize facts and ideas so that they can be compiled into concepts that have meaning in Science (Kang & Howren, 2004). Understanding of these science concepts is needed by students in the process of understanding the meaning of these science concepts and the benefits of science for students' daily lives (Rosalind et al., 1996). Understanding the concept of science is also the result of the process of combining initial knowledge and new knowledge to form a valid scientific concept (Mintzes et al., 2005; Murtadlo et al., 2023; Scott et al., 2007; Yulinda et al., 2023). In addition, understanding concepts in science is also considered the most critical component in Science Literacy (Rini et al., 2021; Zahroh &; Yuliani, 2021), where students not only memorize concepts but make meaning about these science concepts through the learning process in the classroom and are able to relate them to their daily lives.

Until now, understanding concepts in science learning is one of the topics of concern for many studies in the field of education (Olympiou & Zacharia, 2012; Pines & West, 1986; Zahroh & Yuliani, 2021). Over the past 30 years, many researchers have focused on how to transform learners' understanding of science concepts through classroom learning. Research so far has also focused on identifying which science concepts are difficult for students to understand, how to get teachers to convey these concepts more explicitly and specific strategies that teachers need to apply to avoid misconceptions in students (Chiu et al., 2007).

However, in its journey, the process of learning science to help students gain an understanding of science concepts is never free from misconceptions that may occur. Some previous studies have given different terms to misconceptions such as "Alternative Concepts" or "Personal Models of Learner Science" as ways to define learner science concepts that are erroneous or deviate from what they should be (Chiu et al., 2007; Rhosalia, 2017; Smarabawa et al., 2013). Misconceptions can occur because when learning something new, learners may already have prior knowledge of a particular concept without being based on a valid explanation of science. Usually, the initial concepts that have been ingrained in the minds of these students are very strong and difficult to change even though they have learned the concept of science to explain it (Goris & Dyrenfurth, 2010; Lisa, 2019).

Misconceptions will have their own disadvantages for students if they are not identified early by the teacher. Misperception itself can result in errors in understanding the true meaning of a concept. This makes students' understanding become disconnected between one concept and another which eventually makes them confused and errors arise in understanding the concept. Therefore, the process of identifying student misconceptions needs to be done at the elementary level when students begin to recognize science concepts, namely from the junior high school level. The process of identifying student misconceptions from an early age at the junior high school level is very important to help teachers get an idea of things that make students difficult to learn, what science concepts need special attention and what learning strategies need to be applied to certain science concepts.

Until now, research conducted in Indonesia has reviewed more misconceptions of students (Faizah, 2016; Laksana, 2017; Shidik &; Tae, 2022; Yuliati, 2017; Zahroh &; Yuliani, 2021). Therefore, this study aims to not only identify misconceptions in students but also to provide treatment in the form of a scientific approach that teachers can take to minimize misconceptions in students. The Scientific Approach is defined as a learning approach that enables students to build their own scientific concepts through several important stages, namely: observing, formulating problems, proposing or formulating hypotheses, collecting data, analyzing data, drawing conclusions communicating these scientific concepts (Sufairoh, 2017). The Science approach in the Science learning process has several characteristics, including being student-centered, aiming to develop students' Science Process Skills (PPP), developing students' higher-order thinking skills (HOTS) and aiming to develop student character.

This research focuses on Energy materials at the high school level. According to the 2013 Curriculum, Energy material must be studied by students since grade 8 junior high school and then continued in grade XI high school level. Energy is one of the most basic science/physics topics. Understanding the concept of Energy will be very useful for students to be able to understand other materials such as Business, kinematics, Dynamics to practical sciences such as Astronomy. In addition, understanding the Energy kosnep is also the basis for students to understand other concepts in chemistry and biology subjects at the high school level later. Therefore, it is necessary to increase the understanding of the concept of Energy well since the junior high school level which will later be very useful at a higher level.

It is hoped that the results of this research description will be able to provide an overview of which science (Physics) concepts are still misinterpreted by students and the application of the Scientific approach as one of the efforts of the teacher learning approach in reducing student misconceptions. The results of this study can be used as a basis for improving the approach to science learning in the classroom which not only aims to increase students' understanding of science concepts but also reduce the possibility of misconceptions that can be made by students through improvement content knowledge or pedagogical content knowledge teacher (Shulman, 1987, 2011).

So, the formulation of the problem in this study is how does the influence of the scientific approach in reducing student misconceptions? In addition, this study has several benefits. First, to provide information to physics teachers about misconceptions and understanding of concepts owned by students in solving energy problems, so that teachers can find the cause of teaching failures or where students' errors lie in learning energy materials, Second, to provide information about the influence of scientific approaches in learning Physics to reduce student misconceptions and increase students' understanding of concepts on the material Energy.

2. Method

This research was conducted at Noemuti State High School, North Central Timor Regency, East Nusa Tenggara Province. The study time started from the end of July to October 2021. The population of this study was all students who were at Noemuti State High School. Furthermore, sampling was carried out by *Purpossive Sampling* where 2 classes were selected in class XI with 29 students each as the control class and the Experimental class.

This study used Quasi Experimental Design research method with *Nonequivalent Control Group Design* research design. This research design is used because the experimental class and control class are not randomly selected but are selected based on certain criteria, namely these two classes are classes at the same level (class XI) which in the National Curriculum will both study Energy matter. Both groups (experimental class and control class were then given the same tests using CRI instruments.

After that, the two groups were given different treatment, where the Experimental class was given a Scientific Approach to teaching Energy material and the Control class was given a Group

Discussion Learning Method on the same subject matter. At the end of the treatment, both test groups were given tests with the same questions as the CRI instrument. *Pre-test* and *post-test* are given with the aim to see if there is an influence of scientific approach on reducing students' misconceptions on Energy matter. The reasearch design presented in Figure 1.

E	O1	X1	O2
C	O3	-	O4

Figure 1. Research design

Information:
E : Experimental Class
C : Control Class
O1 : Initial tests (before treatment) in the experimental group
O2 : Final Test (after treatment) in the experimental group
O3 Initial tests (before treatment) in the control group
O4 Final Test (before treatment) in the control group
X1 : Application of Scientific Approach

The data in this study used primary data, which means that researchers took their own data by analyzing statistical data (Pramiyati et al., 2017; Suhono &; Fatta, 2021; Tashakkori & Teddlie, 2010). In general, the data collection technique that the author chose was to use multiple choice tests given to the control class and the experimental class before and after the treatment. The test instrument in this study uses the CRI (Certainty of Response Index) method which is a measure of the level of confidence / certainty of respondents in answering each question (question) given (Saehana & Kasim, 2011; Tayubi, 2005). CRI is also used to identify misconceptions that learners have on Energy matter. CRI criteria and categories can be seen in Table 1 and 2.

Table 1. *CRI's criteria*

CRI	Criteria
0	Totally guessed answer
1	Almost guess
2	Not Sure
3	Sure
4	Almost certain
5	Certain

(A'yun et al., 2018)

Table 2. Students' misconception categories

Answer	Low CRI (0-2)		High CRI (3-5)	
	Correct Reason	Wrong Reason	Correct Reason	Wrong Reason
Correct	Lucky/Guessing (L)	Not Understanding Concepts (NUC)	Understanding Concepts/Expert (E)	False Positive Misconceptions (M)
Wrong	Not Understanding Concepts (NUC)	Not Understanding Concepts (NUC)	False Negative Misconceptions (M)	Pure Misconceptions (M)

Quantitative data is obtained from the results of the test of understanding the concepts and misconceptions of learners which are then processed by quantitative descriptive analysis using CRI in accordance with the instruments owned. Data exposure is depicted in the form of Tables, graphs, and diagrams. Next, the data will be tested for normality and homogeneity. And it ends with a hypothesis test using a t-test with the help of the SPSS application.

3. Result and Discussion

Misconceptions of Learners on the *Pre-Test*

The test instrument used is a validated multiple choice question (Shidik & Tae, 2022). The test instrument consists of 25 questions equipped with the confidence level of students when answering the questions using the CRI index (Certainty of Response Index). This data was then analyzed with the following details: these 25 questions were prepared with diverse cognitive abilities in accordance with the Competency Standards and Basic Competencies of the curriculum used at the current high school level. The questions used have been validated in previous studies (Shidik & Tae, 2022) and has been arranged based on the grid of questions made and equipped with a description of the cognitive level tested on the question. Based on the latest level of Bloom's taxonomy (Lafendry, 2023; Wulandari et al., 2020), the cognitive level of students when learning is sorted from C1 to C6 with details of remembering, understanding, applying, analyzing, evaluating to create. The validated questions have 7 questions at level C1, 5 questions at level C2, 7 questions at level C3 and 6 questions at level C4.

Students in the experimental class and control class were given the same questions and asked to answer questions equipped with confidence levels (Index CRI) when choosing these answers. The results of the students' work are then examined and analyzed statistically as follows. The percentage of pre-test misconceptions of Control Class learners can be seen in Table 3.

Table 3. Control class learner pre-test score percentage

	PK/UC	TB/LG	TPK/NUC	MK/MC
%	35.45	8.97	10.07	45.52

Information:

HP : Understand Concept

TB : Lucky Guess

TPK : Don't Understand Concept

MK : Misconceptions

From the data above, it can be seen that there are 4 categories obtained, namely Understanding the Concept (PK) / Understanding the Concept (UC), Lucky Guess (TB) / *Lucky Guess* (LG), Not Understanding the Concept (TPK*) / Not Understanding the Concept* (*NUC), and Misconception (MK) / Misconception (MC).*

After being given the test, it was found that the number of misconceptions in the Energy material was quite large, which was almost half of the students tested (45.52%). While those who really understand the concept are 35.45%, a fairly large number. This is exacerbated by the number of students who are lucky to guess (TB) which is 8.97% and does not understand the perception at all which is 10.07%. percentage of pre-test misconceptions Learners Experimental class can be seen in Table 4.

Table 4. Percentage of pre-test scores of experimental class students

	UC	LG	NUC	(MC)
%	35.17	8.55	10.21	46.07

As for the experimental class, more or less the same data were obtained, namely the misconceptions that students had on Energy matter were almost half (46.07%). This resulted in the level of understanding of students' concepts on energy matter less than 40%, which is 35.17%. Meanwhile, the percentage rate of Lucky Guesses on questions reached 8.55% and those who did not understand the concept at all was 10.21%

Based on both data in the experimental class and the control class, it can be concluded that on average, the misconceptions of students in the experimental class and control class are quite large, with a presentation close to 50%. This is also accompanied by the presentation of students who do not understand the concept and guess with the correct guess, which is around 20%. This number makes the presentation of students who understand the concept of Energy material only about 30%, an alarming number even though Energy material is not a new material, but has been learned by students at the junior high school level.

Furthermore, when studied further statistically, it can be seen that misconceptions that are often made by students are concentrated on questions with certain numbers. This is shown in detail in the graph in figure 2.

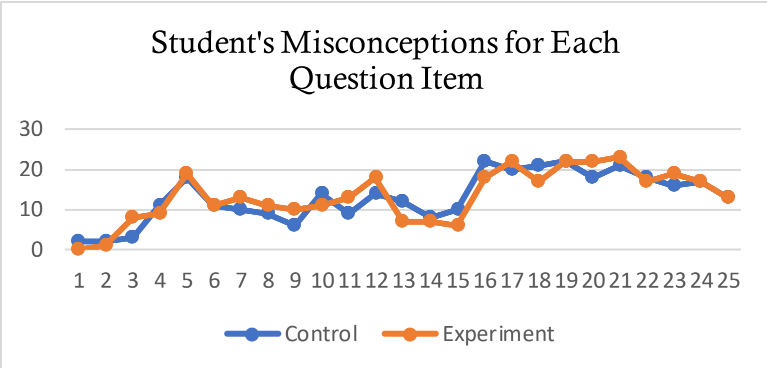

Figure 2. Graph of student misconceptions for each pre-test question item

From the data above, it can be seen that there are several questions where students make a little misconception, namely in questions number 1, 2, 3, 4, 13, 14, and 15 with the number of misconceptions ranging from 2-16 times. Meanwhile, the questions with the highest level of misconception were made by students on 11 questions with the level of misconception ranging from 32 to 44 times. While the remaining 7 questions are question categories where students make misconceptions with a moderate number with a range of 20 to 26 times per question.

Misconceptions that learners make on the material can be influenced by several factors. The first factor can be influenced by low understanding of concepts and the second factor can be related to students' low initial ability regarding Energy matter. This is because Energy material is a mandatory material that students learn when they are still in junior high school. However, the energy material that students learn during junior high school still revolves around understanding the concepts of C1 and C2 levels (remembering and understanding). Thus, when given questions with cognitive levels C3 and C4 (Applying and analyzing), many students make misconceptions. For example, in questions 16 and 17 (levels C3 and C4) where students make many misconceptions. The results of this acquisition are in line with the results of the research obtained Maison et al. (2020), where students' misconceptions in the material work and energy 80% and 43% in the material relationship of kinetic energy with potential.

Misconceptions experienced by students based on the results of this study are on the material of mechanical energy and the application of the law of conservation of mechanical energy in

everyday life. In addition, students are also not fully capable of connecting concepts and formulas that will be used in some calculation problems.
As in question number 11 with the question "When the catapult is drawn there is potential energy but when the catapult is released there is a change in kinetic energy, from this case it can be concluded that the transfer of an energy is always accompanied by the presence of a ...

A. Style
B. Transfer
C. Business
d. mass
e. motion"

This question is to measure the ability of learners to connect Energy and Work which many learners misanswer due to misconceptions. In this problem, many students choose the answer choice "movement and motion" where students cannot see the concept holistically. A thorough understanding should be able to connect the concepts of Displacement and Style that are united through the concept of Business. In Bloom's taxonomy. The activity of connecting the concepts learned is included in the category of analyzing (C4) where students are required to connect several concepts learned separately (for example displacement and force) then unite them in the concept of Business (W) and link it again with the concept of Engeri (E).

On question number 17, used to test students' understanding of the law of conservation of Mechanical Energy, where the form of questions and answer choices are as follows:
"Below which is an example of the event of the law of conservation of mechanical energy is....
a. A child pushes the Table until it changes places
b. A child pushes against a wall but does not experience displacement
c. The fall of manga fruit from the tree
d. Mango fruit that is still hanging on the tree
e. The car when it is in a sharp corner at a certain speed"

Based on the question above, it is known that this question measures the cognitive realm at the C3 level (application), where learners are required to apply the concept of the law of conservation of Mechanical Energy in everyday life. Misconceptions of students on Energy material can occur because students find it difficult to connect the concept of Mechanical Energy as a term that he has just encountered with everyday events such as when manga are still on trees, the process of falling manga fruit or when pushing a Table or wall. Psychologically, theory Bruner (1964) Human Cognitive Development when learning new things can be used to explain this. Bruner argues that there are 3 specific stages when students learn new things, namely the Information stage (new learners learn new information/concepts), the Transformation stage (understanding and digesting the new concept) and the Evaluation stage (providing an assessment of whether the newly learned concept is true or not) (Fauziati, 2021; Unaenah et al., 2020).

So the process of misconception in learners can occur when learners fail to reach the stage of Transformation in cognitive processes in their brains (Dayanti &; Nursangaji, 2019). This results in students failing to relate the concept of the Law of Conservation of Mechanical Energy with everyday events where if the learner understands the knosep correctly then he should understand that eternal mechanical energy can be seen in the process of falling manggga fruit. In this example, the fallen mango undergoes a change in energy form from potential to mechanical energy but no energy is lost, where the mechanical energy is conserved. Most likely students still cannot associate the term Mechanical Energy or the Law of Mechanical Energy with everyday events that he encounters.

Misconceptions of Learners After Post-Test

The next step carried out in this study is the provision of treatment, where in the experimental class teaching is carried out using a scientific approach while the control class uses the group discussion method. The Scientific Approach in the Experiment class is carried out by referring to several main 5M steps, namely Observing, Questioning, Processing, Analyzing Data, and Communicating ideas (Sufairoh, 2017). While the steps of the discussion method in general include the teacher dividing the class into small groups, providing discussion material, giving opportunities for students to discuss and then asking students to present the results of the discussion.

After being treated, students are then given a test of 25 multiple-choice questions which are the same as the questions in the pre-test. These questions are also equipped with the CRI method (Hasan et al., 1999) which asks the level of confidence of learners regarding the answers given. This confidence level is given a scale of 0 to 5 with details of Criteria 0 (Totally Guessed Answer) 1 (Almost Guess) 2 (Not Sure) 3 (Sure) 4 (Almost Certain) 5 (Certain=Sure). The misconception data is then described in detail as in Table 5.

Table 5. Post-test score percentage of control and experimental class students

	Understand the Concept (UC)	**Not Understand the Concept/Lucky Guess (LG)**	**Not Understand the Concept (NUC)**	**Misconception (MC)**
% Control Class	54.76	5.52	4.83	34.90
% Experimental Class	65.52	5.66	8.14	20.69

From the Table above, it can be concluded that there was an increase in students' understanding of concepts in the control class by 19.31% where the initial data was 35.45% to 54.76%. This is also accompanied by a decrease in student misconceptions, where the initial data from 45.52% to 34.90%. As for the experimental class, there was an increase in understanding of concepts and a significant decrease in students' misconceptions on Energy matter. The presentation of learners who really understood the concept rose from 35.17 to 65.52%. Meanwhile, misconceptions made by students also decreased significantly, from 46.07% to 20,69%. This shows that the Scientific approach helps learners to reduce misconceptions that may be possessed when learning Energy material. In more detail, the distribution and frequency made by students can be seen in the graph in figure 3.

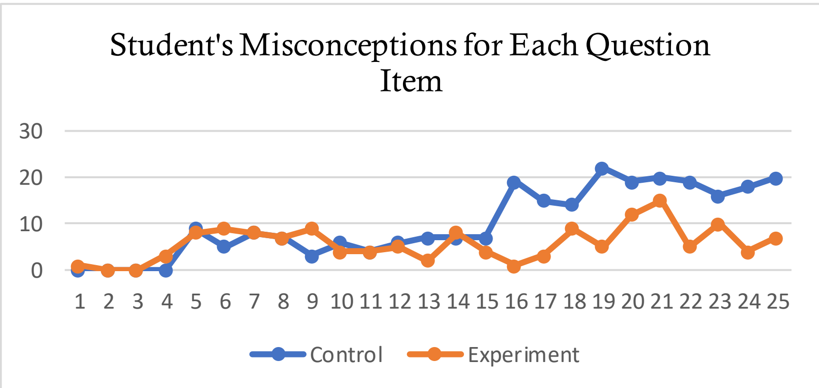

Figure 3. Graph of student misconceptions for each post-test question item

From the graph in figure 3, it can be seen that after being given treatment in the experimental class and control class, on average, there was a decrease in student misconceptions. From figure

3, it is obtained that the category of questions with a low level of misconceptions is increasing, namely 16 questions with a frequency of misconceptions ranging from 0-18 times each question. Also, there was a significant decrease in the frequency of moderate misconceptions only in 7 questions (questions number 16, 18, 19, 22, 23, 24 and 25) with the frequency of misconceptions ranging from 20-27 times per question. High category misconceptions only occur in 2 questions (numbers 20 and 21) with a frequency of errors ranging from 31 and 35 respectively on each question.

After describing the research data, then proceed with prerequisite tests and research hypothesis tests. The prerequisite test carried out is by conducting a normality test and a data homogeneity test. In the normality test, data are obtained as presented in Table 6:

Table 6. Normality test results

Kolmogorov-Smirnova			Shapiro-Wilk		
Statistic	**df**	**Itself.**	**Statistic**	**df**	**Itself.**
.157	29	.065	.940	29	.101
.155	29	.071	.966	29	.466

a. Lilliefors Significance Correction

A normality test is needed in this study to find out if the sample is normally distributed in the experimental class and the control class. From the data above, it can be seen that the control class and experimental class are normally distributed as evidenced by the sig value > α where in the control class sig = 0.101 > α = 0.05 and in the experimental class sig = 0.466 > α = 0.05. Because the data has been distributed normally, it can be carried out to the next statistical test, namely the homogeneity test, presented in Table 7.

Table 7. Homogeneity test results

		Levene Statistic	df1	df2	Itself.
Misconceptions	Based on Mean	.827	1	56	.367
	Based on Median	.531	1	56	.469
	Based on Median and with adjusted df	.531	1	48.486	.470
	Based on trimmed mean	.805	1	56	.373

From the data in Table 7 above, it can be seen that the control class and the experimental class have homogeneous data where the sig value > 0.05, which is 0.367 > 0.05. Departing from this prerequisite test, hypothesis testing can be done using t because the data obtained have been normally distributed and homogeneous. The results of the hypothesis test can be showed in Table 8. Based on Table 8, it can be seen that the value of sig. (2-tailed) < 0.05, so it can be concluded that there is an influence of scientific approaches on reducing student misconceptions, where the value of SIG. 0.00 < 0.05.

Table 8. Results of hypothesis test with t-test

		Levene's Test for Equality of Variances		**t-test for Equality of Means**				
		F	Itself.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Misconceptions	Equal variances assumed	.827	.367	-5.004	56	.000	-2.724	.544
	Equal variances not assumed			-5.004	54.428	.000	-2.724	.544

Based on the results of the hypothesis test, applying a scientific approach can reduce student misperception. When looking at the difference between the experimental class and the control class, it can be seen in figure 3 that although both have decreased misconceptions, there is a significant difference between the experimental class and the control class, where the orange line shows that the experimental class has a much smaller number of misconceptions compared to the control class (blue line).

In the experimental class, treatment is given in the form of a Scientific Approach where the learning steps refer to the 5M, namely Observing, Questioning, Processing, Analyzing Data, and Communicating ideas (Sufairoh, 2016). From the steps of the scientific approach, it can be seen that Learners are guided to discover concepts for themselves through the learning process of constructivism. From Step 5 M, students are invited not only to remember or understand (levels C1 and C2) but are required to think HOTS with a higher cognitive level (C2 and C4). This allows students to be able to analyze questions with a high level of difficulty such as questions number 9, 13, 16, 20, 24 and 25 with a cognitive level of C4. Statistical analysis has shown that there are many misconceptions found in this problem with error rates ranging from 32 to 44 times for each problem.

Nevertheless, the scientific approach provides opportunities for students to be able to analyze problems well, thus training HOTS thinking skills at C3 and C4 levels (applying and analyzing). As a result, after being given a scientific approach, the number of misconceptions in these numbers decreased significantly with the frequency level being 9 times, 2 times, 1 time, 12 times, 4 times and 5 times respectively. This shows that students' misconceptions have decreased significantly before and after being given a scientific approach to Energy matter.

The scientific approach is learning that utilizes scientific approaches and inquiry, where students have a direct role both as individuals and groups to find concepts or principles during the learning process (Marjan et al., 2014). With a scientific approach, it allows students to collect data objectively in solving problems. Therefore, the scientific approach is referred to as the inductive approach, where the scientific approach begins with specific things leading to conclusions with a general nature (Dahliana et al., 2019).

Learning with a scientific approach in experimental groups is conceptualized to involve students in solving problems in several groups, expressing opinions and presenting the results of the discussion. Learning begins with several problems that are close to the daily lives of students and carried out in groups can make students more communicative. Students in their groups, discuss and exchange understanding and present the results (Fauziah et al., 2013; Tawil et al., 2014). In the group too, students express their opinions to other group members, create works to report the results of discussions and present the results of problem discussions in front of the class (Jamil, 2019).

From the learning process that has been carried out using a scientific approach in the experimental group and learning without using a scientific approach in the control group, it is known that these two approaches have different influences in reducing student misconceptions. The influence exerted by scientific approaches is greater when compared to non-scientific approaches. This is in accordance with the opinion that states a scientific approach can improve students' understanding of concepts (Ilyana et al., 2015; Ridzal et al., 2022), so as to reduce misconceptions that learners have.

4. Conclusion

Based on the research hypothesis test and the discussion stated earlier, it can be seen that the misconceptions of students obtained have almost the same percentage, namely in the experimental group is 46.07% and the control group is 45.52%. After the application of the scientific approach in the experimental group and the final test, there was a considerable influence on reducing student misconceptions, where in the experimental group it was obtained 20.68% while in the control group it was 34.90%. The calculation results with t-test, obtained sig value. 0.00 < 0.05 so that it can be concluded that "the application of a scientific approach has a positive effect on reducing student misconceptions compared to those that are not given a scientific approach". The results of this study can be used as a reference for teachers and schools to review student misconceptions. In addition, it can better apply the use of scientific approaches in learning to minimize misconceptions in students.

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