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SCIENTIFIC REASONING IN PROBLEM-BASED DISTANCE LEARNING WITH THE HELP OF EDMODO ON WAVE TOPIC

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ABSTRACT

Abstract: Scientific reasoning ability is the ability to complete the results of an investigation. The purpose of this study was to analyze the ability of scientific reasoning in problem-based distance learning assisted by Edmodo. The design of this research is implanted experimental. Subjects of this research were 70 students of class XI MIPA SMAN 2 Jember. The instrument used in the form of 4 essay questions. The n-gain value of the experimental class was 0.795 (high), the control class was 0.313 (medium). While the effect size of the experimental class is 3.28 (strong) and the control is 1 (enough). This shows that problem-based distance learning assisted by Edmodo has a strong effect on students' reasoning abilities on wave material.

INTRODUCTION

Scientific reasoning is an essential ability for the 21st century (Bao et al., 2018; Khoirina et al., 2018). Scientific reasoning is extremely beneficial for students' in-depth comprehension of subjects. This is because there is a process of thinking and reasoning involved in scientific reasoning (Alshamali and Daher, 2016). In addition, there is a process of deriving new findings from established concepts and facts (Mariana et al., 2018; Sutopo and Waldrip, 2014).

Numerous studies on the capacity for scientific reasoning have been conducted. Among these are the examination of scientific reasoning skills in the field of science (Chen et al., 2019) and the evaluation of scientific reasoning using classroom discourse analysis methods (Lee and Irving, 2018). In physics education, the study of scientific reasoning skills has been extensive. Static fluid materials (Prastiwi et al., 2018; Purwana and Rusdiana, 2021), elasticity and Hooke's law (Firdausi et al., 2020), temperature and heat (Rimadani and Diantoro, 2017), and electrical circuits (Wardani, 2018).) Nevertheless, studies of scientific reasoning on wave matter are still uncommon.

Multiple studies have revealed that students misunderstand the physical link between the wavelength, speed, and frequency of waves (Kryjevskaia et al., 2012; Tumanggor et al., 2020). Misconceptions in understanding the propagation of sound waves and differentiating the features of wave propagation (Caleon and Subramaniam, 2010; Kryjevskaia et al., 2011). The difficulty with which pupils comprehend the wave material indicates that they have not fully comprehended the notion of waves.

There is a need for a learning paradigm that can foster scientific reasoning in students about wave topic. Typically, models for developing scientific reasoning abilities emphasize experimental, project, and evaluation activities (Fazio et al., 2008). Students may actively participate in studying, collecting evidence, and assessing an experiment in order to draw conclusions about a specific theory. According to these activities, learning is problem-based learning. This is a constructivist learning method that employs real-world challenges (Kardipah and Wibawa, 2020; Milana and Jannati, 2018). Nevertheless, problem-based learning is more challenging to apply during the COVID-19 pandemic. This is because the problem cannot be presented in person. Therefore, problem-based learning and distant learning can be combined. Distance learning consists of learning that can be completed anywhere and at any time. In addition, it is cost-effective because there are no travel expenses or other expenses associated with attending face-to-face classes (Kim, 2020). The disadvantage of distant learning, however, is that the learning process is less focused and yields less than optimal comprehension (Bonal and González, 2020). Thus, the utilization of educational technology is required. Several prior research supported the sustainability of problem-based distance learning by utilizing Edmodo. This application is utilized in momentum and impulse materials (Tania et al., 2020), static and dynamic fluids (Herawati and Jumadi, 2020; Tiarasari et al., 2018), and temperature and heat (Yunita, 2016). The media on Edmodo has a good effect on learning. Students are able to comprehend information on their own, allowing for effective learning (Rahmaningrum, 2016). The prior meeting's learning is readily accessible to students (Sugito et al., 2019) facilitating students' ability to recall earlier lessons. Rarely is research conducted about the usage of Edmodo on wave materials. Given the significance of scientific wave matter logic. Therefore, further study is required. This study was undertaken with the purpose of examining scientific reasoning skills in problem-based, Edmodo-assisted remote learning.

METHOD

This research design used *embedded experimental* and uses two classes without manipulating the given treatment variables. The participants of this study were 35 students of class XI MIPA 1 and 35 students of XI MIPA 2 at SMAN 2 Jember. The instrument used in the form of four essay questions by following three patterns of scientific reasoning as follows: *correlational reasoning pattern* on question number 1, *proportional reasoning* pattern on questions number 2 and 3 and the pattern *of probabilistic reasoning* in question number 4.

The first pattern is *correlational reasoning* with the assessment categories in the form of (a) No Answer (score 0); (b) *Intuitive* (score 1); (c) *No Relationship* (score 2); (d) *One Cell* (score 3); (e) *Two Cell* (score 4). The second category of assessment pattern (*proportional reasoning) is* (a) No Answer (score 0); (b) *Intuitive* (score 1); (c) *Additive* (score 2); (d) *Transitional* (score 3); (e) *Ratio* (score 4) . Meanwhile, the third category of scientific reasoning pattern (*porbabilistic reasoning)* includes (a) No Answer (score 0); (b) *Intuitive* (score 1); (c) *Approximate* (score 2); (d) Quantitative (score 3).

The stages of data collection in this study were observation, tests and interviews. Observations were administered before the intervention was implemented. The test was held twice in the form of *pretest* and *posttest.* Meanwhile, interviews were conducted to complete the test data.

Quantitative data in this study were tested for normality using the *Kolmogorov Smirnov.* Then, it was analyzed by calculating the normalized gain average score (*N-gain)* to determine the students' scientific reasoning ability. In addition, the *effect size* calculation was also used to measure the low, medium, and high influence of the learning model on scientific reasoning abilities. After analyzing quantitative data, qualitative data analysis was carried out in the form of interviews. The stages of interview data analysis consisted of reduction, data presentation and conclusion drawing.

RESULTS

Based on the *pretest* and posttest scores of the experimental and control classes, it was found that the largest increase was obtained by the experimental class as shown in the diagram in Figure 1 below.

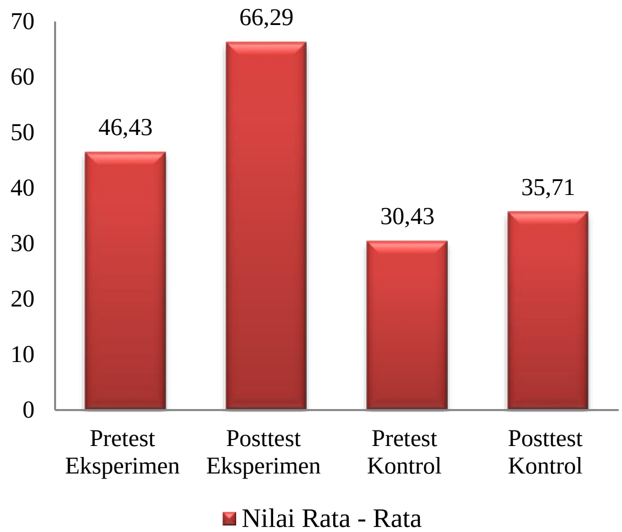

Figure 1. The Scores of Pre-tests and Post-test for Experimental and Control Class

On the first item with a pattern of correlational reasoning for the experimental class, the No Answering (TM) category answers are known to be 31. Meanwhile, there are no students in the No Answering (TM) group on the posttest. This demonstrates that at the time of the posttest, pupils were capable of addressing issue number one. However, not all students could appropriately respond. This is demonstrated by the fact that just 25 students were classified as correlation answers during the posttest. While the answer category for the control class at the pretest contained 24 students in the No Answering (TM) category, the posttest contained 11 students in this category. Thus, some students in the control group cannot solve problem number 1.

Table 1. Answer Category Number 1 Correlational Reasoning

Number	Test	Class	Answer Category					
			TM	I	NR	OC	TC	C
1	Pretest	Experimental	31	0	0	4	0	0
	Posttest	Experimental	0	0	0	10	0	25
	Pretest	Control	24	0	11	0	0	0
	Posttest	Control	11	5	6	0	0	13

In the second item with a proportional reasoning pattern, an image of two ropes joined is shown. The students are then instructed to study the relationship between the wave's wavelength and its speed. During the experimental class's pretest, there were two responses in the intuitive category. They provided the "correct" response without providing an explanation. They should have provided the "correct" explanation. Image analysis reveals that the wavelength of string II is longer than that of string I. Consequently, the speed of wave II will be faster than that of wave one. In contrast, the majority of pre- and post-test responses from students in the control group fell into the No Answering (TM) category. This indicates that the students in the control group cannot answer the second question.

Table 2. Answer Category Number 2 Proportional Reasoning

Number	Test	Class	Answer Category				
			TM	I	Ad	tr	R
2	Pretest	Experimental	22	2	0	5	6
	Posttest	Experimental	5	0	0	13	17
	Pretest	Control	25	6	0	2	2
	Posttest	Control	14	6	0	10	5

The difficulty pertains to item no. 3 "Two ropes of differing densities are joined and then stretched to a specific tension. The end of the little rope is vibrated sinusoidally for a few moments, resulting in the formation of a wave with the pattern depicted in the image below. Students are then instructed to compare the speed of the waves in the two ropes under the same tension. No Answer is the category with the most responses on the experimental and control class pretest (TM). The highest category on the posttest for the experimental class was the Ratio category. They supplied the response "The speed (v)of the smaller rope is greater than that of the larger one. Because vit is affected by the medium, the thinner the media, the quicker it will travel. However, if it is thicker, it will move more slowly. During the posttest, the majority of responses from the control group were classified as No Answer (TM). In the Transitional category, eight students responded "The speed of the waves on a tiny rope is greater than that on a long rope." It can be deduced from these responses that pupils provide a comparison without an explanation. This demonstrates that students are unable to provide an explanation for the given responses.

Table 3. Answer Category Number 3 *Proportional Reasoning*

Number	Test	Class	Answer Category				
			TM	I	Ad	tr	R
3	Pretest	Experimental	20	0	0	9	6
	Posttest	Experimental	2	0	0	8	25
	Pretest	Control	22	0	0	9	4
	Posttest	Control	21	0	0	8	3

In the form of experimental results, a probabilistic reasoning pattern is presented with a challenge. Students are instructed to assess experimental conclusions that explain how voltage affects the speed of wave propagation. During the pretest, the majority of experimental class responses fell into the Intuitive category. They responded with "Yes. This is evident from the table." Students have not been able to provide an explanation for the given answers based on these responses. In addition, many of the interviewees explain that they estimated the answer based on the findings of the interviews. On the posttest, however, the majority of experimental class students replied in the Quantitative group. They are able to provide acceptable reasons and explanations for all difficulties by explicating their interrelationships.

During the pretest, the majority of responses from the control group were Intuitive. They simply guess the answer or provide it without an explanation. During the posttest, the majority of responses fell into the category of Approximate. They provide reasons and explanations, yet there is no connection between the things described. The student responds "Yes. The wave travels faster the higher the voltage. This is affected by the wave's frequency.

Table 4. Answer Category Number 4 *Probabilistic Reasoning*

Number	Test	Class	Answer Category			
			TM	I	ap	Q
4	Pretest	Experimental	15	20	0	0
	Posttest	Experimental	0	0	5	30
	Pretest	Control	31	0	4	0
	Posttest	Control	0	7	23	5

DISCUSSION
Correlational Reasoning

The pattern of scientific reasoning is correlational reasoning in the form of the ability to relate between variables or phenomena being studied (Suryadi et al., 2021). The findings of the experimental class pretest indicate that students continue to be incapable of answering the number one question. It is revealed that 31 students did not respond. Similar to the findings of the pre-test administered to the control group, as many as 24 students did not submit responses. This indicates that students are classified as weak in solving problems requiring a pattern of correlative reasoning. This is consistent with the findings of earlier research indicating that pupils continue to struggle with identifying the cause and impact of an issue. In addition, students' comprehension of the structure of correlational reasoning is typically delayed (Ding, 2018).

The posttest findings of the experimental and control classes revealed, however, that the experimental class students were able to provide more correlational responses than the control class students. This is due to the fact that problem-based remote learning facilitated by Edmodo instructs experimental class students to undertake an experiment. Students' scientific reasoning skills can be enhanced by experiential learning (Putri et al., 2020; Wulandari and Shofiyah, 2018). The following are instances of pre- and post-test responses for students in experimental classes.

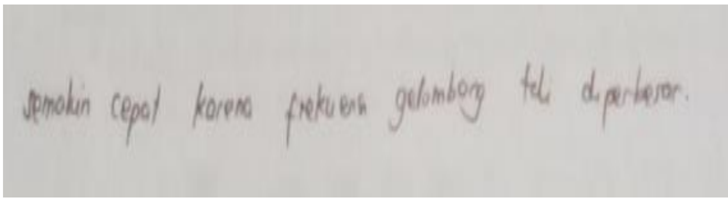

Figure 2. Example of Answers for Pretest Experimental Class Students in the One Cell category

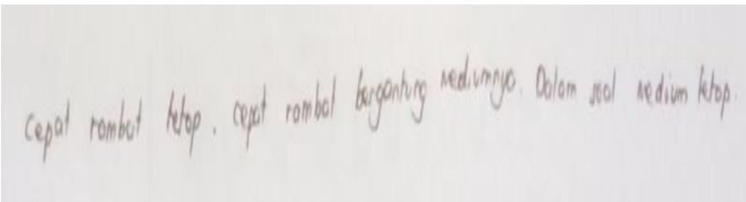

Figure 3. Example of Posttest Answers for Experimental Class Students in the Correlational Category

It is evident from Figure 2 that students responded by referencing a problem. In contrast, the association is less accurate or less consistent with the real theory. According to Table 1, 24 students in the control group did not respond to the pretest, whereas 11 students did not respond to the posttest. Students admitted, based on the findings of interviews, that they were unable to answer the problem in question 1 This indicates that students do not yet comprehend the concept of waves in the number 1. In fact, students require a solid grasp of concepts in order to reason about natural occurrences. In other words, correlational thinking can facilitate students' conceptual understanding (Nieminen et al., 2012). In addition, eleven students answered "no relationship" on the pre-test, but only six on the post-test. They stated that when the frequency increases, the speed of wave propagation will increase. Then, thirteen students responded in the correlation category on the post-test.

Proportional Reasoning

Items number 2 and 3 have a *proportional reasoning pattern*. This pattern directs students to solve problems related to comparisons (Arican, 2021; Brown et al., 2020) . In item number 2, the experimental class at the *pretest* category has the most No Answers (TM). However, at the *posttest* the most category was *ratio*. The following is an example of an experimental class student's answer.

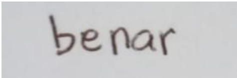

Figure 4. Sample Answer *Pretest* Number 2 Experimental Class Students in the *Intuitive category e*

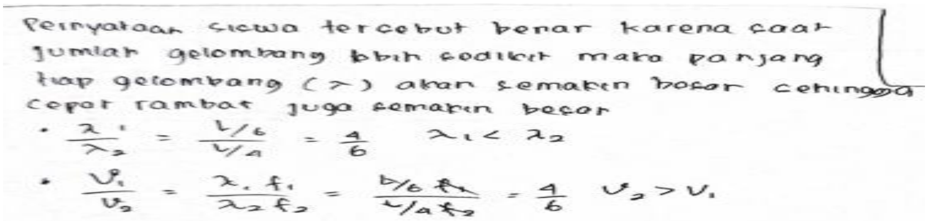

Figure 5. Example of Posttest Answer Number 2 Experimental Class Students in the Ratio Category

Figure 4 depicts the type of intuitive responses provided by students. Students have not yet responded by providing additional explanations. They frequently guess answers and employ unpredictable problem-solving tactics. This demonstrates that the students' knowledge remains insufficient. Have not reached the level of adequate comprehension. Occasionally, students provide answers and rationales. This is seen in table 4 of transitional categories. There is no correlation between responses and solutions (Atabaş and ner, 2017). According to prior study, developing proportional reasoning is challenging. Therefore, goal-oriented learning is necessary (Hilton et al., 2016). Consequently, in this study, Edmodo assisted problem-based distant learning. The success of this learning is demonstrated by the fact that 17 students in the experimental class scored as ratio on the posttest. They deliver solutions by employing the proper method for comparison equations. Different is the case for students in the control class. The following are examples of pre- and post-test responses for students in the control group.

Figure 6 . Example of Answers for Posttest Number 2 Control Class Students in the Intuitive Category

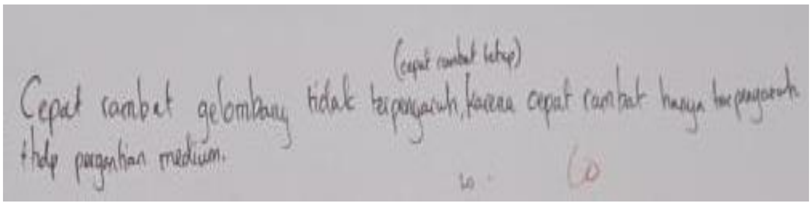

Figure 7 . Sample Answer for Posttest Number 2 Control Class students in the Ratio category

Figure 6 demonstrates that students provided brief responses and preferred to guess. The same applies to students' responses in experimental classes (figure 4). Then, figure 7 displays student responses with explanations of answers. Nonetheless, the category of answer ratio in the control group is lower than in the control group. On the pretest with the transitional category, nine experimental class students answered question 3; they provided the following responses.

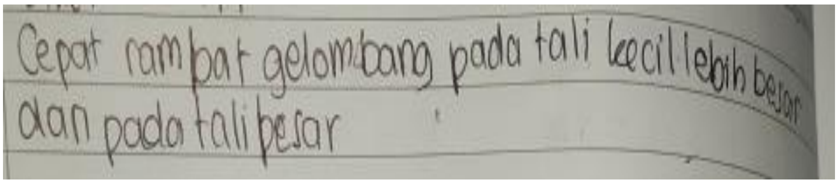

Figure 8. Example of Pretest Answers Number 3 Experiment Class Students in the Intuitive category

Figure 8 demonstrates that students answer questions using comparisons. Nevertheless, these parallels explain comparisons that contradict the actual theory. On the posttest, however, the majority of experimental class students were able to provide responses in the ratio category. These are instances of student responses:

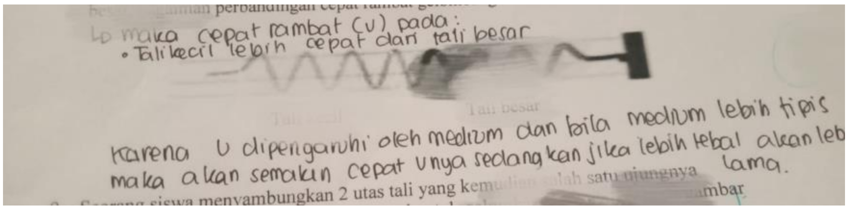

Figure 9. Example of Answers for Pretest Number 3 Experimental Class Students in the Ratio Category

Item question number 3 p is in the control class, and the answer category does not provide a response; there are 20 participants in the pretest and two in the posttest. They explained, based on the findings of the interviews, that they did not comprehend the solution to problem number 3. In the intuitive category, nine individuals took the pre-test, and eight individuals took the post-test. During the pretest, they responded that the speed of the smaller rope was greater than that of the larger rope but did not provide a justification for their response.

Probabilistic Reasoning

Item number 4 has a *probabilistic reasoning pattern.* This pattern directs students to determine the right or wrong conclusion from a problem with the right explanation (Sundari and Rimadani, 2020) . Based on Table 4, in the experimental class, 15 students were categorized as *intuitive.* They give the correct answer. However, it does not provide a reason for this answer. Based on the results of the interview, they admitted that they did not understand the cause. In addition, they admitted that they were not careful with questions that required explanations for their answers.

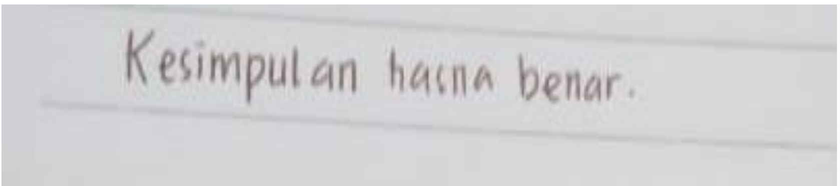

Figure 10. Example of Answers for Pretest Experimental Class Students in the Intuitive Category

The results of the *posttest* experimental class obtained as many as 30 students in quantitative category. This illustrates that students have been able to provide further explanations by providing both qualitative and quantitative evidence (Sari et al., 2017) . In addition, students have been able to interpret the experimental results and produce a conclusion. This can be seen in Figure 11.

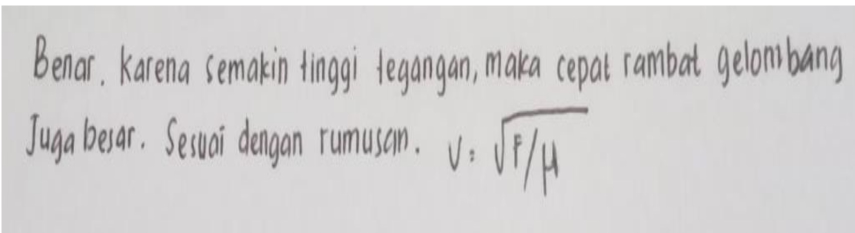

Figure 11. Example of Posttest Answers for Experimental Class Students in the Quantitative Category

The results of the pretest item number 4 in the control class were found to be 31 students in the category of not answering. Meanwhile, at the posttest, most of the answer categories were in the intuitive category. They have not been able to explain with quantitative and qualitative evidence of the answers given. Only 5 students with quantitative answer category. The answer in the quantitative category of the control class is much less than that of the experimental class. This is because in the control class, students are not given the opportunity to think logically, reflect on a phenomenon, and provide explanations regarding certain phenomena (Firdausi et al., 2020) . In other words, learning in the experimental class resulted in weak reasoning abilities.

CONCLUSION

Based on the results and discussion, it was determined that the majority of categories on the pretest for the experimental and control classes were three patterns of scientific reasoning: No Answering, Inference, and Argumentation (TM). It might be concluded that the initial scientific reasoning capacity of the students is poor. However, after receiving instruction, pupils' scientific thinking abilities enhanced in general. In the control group, the majority of correlational reasoning pattern responses are classified as correlation. The pattern of proportional reasoning for items 2 and 3 is classified as not answering. In the pattern of probabilistic thinking, however, the majority of solutions are approximations. This demonstrates that the highest level attained by the control group is the pattern of correlative reasoning. Unlike the post-test outcomes of the experimental class. The majority of replies in the pattern of correlational reasoning fall under the category of correlation. The majority of categories in the proportional reasoning pattern are items 2 and 3, namely the ratio. In contrast, the most prevalent category in the probabilistic pattern is quantitative. This demonstrates that after edmodo-assisted problem-based distance learning, experimental class students' scientific reasoning skill on three patterns may reach the greatest level.

Further research can be done on students' scientific reasoning abilities on wave material by using more scientific reasoning patterns. This can further improve students' understanding of wave materialThis section shows how the work advances the field from the present state of knowledge. In some journals, it's a separate section; in others, it's the last paragraph of the Discussion section. Whatever the case, without a clear conclusion section, reviewers and readers will find it difficult to judge your work and whether it merits publication in the journal. A common error in this section is repeating the abstract, or just listing experimental results. Trivial statements of your results are unacceptable in this section. You should provide a clear scientific justification for your work in this section and indicate uses and extensions if appropriate. Moreover, you can suggest future experiments and point out those that are underway. You can propose present global and specific conclusions, in relation to the objectives included in the introduction.

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