JPPIPA 9(10) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Mathematical Reasoning Ability and Mastery of Science Concepts in High School Students

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Received: August 9, 2023
Revised: September 10, 2023
Accepted: October 25, 2023
Published: October 31, 2023

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DOI:10.29303/jppipa.v9i10.4931

Abstract: Mathematics arises because the human mind deals with ideas, processes and reasoning. The thought process carried out during science activities is a form of thinking called reasoning. In studying the concepts of Natural Sciences (IPA) requires two types of reasoning, namely deductive reasoning (deduction) and inductive reasoning (induction). Both types of reasoning help students think creatively, critically, analytically, meticulously and logically in dealing with everyday life problems. The purpose of this study is for students' ability to do mathematical reasoning, and examine the mastery of science concepts (Physics and Biology) in students of SMA Negeri Kodya Banda Aceh. The research method used is descriptive and correlational, to describe the ability of mathematical reasoning and mastery of science concepts (Physics and Biology). The subjects of the study population were all grade II students of SMA Negeri Kodya Banda Aceh. While the research sample subjects used were six classes from one of the Kodya State High Schools Banda Aceh which were determined purposively by the curriculum field. Research instrument to capture mathematical reasoning ability data using the Mathematical Reasoning Ability Test (TKPM). And mastery of the science concept using the Science Concept Mastery Test (TPKIPA) in the form of a description. As well as using the average value statistic ( ) and using the chi-squared formula (x2). The results of the study that mathematical reasoning skills in learning science concepts (Physics and Biology) on average are still in the category of lacking. The ability to reason mathematics has a high relationship with mastery of science concepts in high school students.

Keywords: Mastery of science concepts; Mathematical; Reasoning ability

Introduction

Along with the development of science and technology in this millennial era, students are required to always improve their abilities and potential through the education they receive at school. Education or learning is expected to provoke the enthusiasm of students to learn things or material that can trigger ideas and mindsets to improve students' skills in reasoning. So that they will become qualified individuals in the future. Therefore, education is very important as an aspect of life (Fadhila et al., 2022).

Education is one of the basic human needs as human needs for food, drink, clothing, home, and health must be met. This is because humans at birth do not know anything (Syafrin et al., 2023). Education has a very important role for the continuity of human life. Education is placed by Indonesia as an important and main variable in the context of nation and state development (Magfirah et al., 2019). Likewise, stated by Notoadmojo, education includes the process of making changes to one's attitude and behavior in order to mature themselves through teaching and training activities (Nafrin et al., 2021).

Therefore, improving education, especially in Indonesia, is very necessary. Good quality education can be seen from the development of the teaching and learning process in applied learning activities (Saputri et al., 2018). The quality of education can develop and have

How to Cite:
Roslina, R., Apriana, E., Armi, A., Hakim, L., & Andalia, N. (2023). Mathematical Reasoning Ability and Mastery of Science Concepts in High School Students. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8934–8940. https://doi.org/10.29303/jppipa.v9i10.4931

a great influence on the learning process in the classroom, one of which is mathematics learning.

Mathematics is a widespread science and underlies the development of modern technology which is an important part of national education (Lestari et al., 2021). Mathematics is a school lesson that does not only learn about numbers (Puspaningtyas, 2019). Every level of education in Indonesia from elementary to upper secondary education, mathematics is one of the compulsory subjects to be taught to students (Saputri et al., 2018). Therefore, mathematics is a very important subject in learning at school. At every level of education, the process of learning mathematics does not all go well. Many students think that mathematics is a very difficult subject (A. Rahmawati et al., 2021).

Mathematics is a subject that must be given to all students or students starting from elementary school to the next level of education. This is so that students can think logically, analytically, systematically, and critically. Mathematics is generally seen by students as a difficult subject. Until now, there are still many students who have difficulties and feel afraid to learn mathematics. This is because learning is monotonous or because it is not so fun to learn mathematics (Mulyati et al., 2020).

Mathematics is not only concerned with numbers and their operations. But with regard to other elements, mathematics cannot be defined as a science related to quantity. Because in geometry quantity gets less emphasis than position. In today's century the development of mathematics leads to relationships, patterns of form and structure in everyday life, mathematics is closely related to life. This proves that mathematics has contributed a lot in developing Natural Sciences (Science) and technology.

Mathematics as a field of study taught in formal education is an important part of efforts to improve the quality of education. Mathematics lessons require concentration of thought to remember and re-recognize the material learned so that students must be able to master the concept of the material (Murnaka et al., 2018). The success of mastering the initial concepts of mathematics paves the way in the delivery of mathematical concepts in the next material. A concept is an abstract idea with which we can group objects into examples or non-examples (Mendrofa, 2018; Zagoto, 2022; Zagoto et al., 2018). As a result of the abstract nature of mathematics, not a few students still think mathematics is difficult.

Annajmi (2018) which revealed that the mathematics ability of Indonesian students is far below the international average. Students in Indonesia scored an average of 378 on the knowledge domain, 384 on application, and 388 on reasoning according to the 2011 TIMMS survey, placing them in the low (400) and far from advanced categories (625). Meanwhile, research from the Program for International Student Assessment (PISA) shows that Indonesian students do not have good skills in mathematics. Indonesia scored below the OECD average of 594 in the Programme for International Student Assessment (PISA), ranking it 63 out of 70 countries in 2015, 64 out of 65 countries in 2012, and 61 out of 65 countries in 2009. Based on the results of PISA 2018, Indonesia is ranked 7th out of 73 countries. Indonesia's average science score of 396 places Indonesia in 71st position out of 144 countries (Ministry of Education and Culture, 2018).

The limitations of students' ability to reason mathematically can be traced to the school's dependence on approaches or models of teaching mathematics that have been tested and correct, in addition, students are not motivated by their perception that mathematics is difficult, so they forget what they have learned and need to be explained again. Students are not motivated to learn maths because they find it difficult; as a result, they forget what they have learned and need to be explained again (Izza et al., 2023).

In studying science, many mathematical concepts are found that are used to solve natural phenomena. Because science is the result of human activities in the form of knowledge, ideas, and concepts that are organized about the environment obtained from experience through a series of scientific processes. Therefore, a student is required to be able to think abstractly in drawing conclusions about a natural event. So that the concepts of science can be mastered properly.

Mathematical reasoning, according to Math Glossary (Kusumawardani et al., 2018), is "the process of thinking logically about a mathematical problem to get a solution," and "requires the ability to sort out what is important and what is not important in solving a problem and to explain or reason for a solution."

Hasratuddin (2018) defines mathematical reasoning as the process of arriving at a conclusion using a correct series of deductions. There are two main categories of reasoning: inductive and deductive.

Inductive Reasoning

Using inductive reasoning, one can arrive at a conclusion or formulate a new general statement by extrapolating from a series of premises that have been proven to be true. Inductive reasoning can be used in the classroom to help students understand difficult topics or theorems. The process of inductive generalization refers to a method of inductive reasoning that first investigates certain examples before proceeding to obtain broader generalizations. Generalizing means drawing generalizations about many different things based on a small sample.

Deductive Reasoning

Deductive reasoning is the process by which one true idea or statement leads to another true idea or statement. To prove something deductively, it is necessary to use other mathematical ideas or formulas that have been proven to be deductively accurate. To use deductive reasoning, one must think from general things (statements) to specific things (Hasratuddin, 2018). In short, mathematical reasoning can be defined as a mental process used to reach logical and reasoned conclusions regarding mathematical problems.

The aspects studied in mathematical reasoning are deductive reasoning and inductive reasoning, deductive reasoning is a reasoning process that runs from the general principle of a specific thing. While inductive reasoning is as a process of reasoning from the specific to the general.

Method

Research Design

This study used descriptive and correlation methods. The descriptive method is used to describe mathematical reasoning abilities. Mastery of science concepts (physics and bology). And difficulties in doing mathematical reasoning in high school students. Through descriptive analysis of the data that has been collected, it is summarized to be generalized to a limited scope.

Research Subjects

The population subjects in this study were all grade II students of SMA Negeri Kodya Banda Aceh. While the subjects of the research sample used were six classes from one of the Kodya State High Schools in Banda Aceh which were determined puposively by the curriculum field.

Research Instruments

To capture data on mathematical reasoning skills and mastery of science concepts (biology and physics). Two research instruments were used, namely tests (two types of tests) and questionnaires. In detail, the instruments used are described as follows: a) To measure students' mathematical reasoning ability in learning science concepts, a mathematical reasoning ability test (TKPM) is used in the form of a description. The test covers both deductive and inductive reasoning aspects. b) To measure mastery of science concepts (biology and physics), a science concept mastery test (Biology and Physics) is used, abbreviated as TKPIPA. The test is arranged in the form of a description based on aspects of the cognitive realm (memory, understanding, application, analysis, synthesis, evaluation). c) Questionnaires are used to obtain difficulties in doing mathematical reasoning in students. d) To review students' ability to do mathematical reasoning in terms of differences in science concepts (biology and physics), TKPM results are used.

Data Analysis Techniques

After the necessary data is collected. Then data analysis is carried out with the following steps:

a. Data on mathematical reasoning ability and mastery of science concepts (biology and physics). What is obtained from student learning results in the form of scores from each item of the description test (the ideal score of each question item is 5) is categorized into four levels, while the empaat levels are very good, good, medium, and less. Each level if achieved is as listed in the following table.

Table 1. Levels of Mathematical Reasoning Ability and Mastery of Science Concepts (Biology and Physics)

Categories	Percentage Achievement	Score	Information
Very	80%-100%	4-5	V
Good	66%-79%	3.3-3.90	G
Keep	36%-65%	2.8-3.20	K
Less	≤	≤	L

Then also the data is analyzed quantitatively and qualitatively, both in the average of the whole, each aspect, and category using the average value statistic (X) and in the form of percentages.

b. Analyze and summarize the results of questionnaires of students' difficulties in conducting mathematical reasoning in learning science concepts (biology and physics).
c. Analyze correlations to determine the magnitude of correlation between mathematical reasoning ability and mastery of science concepts (biology and physics) using the chi-squared formula (X2).

Analyze and interpret to come up with a conclusion about mathematical reasoning skills and mastery of science concepts (biology and physics) using relevant theories and research results.

Result and Discussion

The results of this study describe mathematical reasoning in the concept of science, and the relationship of mathematical reasoning with mastery of the concept of science. The discussion of the results of this study is as follows.

Mathematical Reasoning on Science Concepts

The results of processing mathematical reasoning ability data through the Mathematical Reasoning Ability Test (TKPM) in learning science concepts of high school

students are presented in a table of the aspects studied by TKPM high school students are aspects of deductive and inductive reasoning.

Based on the analysis of the data in the table, it can be stated that the ability to do mathematical reasoning in the concept of Science (Biology and Physics) on average, as well as categories is still in the category of lacking. While the aspect of inductive reasoning in physics and biology is in the medium category. When viewed from the category of mathematical reasoning ability in physics concepts (inductive aspects), the majority are classified as medium categories. For students the category for once, both in the inductive and deductive aspects of minorities vary greatly. As for the less category, the majority of students from the aspects of deductive and inductive reasoning in learning science concepts.

Table 2. Mathematical Reasoning Ability in Learning Science Concepts in High School Students Mathematical Reasoning Ability

Biology						
	D			ID		
	8.75			13.75		28
%	35			55		56
C	f	%	f	%	f	%
V	12	5	19	8	36	15
G	24	10	36	15	48	20
K	15	15	60	25	84	35
L	96	70	125	52	72	30
S	240	100	240	100	240	100
Physics						
	D			ID		
	10.75			14.75		21.25
%	43			59		42
C	f	%	f	%	f	%
V	0	0	17	7	0	0
G	22	9	31	13	19	8
K	58	24	101	42	53	22
L	163	68	91	38	168	70
S	240	100	240	100	240	100
Natural science						
	D			ID		
	8.5			10.5		67.5
%	3.4			42		43
C	f	%	f	%	f	%
V	19	8	22	9	38	16
G	31	13	36	15	48	20
K	65	27	62	26	72	30
L	125	52	120	50	82	34
S	240	100	240	100	240	100

Information:
Average KPM Natural science
Average KPM Science (Biology, Physics)
Average KPM Science (Biology, Physics) of each aspect
V (Very) : (80-100%
G (Good): (66-79%
K (Keep) : (56-65)%
L (Less) : ≤ 55%
C : Category
S : Sum
D : Deductive
ID : Inductive

Many high school students lack mathematical reasoning skills towards learning science concepts (biology and physics) due to difficulties in logical thinking. In this case, it is put forward based on the answers of students who cannot distinguish between deductive and inductive reasoning conclusions. Reasoning as a process of reaching logical conclusions based on relevant facts and sources. Mathematical reasoning is one of the many important elements in the mathematics learning process where students are directed to improve their ability to think higher-order, especially mathematical reasoning (Fadhila et al., 2022). The examples of inductive reasoning processes are: metal 1 is hot and expands, metal 2 is heated and expands, and metal 3 is heated to expand and so on metal to metal 10. Thus the conclusion of all heat able metals expands.

Based on the examples presented above, it shows that reasoning activities that describe mathematical views are processes and products in providing conclusions on science-physics problems. In line with the research proposed by Festiawan et al. (2021) and Suryaningrat et al. (2021) where mathematical reasoning is very important in helping individuals not only remember facts, rules and problem-solving steps, but also use their reasoning skills in making guesses based on their experience so that those concerned will gain an understanding of interrelated mathematical concepts and learn meaningfully (meaningful learning). The statement shows that reasoning is needed to construct a mathematical idea and to show proof of the truth of that idea.

Smith et al. (2020) explain the term reasoning in general is a thought process that seeks to connect known facts to a conclusion. In line with the opinion expressed by Izzah et al. (2019) which states that reasoning is a logical thinking activity to collect facts, manage, analyze, explain and make conclusions. In mathematics, mathematical reasoning is the process of reaching logical conclusions based on relevant facts and sources (Smith et al., 2020).

The ability of mathematical reasoning in biology is on average classified as medium category. This shows that students can come up with a logical conclusion about an event based on existing premises. Examples in inductive reasoning are all roses smell good, all jasmine

flowers smell good, all ylang ylang flowers smell good, all flowers smell good. The conclusion put forward by the students is an event that can be done directly experiments on the flowers. Thus formulating the conclusion that all flowers smell good. In line with what was stated by Hermawan et al. (2018) the activities included in mathematical reasoning activities include: drawing logical conclusions; use explanations using models, facts, properties, and relationships; estimating answers and solution processes; using patterns and relationships; to analyze mathematical situations, draw analogies and generalizations; drawing up and testing conjectures; provide counter examples; follow inference rules; checking the validity of arguments; drawing up valid arguments; compile direct, indirect proofs and use mathematical induction.

The Relationship of Mathematical Reasoning to Mastery of Science Concepts

Judging from the mastery of science concepts (Biology and Physics), there is a very high relationship between mathematical reasoning ability and mastery of science concepts for high school students. Aditya et al. (2022) stated the advantages of students when mastering mathematical reasoning skills, including being able to find out the level of reasoning power they have, expanding beliefs, finding truth, convincing, easier to understand the material, being able to explain, making it easier to draw conclusions, having the ability to think realistically in dealing with problems or everything that happens realistically, having a coherent way of thinking. The weakness of students when they lack mastery of reasoning skills is that it will result in misunderstandings with what will be understood, resulting in confusion in understanding the questions and resulting in conclusions and wrong answers.

Based on the results of the findings above, it shows that there is still a lack of mathematical reasoning skills in learning science concepts (Biology and Physics) for high school students, in connection with the very close relationship in mastering science concepts. This is also reinforced by research conducted by Fadillah which states that 71.8% of students have low mathematical reasoning skills (Fadhila et al., 2022). The factors that cause students' lack of mathematical reasoning skills are students are less able to understand well and correctly the concepts used to solve the given problems, lack of understanding of the material that has been learned, there is a lack of confidence in solving problems resulting in problem solving there are still errors, and students lack in practicing to do problems that aim to deepen and expand abilities and materials he has learned (K. D. Rahmawati et al., 2022).

Conclusion

Based on the results of the discussion in part five, it can be stated that the ability of mathematical reasoning in learning average science concepts and categories from deductive and inductive aspects is still classified as lacking. In the aspect of deductive and inductive reasoning, there is also the ability to reason mathematics which is categorized as very good and good. While the aspect of inductive reasoning in the concepts of Physics and Biology is classified as a medium category. From the distinction of the concept of science (Biology and Physics), mathematical reasoning ability is also a less category. In doing mathematical reasoning, the difficulties faced by students still have many difficulties in relational understanding and abstract thinking. The ability to reason mathematics has a high relationship with mastery of science concepts in high school students.

Acknowledgments
The research team would like to thank the Universitas Serambi Mekkah.

Author Contributions
Conceptualization: Roslina, Armi, Lukmanul Hakim, Data curation: Evi Apriana, Funding acquisition: Nurlena Andalia, Methodology: Roslina, Visualization: Evi Apriana, Armi, Lukmanul Hakim, Roslina, Nurlena Andalia. Writing–original draft: Armi, Nurlena Andalia, Writing–review & editing: Evi Apriana, Armi, Nurlena Andalia.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

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