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Study Literature of PISA-Based Test Instruments on Students' Mathematical Reasoning Ability

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Abstract

This research was motivated by the lack of students' mathematical reasoning abilities in learning mathematics. Indonesia in the past few years has always been in the bottom 10 ranks in the PISA test, which is proof that the level of students' mathematical reasoning is still low. The use of PISA-based test instruments is still rarely used in the Indonesian education system. This study aims to analyze the PISA-based test instrument on students' mathematical reasoning abilities. This research was structured with a literature study approach, then the data were analyzed descriptively by presenting facts or findings which were then reviewed theoretically. Based on what has been studied, the PISA-based test instrument can develop students' mathematical reasoning abilities. The conclusion of this literature study can be stated that the development of PISA-based test instruments can measure students' mathematical reasoning abilities.

Keywords:

Mathematical reasoning, PISA-based test

1. Introduction

Mathematics is a universal science that supports the development of modern technology, plays an important role in various disciplines, and develops human thinking. The rapid development in the field of information and communication technology today is based on the development of mathematics in the fields of number theory, algebra, analysis, probability theory, and discrete mathematics. In essence, mathematics requires students to continue learning, work independently, and become a necessity in structured reasoning skills in order to solve mathematical problems without relying on others (Brodie, 2009). According to Sumarmo (2005), one of the visions of learning mathematics is to understand the mathematical concepts needed to solve mathematical problems and other scientific problems and equip students with mathematical reasoning skills. This is in line with what was formulated by the *National Council of Teachers of Mathematics* (2000), namely: mathematical communication skills (mathematical communication); mathematical reasoning ability (mathematical reasoning); problem solving ability (mathematical problem solving); mathematical connections.

PISA (*Programme for International Students Assessment*) is an international study of the reading, mathematics and science literacy of 15-year-old school students. The study was coordinated by the OECD (*Organisation for Economic Cooperation and Development*) based in Paris, France. PISA is a study that is held every three years, namely in 2000, 2003, 2006, 2009, and so on (OCED, 2009). Based on research conducted by PISA in 2002 – 2018 shows that the ranking of Indonesian students has always been ranked in the 12 lowest countries of the countries participating in PISA (Stacey, 2011). It can be seen that Indonesia in 2015 was ranked 63 out of 75 countries, and in 2018 out of 79 countries Indonesia ranked 73rd. This shows that the mathematical ability of Indonesian students is still low on the content and cognitive dimensions. The content dimensions in the domain are assessed: numbers, algebras, geometry, data, and probabilities, while the cognitive dimensions in the domain are assessed: 1) Knowledge, including facts, concepts, and procedures that students should know; 2) Application, which

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focuses on students applying knowledge and conceptual understanding to solve problems or answer questions; 3) reasoning, which focuses on solving unconventional problems, complex environments and performing many problem-solving steps (Balitbang, 2011).

In PISA questions, there are eight characteristics of mathematical cognitive abilities, namely mathematical thinking and reasoning, mathematical argumentation, modeling, questioning and solving problems, representation, notation and formalism, communication, and the use of aids. All cognitive abilities in PISA questions are related to the objectives of learning mathematics contained in the curriculum. Teachers are often faced with a shortage of questions specifically designed to answer the potential of students and the character of students, so it is assumed that students do not have the potential to use reasoning. in answering the question get the best progression. Mathematics according to Sujono (1988) is the science of logical reasoning and problems related to numbers. Reasoning skills allow students to solve problems in life both inside and outside of school. The activities included in the activities of mathematical reasoning include: drawing logical conclusions; explain using models, facts, traits, and relationships; estimating answers and the settlement process; using patterns and relationships; analyze mathematical situations, make analogies and generalizations; drawing up and testing conjectures; gives a counterexample ; follow the rules of inference; checking the validity of arguments; write valid arguments; compiling direct and indirect evidence and using mathematical induction (Sumarmo, 2003). The matter of PISA demands not only the ability to apply concepts, but also how to apply concepts in various situations, as well as the ability of students to reason. Students with good mathematical reasoning abilities are those who are able to formulate conjectures, manipulate mathematics, draw conclusions, compile evidence by providing evidence of the truth of the cause or solution, and find patterns or properties of symptoms to generalize (Fauzi, 2017).

Based on the description above, the purpose of this literature study is to analyze PISA-based test instruments on students' mathematical reasoning ability to study, record and
manage relevant journals.

2. Discusion

2.1 *Mathematical Reasoning*

Reasoning is an activity or thought process to draw conclusions or make new statements that are based on previous statements and their correctness has been proven. Copi in Shadiq (2014) explained that reasoning is an activity, process, or activity of building a link between mathematical ideas or concepts, between mathematics and other objects, and between mathematics and everyday life. Mathematical reasoning ability is the ability that students need to analyze new situations, make logical assumptions, explain ideas and make conclusions (Mufidi et al, 2012). According to Gardner et al (Lestari and Yudhanegara, 2015) mathematical reasoning ability is the ability to analyze, generalize, synthesize, or integrate, give appropriate reasons, and solve non-routine problems. According to Shadiq (2014) "mathematical reasoning is an activity, a process or an activity of thinking to draw conclusions or make a new statement that is true based on some statement whose truth has been proven or assumed previously".

Mathematical reasoning ability is one of the thought processes carried out by drawing a conclusion where the conclusion is a valid or accountable conclusion. Turmudi (in Sumartini, 2015) said that the ability of mathematical reasoning is a habit of the brain as is the case with other habits that must be developed consistently using various kinds of contexts, knowing reasoning and proof are fundamental aspects in mathematics. Mathematical reasoning is one of the necessary and important abilities that must be mastered by students. Reasoning ability takes place when a person thinks about a problem or solves a problem.

Mathematical reasoning abilities (in Hendriana et al., 2017) include:

a. General reasoning related to the ability to find solutions or solutions to problems.

b. Abilities related to drawing conclusions, such as in syllogisms, and those related to the ability to assess the implications of an argument.

c. The ability to see relationships, not only the relationships between objects but also the relationships of ideas, and then use those relationships to acquire other objects or ideas.

Based on this, mathematical reasoning skills are very important for students to have. One way to develop this capability is to use PISA-based tests. The PISA framework is designed to find out how far students are capable of mathematical reasoning.

2.2 *PISA-Based Tests*

In the PISA 2022 framework, the test is focused on mathematical reasoning skills that are integrated with 21st century abilities such as critical thinking, creativity, research & inquiry, and so on. The PISA 2022 mathematics framework defines the theoretical underpinnings of the PISA mathematics assessment based on the fundamental concept of mathematical literacy, relating mathematical reasoning and three processes of the problem-solving (mathematical modelling) cycle. The framework describes how mathematical content knowledge is organized. Here is one example of a question on the PISA test sourced from the official website of the OECD.

Gambar 1. Question on the PISA test sourced from the official website of the OECD.

Various research, training and development of PISA-based test questions have also been carried out. Susanto et al. Has carried out training on the development of PISA-based test instruments for teachers of Bengkulu Mathematics Junior High School which was attended by 45 junior high school / MTs teachers who are members of the Bengkulu city mathematics MGMP. The training resulted in a test instrument consisting of 20 multiple-choice questions and 5 description questions. The developed test instruments have met the criteria of content validity, high reliability, and good category differentiating power. In addition, this activity also discusses guidelines for the preparation of PISA-based test instruments if there is further research.

Tabel 1. Guidelines for instrument preparation

Dimension	Materials
Content	a. Change and relationship
	b. Space and form
	c. Quantity
	d. Data uncertainty
Process	a. Able to formulate problems mathematically
	b. Able to use concepts, facts, procedures and reasoning in mathematics
	c. Interpret and aplly, evaluate the result of a math process
Context	a. Personally
	b. Job
	c. Social

Charmila (2016) has also developed a PISA model math problem for junior high school students using a valid, practical, and potential Jambi context. In this study, 14 points of mathematical problems of the PISA model were obtained using the Jambi context which had been tested for validity. The characteristics built in the development of this question are that the question tools developed have the characteristics of PISA questions and use the context of Jambi Province and have a potential effect. The potential effects that arise include being able to attract interest and motivate students so that they feel challenged to solve the problem. This problem also makes students involve various basic mathematical skills and critical thinking skills in solving them.

2.3 *Reasons PISA-based test can measure mathematical reasoning abilitys*

PISA 2022 aims to consider mathematics in a rapidly changing world driven by new technologies and trends in which citizens are creative and engaged, making non-routine judgments for themselves and the society in which they live. This brings into focus the ability to reason mathematically, which has always been a part of the PISA framework. In addition, in the PISA framework, there are at least six key understandings provide structure and support to mathematical reasoning. These key understandings include, (1) understanding quantity, number systems and their algebraic properties, (2) appreciating the power of abstraction and symbolic representation, (3) seeing mathematical structures and their regularities, (4) recognizing functional relationships between quantities, (5) using mathematical modelling as a lens onto the real world(e.g., those arising in the physical, biological, social, economic and behavioural sciences), and (6) understanding variation as the heart of statistics.

3. Conclusion

Reasoning is an activity or thinking process to draw conclusions or make new statements based on previous statements and the truth have been proven. The mathematical reasoning ability is one og thinking processes carried out by drawing a conclusion or make be accounted for. The mathematical reasoning ability is very important for students. One way to develop this ability is to use a PISA-based test. Based on what has been in the discussion, it can be concluded that this literature study can be stated that the development of PISA-based test instruments is able to measure students' mathematical reasoning ability.

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