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Students' Mathematical Literacy in Solving PISA Model Questions: A Case Study of Systematic and Intuitive Cognitive Style

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Abstract

This research is a qualitative descriptive study that aims to describe the mathematical literacy of high school students with a systematic and intuitive cognitive style in solving PISA model questions. The cognitive style test, cognitive style inventory, and mathematics ability test were used to select research subjects. One student with a systematic cognitive style and one with an intuitive cognitive style were selected with equivalent mathematical abilities and the same gender. The results of the mathematical literacy test and test-based interviews were used to collect data on students' mathematical literacy. Time triangulation was used to test the credibility of the findings obtained. Data analysis techniques include data reduction, presentation, and drawing conclusions. The research results show that in formulating problems, systematic students identify the information obtained from the two questions in more detail and are more careful in understanding the questions, while intuitive students identify the necessary information to solve the problem in general. In applying problems, systematic students design and use strategies to find solutions, identifying known information from the problem first, while intuitive students create and use strategies to find solutions and solve problems using the concept of comparison. For the interpreting aspect, the two students reinterpreted the mathematical results they obtained into contextual problems, stated the truth of the answers they obtained, and provided arguments to support their answers.

Keywords: Intuitive cognitive style, mathematical literacy, PISA Model, systematic cognitive style

INTRODUCTION

Mathematical literacy is one of the abilities needed in 21st century competition (Nurjanah & Saputra, 2023). In facing 21st century competition, it is very important for students to have good provisions, one of which is mathematical literacy skills, which are needed as the ability to use mathematics to answer real world-problems (Pratama, Saputro, & Riyadi, 2018; Rizki & Priatna, 2019). To prepare students with 21st century skills, the government is conducting a Minimum Competency Assessment (AKM) in 2021, including a mathematical literacy assessment, namely an assessment of the ability to reason using mathematics. The Ministry of Education and Culture (2021) stated that the evaluation in AKM refers to the benchmarks contained in the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). If students and teachers master mathematical literacy well, it is hoped that students will be able to work on AKM questions and make students develop analytical skills based on information well.

The Program for International Student Assessment (PISA) is an international scale assessment that aims to measure students' mathematical literacy (Guzel & Berbereglu, 2010). OCED (2017) states that there are 3 areas assessed in the PISA study, namely mathematical literacy, reading literacy, and scientific literacy. Mathematical literacy is one of the components assessed in PISA. Mansur (2018) stated that achieving good mathematics results in the PISA assessment will also indicate good mathematical literacy because achieving mathematics results in PISA can be called mathematical literacy. Indonesian students have

taken the exam seven times, but they still rank in the bottom 10. Wardono and Kurniasih (2015) stated that the PISA results show that the ability of Indonesian students to solve questions that require mastery of aspects of mathematical literacy is still very low. Apart from that, the mathematical literacy achievements of Indonesian students are still going up and down. Even in the last PISA assessment, namely in 2018, Indonesian students experienced a decline. This can be seen clearly through the Figure 1.

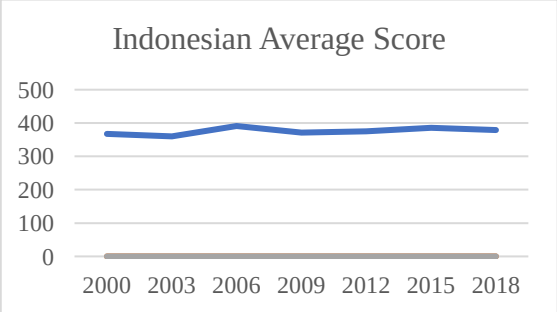

Figure 1. Figure 1. The Achievements of Indonesian Students' Mathematical Literacy in the Years 2000-2018

Furthermore, for the results of the 2022 PISA data, Indonesian students got the highest score in the Space and Shape content with an average score of 367, while the lowest was in the Change and Relationship content with an average score of 362 (see Table 1).

Table 1. PISA 2022 Mathematics Scale Score Average of Indonesian Students

Content	Change and relationship	Quantity	Space and shape	Uncertainty and data
Average score	362	363	367	363

PISA 2022 results on change and relationship content, Indonesia scored 362, the lowest score compared to other content. Rifai and Wutsqa (2017) stated that mathematical literacy is still foreign to most teachers and students, so it is natural that students' mathematical literacy is still not developed. For this reason, educators have to make mathematical literacy one of the focuses in the learning process in an effort to pay attention and try to improve students' mathematical literacy in order to make a positive contribution to exam results and daily life. It is hoped that the importance of good mastery and understanding of mathematical literacy for teachers and students will be useful for developing students' mathematical skills, helping them make wise decisions, and overcoming educational problems related to mathematical literacy.

Mathematical literacy assessments can be carried out using PISA model questions to see a picture of students' mathematical literacy. Mansur (2018) stated that to determine students' mathematical literacy, an assessment can be carried out using PISA questions. Therefore, this research will use PISA model questions to obtain data and an overview of students' mathematical literacy. PISA model questions include the process, content and context contained in PISA. The process consists of formulating, implementing, and interpreting. Context includes personal, social, work, and scientific. Content includes numbers, space and shape, change and relationships, uncertainty and data (OECD, 2019).

PISA targets students around the age of 15 because at this stage they have completed most of the compulsory curriculum at the secondary level and have achieved a significant level of cognitive readiness. They have sufficient foundational knowledge and skills to be measured in mathematics, science, and reading. Besides that, students in grade 10 of high school are generally in this age range, making them a good choice for inclusion in the PISA study. This allows PISA to evaluate students' ability to understand and apply their knowledge and skills. According to OECD (2019), class X high school students who participated in the PISA study were 49.2%. This percentage is the largest for Indonesian students taking the PISA study compared to other classes. Therefore, this research will be carried out with class X high school students because the students have received this material. This research uses one question on the PISA

uncertainty and data model, which has an occupational context.

PISA aims to provide insight into students' readiness to face the challenges of future education and careers. Selecting 10th grade students allows PISA to assess the extent to which students have developed the skills necessary for future success, whether continuing their education to a higher level or entering the workforce. 10^{th} grade students have generally reached a level of cognitive maturity that allows them to respond well to and complete the PISA test. This question includes statistical material chosen because the material is essential for students to understand, but students' interest in statistics is still very low, students also experience difficulties solving statistical problems (Mahura, 2016). It is hoped that using statistics questions in research can help students become familiar with these questions. The work context was chosen because this context is the one that students have the least control over (Hamidy & Prabowo, 2020).

There are several factors that need to be considered when assessing students. These factors include students' cognitive styles (Au, 1997). Different cognitive styles will influence how students acquire, process, organize, and remember information from various learning sources. Cognitive style is defined as the characteristic, self-consistent modes of functioning that individuals show in their perceptual and intellectual activities (Jain & Kumar, 2013). Additionally, Sagiv et al. (2014) say a cognitive style is a stable personal attribute reflecting the consistent way in which individuals organize and process information and ultimately make decisions and act. Nurdianasari, Rochmad, and Hartono (2015) also stated that one of the factors that needs to be considered in learning activities and solving mathematical problems is differences in students' cognitive styles.

Systematic and intuitive cognitive style is one of the dimensions of cognitive style (Sagiv et al, 2014). This research focuses on systematic and intuitive cognitive styles because these cognitive styles emphasize differences in choosing strategies for solving problems compared to other cognitive styles (Khoyimah, 2021). Systematic-intuitive cognitive style is a cognitive style that is classified based on how to evaluate information and choose strategies for solving problems (Subanji et al, 2021). Students with a systematic cognitive style use step-by-step, sequential thinking, making plans to solve problems and making decisions. Meanwhile, students with an intuitive cognitive style use a sequence of analytical steps that are unplanned and spontaneous, based on their experience, and try to explore various alternatives to solve problems. These differences in cognitive styles will likely influence students' ability to solve problems.

Research by Fadillah, Kartono, and Supriyadi (2019) has shown that students' choice of problem-solving solutions varies due to differences in their cognitive styles. Similarly, Muhtarom et al. (2018) have found that cognitive styles influence students' ability to solve mathematical problems. When students have different cognitive styles, their problem-solving methods also differ. Based on this, differences in cognitive styles will influence students' mathematical literacy outcomes. Based on the background above, this research aims to describe the mathematical literacy of high school students with a systematic and intuitive cognitive style in solving PISA model questions.

METHODS

This type of descriptive research with a qualitative approach aims to describe the mathematical literacy of class X high school students in solving PISA model mathematics problems. Selecting 10^{th} grade students allows PISA to assess the extent to which students have developed the skills necessary for future success, whether continuing their education to a higher level or entering the workforce. 10^{th} grade students have generally reached a level of cognitive maturity that allows them to respond well to and complete the PISA test. The subjects

in this research consisted of one student with an intuitive cognitive style and one student with a systematic cognitive style.

The instruments in this research consisted of a cognitive style test and a math ability test given in one class. Through the cognitive style test, students are grouped into two, namely the systematic group and the intuitive group. After that, one student was selected with an intuitive cognitive style and one with a systematic cognitive style. The cognitive style test consists of 40 questions, each of which contains 20 questions related to intuitive and systematic items, which are distributed randomly. The researcher gave a rating of 5 for "strongly agree", 4 for "agree", 3 for "not sure", 2 for "disagree", and 1 for "strongly disagree".

Then each item is grouped into its respective cognitive style and then each group of cognitive styles is added up. The highest score for each cognitive style shows the subject's tendency towards their cognitive style. This selection also takes into account that subjects of the same gender are selected who can represent each cognitive style and have equivalent mathematical abilities namely the range of scores obtained by students does not exceed 5% of the total score or 5 points because the total score used in mathematics ability test is 100. Through cognitive style inventory was obtained by a group of students who had a systematic and intuitive cognitive style. (2) The mathematics ability test is given after the cognitive style test. A mathematics ability test is used to determine each student's mathematical abilities. (3) The mathematical literacy test created in this research is a PISA model mathematics question that fulfills the process, content, and context components in PISA.

RESULTS AND DISCUSSION

Mathematical literacy in this research is seen from the three processes described by PISA, namely formulating, applying and interpreting.

Systematic Students' Mathematical Literacy in solving PISA Uncertainty and Data Model Questions.

Systematic students in the aspect of formulating problems with indicators identify the information needed to solve the problem, do the following (1) identify the information obtained from both questions in more detail and be more careful in understanding the questions (2) identify the information that needs to be sought from both questions use their own sentences. This finding is supported by research by Mahmudah & Setianingsih (2022), namely that students who have a systematic cognitive style identify data by writing down information that is known from the data in the question, and explaining orally the known information and the information asked about in the question in a structured manner.

The findings in this research are also supported by research results which state that students with a systematic cognitive style know well the information provided in the questions to be solved (Hidayat, Amin, & Fuad, 2017). A similar thing was stated by Pangastuti, Nugroho, and Muhtarom (2022) who stated that students with a systematic cognitive style tend to analyze and interpret problems and make careful plans before starting the solving process to avoid repeating problem solving steps so that they seem very careful. Apart from that, the findings in this research are also supported by research by Khoyimah (2021), namely that students with a systematic cognitive style can write down the information in the questions and write down the information that must be searched for.

In the aspect of formulating with indicators, representing the problem mathematically using symbols, diagrams and appropriate modeling, systematic students do the following (1) mention the concept or material related to the problem, namely the concept or material of percentage, comparison, addition and multiplication. The multiplication is intended to find damage to each type of goods in each company and then the total amount and percentage of damage can be found; (2) change

the problem into appropriate symbols or mathematical models including mathematical models for damage to each type of goods, total damage to each company per day, and finding the overall percentage of damage to each company. This finding is supported by the research results of Khoyimah (2021), namely that students with a systematic cognitive style are able to identify information from the problem in the problem and explain the relationship between the information contained in the problem and relate it to the knowledge that the student has. Something similar was expressed by Pangastuti et al. (2022) which states that "determining mathematical models, subjects with a systematic cognitive style use logical and concrete examples". This is because an individual or student with a systematic cognitive style tends to analyze a particular problem or situation logically and realistically (Sagiv et al., 2010).

Systematic students in the employment aspect of problems with indicators design and use strategies in the process of finding solutions, systematic students solve the problem by applying the strategy of identifying information known from the problem first and then applying it to addition, division and multiplication. This finding is supported by the research results of Khoyimah (2021), namely that subjects with a systematic cognitive style are able to link the information contained in the problem with a solution strategy based on the knowledge that students previously knew. This finding is also supported by the research results of Hidayat et al. (2017), namely at the planning stage, students with a systematic cognitive style explain the plan for using quantities by grouping the parts that are known first.

In the application aspect with indicators of applying facts, procedures, concepts and mathematical reasoning in finding solutions, systematic students use multiplication to find damage to each type of goods from both companies. Systematic students uses the sum to determine the total damage to both companies' goods. Systematic students uses multiplication to convert the total damage to goods into a percentage. This finding is supported by the research results of Khoyimah (2021), namely that subjects with a systematic cognitive style can fulfill the indicators of rational thinking in solving problems at the stage of implementing a problem-solving plan. Something that is no different was expressed by Martin (1998), namely individuals who typically operate with a systematic style using a well-defined, step by-step approach when solving a problem; looks for an overall method or programmatic approach; and then makes an overall plan for solving the problem. Smith and DeCoster (2000) stated that individual with a systematic (rational) style tend to apply rule-based thinking.

Systematic students in the problem interpretation aspect with indicators reinterpret the mathematical results obtained into contextual problems, state the truth of the answers they obtain and provide supporting arguments. In the aspect of interpreting with indicators explaining and providing logical arguments from the mathematical results obtained, the subject systematically explains why the results of his work are logical and acceptable with supporting arguments. This finding is supported by the research results of Pangastuti et al. (2022), namely that subjects with a systematic cognitive style are able to draw appropriate conclusions. This conclusion is able to answer questions and resolve the problems presented in the question on indicators that provide the validity of a subject's argument with a systematic cognitive style that is able to provide the validity of the argument in the conclusions obtained.

Mathematical Literacy of Intuitive Students in solving PISA Uncertainty and Data Model Questions.

Intuitive Students in the problem formulation aspect with indicators identify the information needed to solve the problem, do the following (1) identify the information needed to solve the problem in general look at the questions and data in the table then make a flow of thinking about how to do it by comparing

total damage with total goods to find the highest percentage of overall damage between the two companies; (2) identify what needs to be looked for from the two questions, namely the average number of goods made and the percentage of goods failures for each company, then look for the number of failures for each type of goods. The findings are supported by the research results of Khoyimah (2021), namely that subjects with an intuitive cognitive style are able to understand the problems contained in the questions and identify known and unknown information in the questions to solve the problem. In writing information, intuitive subjects do not write sequentially and directly connect the information to questions with previously known knowledge. This finding is also supported by the research results of Mahmudah & Setianingsih (2022), namely that subjects with an intuitive cognitive style wrote down information that was known from the data in the questions but only in general but not specifically.

In the aspect of formulating with indicators, representing the problem mathematically using symbols, diagrams, appropriate modeling, intuitive students do the following (1) represent the concept or material related to the problem, namely the concept or material of comparison, addition and multiplication. Multiplication is used to find the amount of damage to each item, the concept of addition is used to add up the total damage to each company and the total production of goods at each company, while comparison is used to compare the total damage and total production of goods at each company; (2) converting the problem into appropriate symbols or mathematical models including mathematical models for damage to each type of goods, total damage to each company per day, and finding the percentage of overall damage for each company by comparing the total failed products with the total goods produced per day. This finding is supported by the research results of Khoyimah (2021), namely that subjects with an intuitive cognitive style are able to connect the information in the problem with concepts previously known to the intuitive subject and then link the two to solve the problem.

Intuitive students in the employment aspect of problems with indicators design and use strategies in the process of finding solutions, solving problems using the concept of comparison. The comparison referred to is first finding the amount of damage to each type of goods in the company and then finding the total number of goods produced in each company and then using the concept of comparison to compare the total damage with the total production of goods. In the aspect of applying indicators, applying facts, procedures, concepts and mathematical reasoning in finding solutions, using multiplication to find damage to each type of goods from both companies. IN uses addition to find the total damage to goods and the total production of goods for both companies. IN compared the total damage to goods with the total production of the two companies. This finding is in accordance with the opinion of Martin (1998), namely an individual who rates low on the systematic scale and high on the intuitive scale is described as having an intuitive style. Someone whose style is intuitive uses an unpredictable ordering of analytical steps when solving a problem, relies on experience patterns characterized by unverbalized cues or hunches, and explores and abandons alternatives quickly.

Intuitive students in the interpret aspect of problems with indicators reinterpret the mathematical results obtained into contextual problems, state the truth of the answers they obtain and provide supporting arguments. In the aspect of interpreting with indicators, explaining and providing logical arguments for the mathematical results obtained, the intuitive subject explains why the results of his work are logical and acceptable with supporting arguments. This finding is supported by the research results of Khoyimah (2021), namely that subjects with an intuitive cognitive style have re-checked the results of their answers by examining and matching the answers with the information in the questions. From the steps taken by the subject, the subject has fulfilled the

indicators of relational thinking in solving problems by double-checking the answers and finding the relationship between the answers they have obtained and the problems given. Pangastuti et al. (2022) also explains that subjects with an intuitive cognitive style are able to provide validity of arguments to the conclusions obtained, while subjects convey this validity as a way of ensuring the correctness of the solutions obtained.

CONCLUSION

In the aspect of formulating problems, systematic students identify the information obtained from the two questions in more detail and are more careful in understanding the questions. Meanwhile, intuitive students identify the information needed to solve the problem in general, look at the question and data in the table and then create a train of thought on how to solve the problem. In the aspect of applying problems, systematic students design and use strategies in the process of finding solutions, identifying information known from the problem first, then applying it to addition, division and multiplication. In contrast to intuitive students, who design and use strategies in the process of finding solutions, solving problems using the concept of comparison.

The final aspect, namely the interpreting aspect, is that systematic students and intuitive students reinterpret the mathematical results obtained into contextual problems, state the truth of the answers they obtain and provide supporting arguments, explaining and providing logical arguments why the mathematical results they obtain are acceptable.

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