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Identify Student's Scientific Reasoning Skill in Straight Motion Material

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ABSTRACT

Objective: This study aims to identify the level of scientific reasoning skills of students. **Method:** The type of research used is descriptive quantitative. The subjects of this study were 10th-grade students at 1st State SHS Menganti. The test given is five questions, each of which includes four indicators of scientific reasoning skills: theoretical reasoning, correlational reasoning, proportional reasoning, and probabilistic reasoning. The research method used is a preliminary study through reviews, determining research objectives, developing research instruments, validating instruments, collecting data, and analyzing and interpreting data. **Results:** The results of the research conducted show that the level of students' scientific reasoning skills in the theoretical reasoning pattern is quite good because they can interpret the existing theory with the data on the problem. Students' scientific reasoning skills in the correlational reasoning pattern still need to improve because only one student can answer questions at level 5. Students' scientific reasoning skills in the proportional reasoning pattern still need to improve because only one student's answer reaches the level 4 Ratio (R). The students' scientific reasoning skills in the probabilistic reasoning pattern still need to improve because only three are at level 3. **Novelty:** With this research, it is hoped to provide information about the importance of training students' scientific reasoning skills. Scientific reasoning skills are essential and related to science education (not only in scientific contexts but also in everyday life).

INTRODUCTION

Based on the 2022 public education report for the public high school level in the province of East Java states that the results achieved by students show that the literacy skills of most of the participants have reached the minimum competency limit for reading but need to encourage more students to become proficient. Meanwhile, the ability to count shows that less than 50% of students have reached the minimum competency limit for arithmetic. This is undoubtedly related to the quality of the participant's learning process, where the teacher's reflection index is still classified as passive, namely efforts to improve the quality of learning sporadically only to complete assignments (Alexandra et al., 2019). The teacher uses an iterative method to carry out learning, and there is no visible reflective process. Based on the Program for International Student Assessment (PISA) is a three-year survey of 15-year-old students that assesses how much they have acquired the critical knowledge and skills essential for full participation in society. The assessment focuses on proficiency in reading, mathematics, science, and the innovative domain (in 2018, the innovative domain is global competence) and the well-being of students. Indonesian students score lower than the OECD average in reading, math, and science (Ding, 2014). About 40% of students in Indonesia achieve Level 2 or higher in science (OECD average: 78%). Learners can identify correct explanations for familiar scientific phenomena and can use that knowledge to identify, in simple cases, whether a conclusion is valid based on the data.

In Indonesia, the percentage of students in science at Level 5 or 6 is low (OECD average: 7%). These learners need to be more creative and independent in applying their science knowledge to various situations, including unfamiliar situations (OECD, 2019). Learning in schools should develop scientific reasoning skills to help the younger generation deal with problems in the surrounding environment. Hence, students can think and reason correctly (Fulmer, 2015). In addition, scientific reasoning skills are essential to know because they represent the skills needed to solve problems in scientific investigation (Han, 2013). Scientific reasoning skills are a skill in conclusions based on existing evidence (Yao et al., 2016). Reasoning is the process of describing conclusions from the evidence. The transfer of learning calls forth a meaningful learning process relevant to the subject's characteristics (Jatmiko et al., 2016). Physics encompasses characteristics pertinent to concepts and mathematics through the scientific method (Fadlillah, 2014). The inquiry has been the cornerstone of effective science learning to construct knowledge through scientific method and reasoning since the 1960s (Barz & Achimaş-Cadariu, 2017). Scientific arguments are prepared orally and written to empower students' reasoning. They are encouraged to ponder the characteristics of certain subjects, especially Physics, on the topic of straight-motion material (Kant et al., 2017). The learning process in Physics requires theoretical content of Physics in the form of fact, concept, or principle and calls for investigation, evidence collection, analysis, and evaluation of the understanding of Physics (Erlina & Wicaksono, 2016; Toplis, 2015). Mastering empirical Physics content requires evidence or fact and systematic reasoning resulting from investigation to encourage meaningful teaching of Physics (Cepni, 2017; Erlina et al., 2017; Susantini et al., 2016).

Based on the research results at 1st State SHS Menganti, it can be identified that the term scientific reasoning 90% of students have never heard of. Scientific reasoning patterns such as theoretical, correlational, proportional, and probabilistic reasoning have never been taught. So, it is necessary to train scientific reasoning skills, especially in physics subjects, in straight-motion material, to improve numeracy skills. In science education, developing scientific reasoning ability is an important goal that has long been pursued and prioritized (Jan et al., 2016). Thus, one of the primary tasks of science education is to cultivate students into good reasoners and become scientific literate (Luo et al., 2020). Science educators have also made great efforts to foster students' scientific thinking and reasoning by engaging in familiar phenomena in daily life contexts (Kind & Osborne, 2017; van der Graaf et al., 2019). Students' low scientific reasoning is evinced by the fact that they can choose mathematical equations correctly, but there is still potential ambiguity when determining their meaning (Brookes & Etkina, 2015).

The framework for science education adopted in the United States regards "engaging in argument from evidence," which was based on the reasoning ability to evaluate evidence about correlation and cause, as one of the eight significant practices in science and engineering (Yao & Guo, 2017). The ability and processes of collecting data based on observation and formulating evidence are essential to scientific inquiry and should be emphasized (Insani & Sunarti, 2018). However, in existing scientific reasoning assessments, how students use evidence to support their reasoning processes needs to be more adequately considered and evaluated (Osborne, 2013). Cognitive psychology is divided into two main aspects to develop scientific reasoning: the investigative process of procedural knowledge and the inferential process of conceptual knowledge (Pelamonia & Corebima, 2015). The scientific reasoning using EBR, especially in inquiry-based Physics teaching, can show how competent students are to perform the components of scientific reasoning, i.e., control of variables, proportional thinking, probabilistic thinking, correlational thinking, and hypothetical-deductive reasoning (Ding et al., 2016b; Piraksa, Srisawasdi, & Koul, 2014). Scientific reasoning skills are critical and related to science education (in scientific contexts and everyday life) (Ding et al., 2016a). Scientific reasoning skills are "skills to understand and apply scientific concepts, methods, and findings that are appropriate when solving scientific problems in research, professional practice, and everyday life" (Berndt et al., 2021). Based on the description above, various research sources and pre-research results state that scientific reasoning skills are critical to be applied to learning, including physics (Wati & Sunarti, 2019).

RESEARCH METHOD

The type of research used is descriptive quantitative to identify the scientific reasoning skills of grade 10 students at 1st State SHS Menganti. The data retrieval method used is in **Figure 1**.

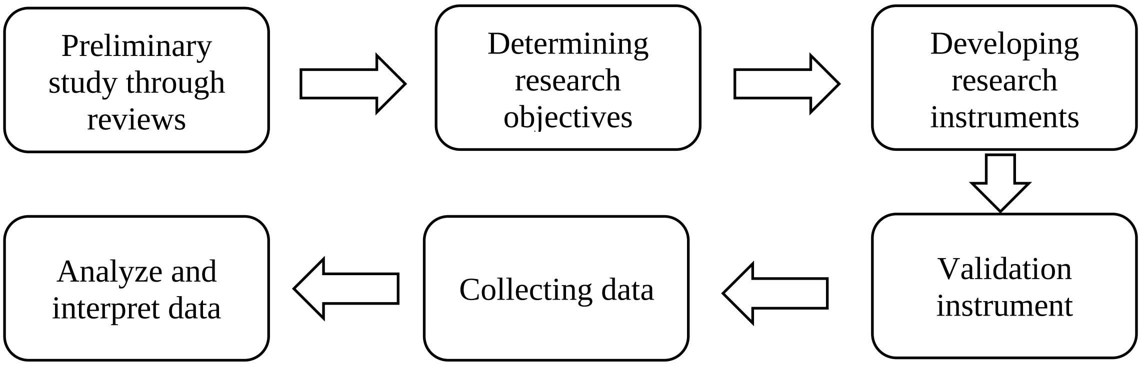

Figure 1. Flowchart of research procedure (Sugiyono. 2017).

This test determines the level of a student's scientific reasoning skills. The subjects of this study were 11 students in grade 10 at 1st State SHS Menganti. The test given is five questions, each of which includes four indicators of scientific reasoning skills: theoretical reasoning, correlational reasoning, proportional reasoning, and probabilistic reasoning. The analysis of students' scientific reasoning skills is categorized in **Table 1**.

Table 1. Patterns of scientific reasoning skills.

Pattern	Category	Level	Information
Theoretical Reasoning	Students' skills in applying theory to interpret data (Shofiyah, 2013).	-	
Correlational Reasoning	No answer (TM)	0	No answer
	Intuitive (In)	1	Guess the answer using number operations, but the answer is not logical
	No Relationship (NR)	2	Give reasons and explanations, but the things described are not related
	One Cell (OC)	3	Give reasons with the relevance of a problem

Pattern	Category	Level	Information
	Two Cell (TC)	4	Give reasons for the relationship between the two problems
	Correlation (C)	5	Give reasons and answers correctly for all problems and explain the relationship between problems and reasons.
Proportional Reasoning	No answer (TM)	0	No answer
	Intuitive (In)	1	Guess the answer using number operations, but the answer is not logical
	Additive (Ad)	2	Use a finishing strategy but focus on different things
	Transitional (Tr)	3	Implement and use the ratio strategy and determine the value but it needs to be revised.
	Ratio (R)	4	Implement and use ratio strategy and determine value appropriately
Probabilistic Reasoning	No answer (TM)	0	No answer (TM)
	Intuitive (In)	1	Guess the answer using number operations, but the answer is not logical
	Approximate (Ap)	2	Provide explanations and reasons with qualitative descriptions
	Quantitative (Qn)	3	Provide explanations and reasons with a quantitative description

(Rimadani et al., 2017)

RESULTS AND DISCUSSION

Results

This study aims to determine the results of the scientific reasoning skills of 11th-grade students at 1st State SHS Menganti on the material of straight motion. Four patterns of scientific reasoning skills indicators are used: theoretical reasoning, correlational reasoning, proportional reasoning, and probabilistic reasoning (Xiao, 2018). Thus, the scientific reasoning skills test consisting of five questions obtained the **Figure 2**.

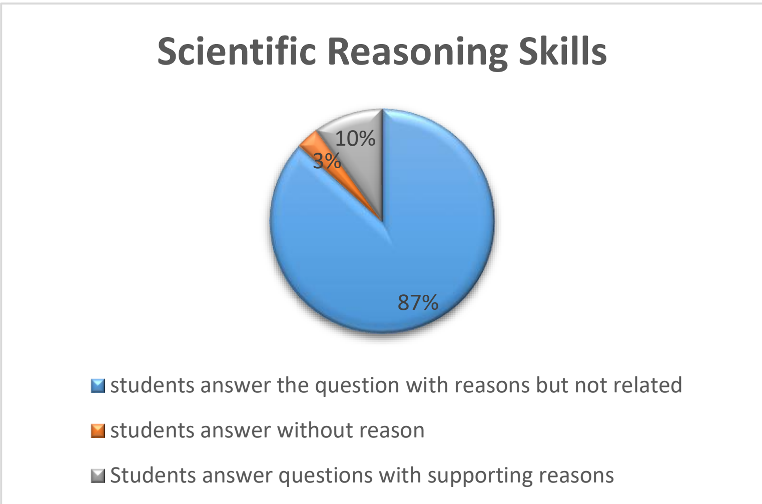

Figure 2. The results of students' scientific reasoning skills.

Based on the research that has been done on the test questions, patterns of scientific reasoning such as theoretical reasoning, correlational reasoning, proportional reasoning, and probabilistic reasoning have never been taught. This is evidenced by several scientific reasoning questions on straight-motion material that were tested on students, namely 87% of students answered the question with reasons but not related, 3% of students answered without reason, and only 10% answered questions with supporting reasons.

Discussion

In the first pattern, the question of scientific reasoning skills is the theoretical reasoning pattern. Students are presented with a distance graph against time; then, students are asked to analyze the speed of the uniform, straight motion. Some students have been able to use the theory correctly. However, there still needs to be an interpretation related to the data presented. Student data on the theoretical reasoning pattern can be presented in **Table 2.**

Table 2. Respondents on theoretical reasoning pattern.

Theoretical Reasoning	Uniform Straight Motion Theory s = v.t	Data on questions	
		Distance (s)	Time (t)
Suitable	6	8	8
Less Suitable	2	0	0
No Answers	3	3	3

Based on **Table 2** and the category scientific reasoning skills Rimadani et al. (2017), it is known that of the 11 students who answered scientific reasoning questions with a theoretical reasoning pattern that matched the theory, as many as six people who answered less appropriate as many as two people, and three people who answered inappropriately. There were no students who answered less appropriately, and there were three students who did not answer. Thus, students' scientific reasoning skills in the theoretical reasoning pattern are pretty good. Meanwhile, students who can answer questions by interpreting data on distance questions with time and students who answer according to as many as eight people. Students are asked questions about analyzing physical quantities in straight motion with constant (fixed) speed and straight motion with constant (fixed) acceleration. In the second pattern, the question of scientific reasoning skills is the correlational reasoning pattern. Student data on the correlational reasoning pattern can be presented in **Table 3.**

Table 3. Respondents on correlational reasoning patterns.

Correlational Reasoning	No Answer (NA)	Intuitive (In)	No Relationship (NR)	One Cell (OC)	Two Cell (TC)	Correlation (C)
Answer	1	2	3	2	2	1
Level	0	1	2	3	4	5

Based on the table and theory from Rimadani et al. (2017), it is known that of the 11 students who answered scientific reasoning questions with a correlational reasoning pattern, many were still unrelated. One student's answer in the non-answer category (NA) level 0 proves this. Intuitive (In) level 1 category is guessing the answer using operating numbers but illogical answers as many as two people. Category No Relationship (NR) level 2 provides reasons and explanations, but the things described are unrelated to as many as three people. One Cell (OC) level 3 category is to give reasons with the connection of a problem as many as two people. Category Two Cell (TC) level 4 provides reasons for the relationship between two problems and as many as two people. Category Correlation (C) with level 5 can provide reasons and answers correctly for all problems and explain the relationship between problems and reasons for only one student. Meanwhile, nine other students could answer the questions, but there was no relationship between the quantities presented in the questions. In addition, the number of students' cognitive performances reaching high levels in Physics learning examinations was still low. The types of problems in the examination did not contain high-level questions, even though students mastered the Mathematics skills needed to solve problems in Physics. The mathematical skills students mastered did not help them apply concepts to specific contexts in Physics (Motlhabane, 2017). Thus, students' scientific reasoning skills in the correlational reasoning pattern are still low. In the third pattern, the question of scientific reasoning skills is the proportional reasoning pattern. In this pattern, students are presented with questions in the form of straight-motion experimental data along with variables such as distance and time. Students are asked to compare experimental data and the variables that influence it from these questions. Student data on the proportional reasoning pattern can be presented in **Table 4**.

Table 4. Student data on the pattern of proportional reasoning.

Proportional Reasoning	Not Answered (NA)	Intuitive (In)	Additive (Ad)	Transitional (Tr)	Ratio (R)
Answer	1	4	3	2	1
Level	0	1	2	3	4

Based on **Table 4** and the theory from Rimadani et al. (2017), it can be seen that one student can answer the questions with a proportional reasoning pattern in the No Answering (NA) category at level 0. Intuitive (In) level 1 category is guessing the answer using operating numbers but illogical answers by as many as four people. The Additive (Ad) level 2 category uses a settlement strategy but focuses on different things, as many as three people. The level 3 Transitional (Tr) category is to apply and use the ratio strategy and determine the value, but it is different from two people. Meanwhile, in the Intuitive (In) category, only one answer from students who reached level 4 Ratio (R) could apply and use the ratio strategy and correctly determine the value. This shows that some students have yet to be able to answer questions in the category of comparative questions (Hilton, 2013). In addition to the low achievement, the information students gained to support their work on Physics resulted from free learning resources without a facilitator. Freedom of information generated irrelevant information that triggered student misconceptions (Erman, 2017). So, students' scientific reasoning skills in the proportional reasoning pattern are still low. In the fourth pattern, the question of the category of scientific reasoning skills is the pattern of probabilistic reasoning. In this plan, students are presented with questions in the form of experimental data. Then, students are asked to conclude acceleration based on existing data (displacement and time). The student data results on the probabilistic reasoning pattern are presented in **Table 5**.

Table 5. Student data on probabilistic reasoning patterns.

Probabilistic Reasoning	Not Answered (NA)	Intuitive (In)	Approximate (Ap)	Quantitative (Qn)
Answer	0	2	6	3
Level	0	1	2	3

Based on the table and theory from Rimadani et al. (2017), it can be seen that those who can answer questions with a probabilistic reasoning pattern with the approximate (Ap) category, namely providing explanations and reasons with more qualitative descriptions, namely six students at level 2 than in the quantitative (Qn) category, namely providing explanations and reasons with quantitative description, namely three students are at level 3. Thus, scientific reasoning skills in probabilistic reasoning patterns are still low. Piaget's theory contributes to optimizing the stage of student development through the scientific reasoning inquiry process because scientific reasoning is the end of the developmental ability and the characteristic of intellectual maturity that can be trained (Piaget et al., 2013).

CONCLUSION

Fundamental Finding: Based on the research that has been done, the level of students' scientific reasoning skills in the theoretical reasoning pattern is good enough because they can interpret the existing theory with the data on the problem. **Implication:** Students' scientific reasoning skills in the correlational reasoning pattern still need to improve because only one student can answer questions at level 5. Students' scientific reasoning skills in the proportional reasoning pattern still need to improve because only one student's answer reaches the level 4 Ratio (R). The students' scientific reasoning skills in the probabilistic reasoning pattern still need to improve because only three are at level 3. **Limitation:** Scientific reasoning skills are essential to maintain because they are 21st-century skills and support students in developing literacy and numeracy skills. **Future Research:** It is hoped that further research will develop scientific reasoning skills instruments and their assessment instruments.

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