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An Analysis of Student Decision-Making in Answering Reasoning Questions Based on Gender

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abstract

The suboptimal empowerment of decision-making skills in young adolescents can hinder their ability to navigate complex choices. This research aims to determine how students make decisions when answering TIMSS science reasoning questions. This quantitative descriptive research was conducted on 178 (104 female and 74 male) 8th grade Junior High School students in Bandung. Samples came from 6 schools selected through a stratified random sampling technique. The instrument of this research is a constructed response to TIMSS questions in the cognitive domain of reasoning. Ten questions were asked to the samples. Quantitative data analysis was used in this research to determine the tendency of students to answer questions. The results show the tendency of students to make decisions when answering questions. Both male and female students use intuition, rational, and combination intuition-rational categories. These findings highlight the multifaceted nature of student decision-making in reasoning tasks. Further research is needed to explore the factors influencing these strategies and develop effective interventions to enhance decision-making skills in this crucial developmental stage.

1. Introduction

Indonesia is a developing country currently trying to improve students' competence in several aspects (Misbah et al., 2019). One of the goals of science learning in Indonesia is for students to have the competence to develop reasoning abilities in thinking of inductive and deductive analysis using the concept and principles of science to explain natural events and solve problems qualitatively and quantitatively (Nida et al., 2020). The objective is very appropriate to improve the quality of current Indonesian students' reasoning because the reasoning of Indonesian students is still low (Novianawati & Nahadi, 2019).

Learning in Indonesia is also directed to train learners to think analytically (decision-making) instead of mechanistic thinking (routine) and be able to collaborate and collaborate in solving problems (Budaev et al., 2019). Junior High School students enter adolescence where they can make or choose decisions that will influence their future decisions (Bolat & Odacı, 2017). Almost

every day, people always solve problems and make decisions, whether at home, in class, or anywhere else (Luescher-Mamashela, 2013). Decisions are generally influenced by three factors: decision characteristics, situational factors, and individual differences (Germeijs et al., 2012). Decision-making is a daily part of human life that affects life both individually and for many people, depending on the position of the decision-maker (Fang et al., 2019). Wilson and Keil state that decision-making is the process of choosing the preferred choice of choices based on specific criteria (Stahnke et al., 2016). According to Santrock, making a decision is a thought in which individuals evaluate the various choices and decide the choice of the many choices (Griffith et al., 2016). Thus, decision-making can be said to be a process of choosing from several choices by evaluating those choices using specific criteria (Dowling-Hetherington, 2020). There are three basic assumptions when a person makes a decision: (1) the decision maker knows all the information and possibilities that can occur, (2) the decision maker knows the difference in detail between the options, and (3) the decisions maker can make rational decisions (Gati, Levin, and Landman-Tal 2019; Munda, 2016). Decision-making undertaken by a person is fundamental and can help form a decision (Jho et al., 2014; Troisi et al., 2020).

Indonesia is also a participating country participating in Trends In International Mathematics and Science Study (TIMSS) (Cordero et al., 2018). TIMSS is an international study of the achievements of science and mathematics students whose basic assessment is categorized into two domains, namely content and cognitive. The content domain for science consists of chemistry, physics, biology, and earth sciences. Each tested question is a verb intended to assess the cognitive domain of TIMSS, i.e., knowledge, application, and reasoning. The three cognitive domains in TIMSS illustrate the thinking processes students are expected to use when dealing with problems (Kobakhidze, 2016).

The knowing domain aims to know students' ability to remember and explain facts, concepts, and procedures needed as a strong foundation in science (Opfer et al., 2012). Applying domain aims to know students' ability to use their knowledge to explain and solve practical problems (Hwang et al., 2020). The reasoning domain aims to know the student's ability to use the evidence and knowledge to analyze, synthesize, and generalize in new and complex situations (Molnár et al., 2013).

During the years of its participation, Indonesia has always been below international standards (Novianawati & Nahadi, 2015). The low achievement in science in TIMSS, among others, is due to the ability of Indonesian students still on average knowing ability, and Indonesian students are not accustomed to solving applying and reasoning problems (Wijaya, 2017). The difficulties Indonesian students face in dealing with such questions are due to the Indonesian students' reading strategy, which is still so poor that the reasoning level is still low, linear, and separated (not comprehensive) (Jones & Pratomo, 2016). It is necessary to emphasize the implementation of the expected competency-oriented curriculum (Kamaliyah et al., 2013). Learning is directed to encourage learners to find out from various sources of observation, able to formulate problems (ask), and not just solve the problem (Schmidt et al., 2011).

Enhancing science reasoning skills is a global concern, and Indonesia, a developing nation striving to improve student competency, is no exception (Soeharto & Csapó, 2022). While the national curriculum emphasizes reasoning abilities, including inductive and deductive analysis, recent TIMSS assessments indicate that Indonesian students consistently fall below international standards in science reasoning (Novianawati et al., 2022). This performance gap suggests a need to explore student decision-making processes during science reasoning tasks. While research emphasizes the importance of critical thinking in science learning (Zlatkin-Troitschanskaia et al., 2020), the specific strategies students employ when making choices within reasoning problems remain under-investigated in the Indonesian context (Heijltjes et al., 2015).

This study addresses this gap by investigating the decision-making strategies employed by eighth-grade students when tackling TIMSS science reasoning questions. By analyzing their approaches through a gender lens, we aim to gain deeper insights into potential variations and contribute to developing targeted interventions that can enhance students' reasoning skills. Current science learning develops students' thinking skills, from fundamental to complex thinking (Jensen et al., 2014). There are four high-level thinking patterns: critical thinking, creative thinking, problem-solving, and decision-making (Cargas et al., 2017). Curriculum Indonesia now emphasizes strengthening critical learning patterns (Higgins, 2014). according to Liliasari, critical thinking is the basis of other complex thinking patterns (Daniel & Auriac, 2011). Cognitive significantly affects decision-making (Özgelen, 2012). There are four categories of decision-making done by a person that is based on intuition, empirical, heuristic, and rational (Grace et al., 2015). Decisions will affect the outcomes achieved (Stahnke et al., 2016). The purpose of this research is to know the way 8th-grade students make a decision in solving the TIMSS reasoning problem viewed by gender.

2. Method

The TIMSS questionnaire utilized in this study was initially prepared in English. A translation and validation process was done to ensure appropriate use in Indonesia. Multilingual professionals who spoke both languages fluently translated the questionnaire from English to Indonesian. Following the translation, validation was carried out to confirm the questionnaire's content validity, cultural relevance, and linguistic accuracy for the intended audience. This validation method entailed testing the translated questionnaire with a small sample of Indonesian students, collecting input on comprehension and clarity, and making necessary adjustments based on the feedback. The translation and validation process resulted in the final version of the questionnaire utilized in this study.

This research is a descriptive study. The description is usually in the form of statistics. Graphs and other visual images of the results are often used (Creswell & Creswell, 2018). In this research, the information will be providing the students' decision-making tendencies. The sample in this study is 8th-grade junior high school students in Bandung, with as many as 178 students; 104 were female, and the rest were male. The students from 6 junior high schools in Bandung were chosen using a stratified random sampling technique. The sample-choosing process is based on a stratum or group in a population. The strata of this study were differentiated based on the cluster system of junior high schools in Bandung. The research sample is shown in Table 1.

Table 1. The details of samples from every school

School Code	Cluster	Gender		Total Students
		Male	Female	
S01	1	18	14	32
S02	1	14	21	35
S03	2	10	17	27
S04	2	9	22	31
S05	3	11	17	28
S06	3	12	13	25
		74	104	178

The instrument used in this study is the TIMSS questions of the cognitive domain of reasoning, as many as 10 constructed response items, which consist of 4 items biological content,

2 items chemistry content, and 2 items physics content. Biology content topics consist of Ecosystem (3 questions), Cells and their functions (1 question); Chemistry content topics consist of Chemical changes (1 question), Classification and composition of matter (3 questions); and consist of only 1 physics content topic, namely Energy, heat and temperature changes (2 questions).

The answer sheet equipped with the tools to know the categories of decision making used by the students. After writing their answer then, they were asked to choose the provided decision-making option category consisting of a) My feeling, b) Learning process experience in the class, c) Related theory, concept, and information, d) Logical thought and consideration. This method ensures clarity regarding the preparation of the data collection instrument and the process involved in selecting the sample for the study. Explanation of the decision-making category choices is shown in Table 2.

Table 2. Explanation of decision-making categories choice

Option	Category	Explanation
My feelings	Intuition	Based on which option is easier and more frequently heard, inclinations and conjectures, and statements for which there is no evidence
Experiences from learning	Empirical	Based on the results of experiments, estimations or estimates, prior knowledge
Theories, concepts, and related information	Heuristic	Based on scientific theories, existing rules, and limited information
Reasonable or logical thoughts and considerations	Rational	Based on the problem, advantages and disadvantages, and the various options available.

3. Result and Discussion

Students' Decision Making

Decision-making can be defined as choosing the most appropriate option among possible alternatives or actions to solve a problem (Jho et al., 2014). There are four categories of decision-making methods, namely based on intuition, empirical, heuristic, and rational (Wang & Ruhe, 2011). The research obtained the categories of decision-making approaches of students through 10 science reasoning questions in the form of constructed responses. The students were permitted to use one or multiple decision-making categories when answering. There are a total of fifteen decision-making categories available for students to use in answering these questions.

Figure 1 shows that male and female students widely use the decision-making category, intuition (I), followed by the rational category (R). In addition, many students still do not make a decision (-). This happens because they cannot answer the question. Another category chosen by students is a combination of intuition and rational categories (IR). This result is in accordance with Haidt's statement that one is more inclined to follow his intuition in making a decision (Grace et al., 2015). The second largest category used by students is the rational category. The third and fourth most used categories of students in answering the questions are random combinations of intuition – rational and combination of heuristics – rational category. Thus, students are more likely to use their feelings (intuition) than by using the learning experience or theories they know in answering the TIMSS science reasoning questions.

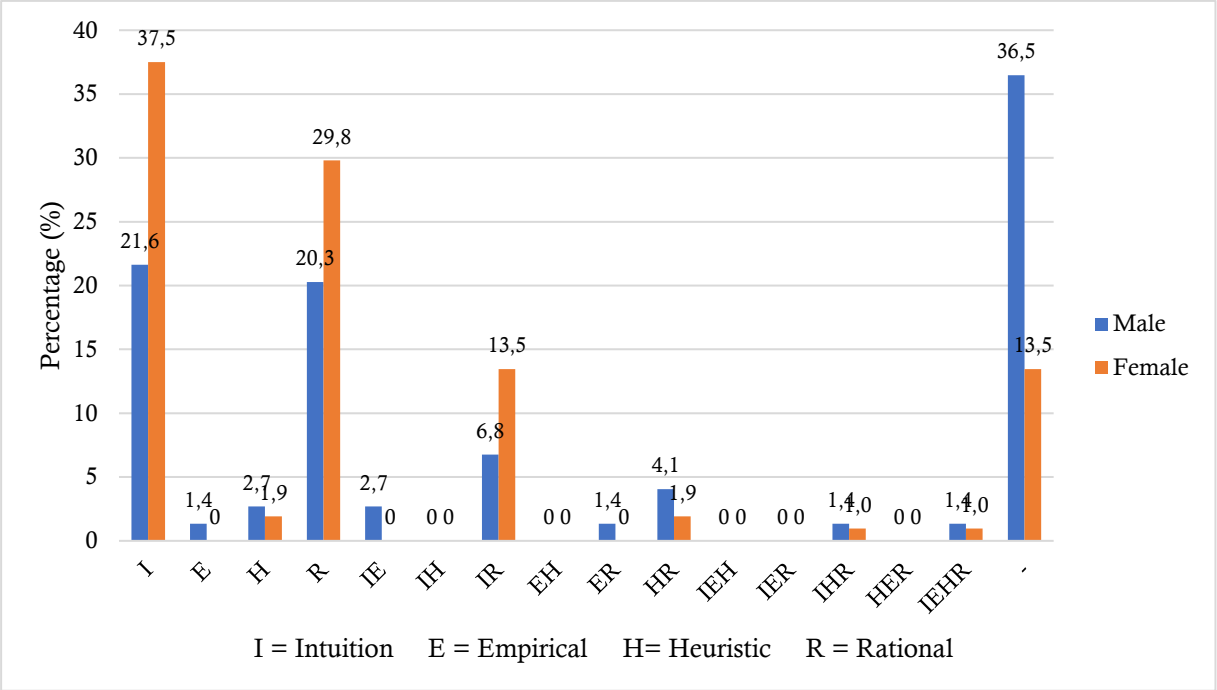

Figure 1. Category of students' decision-making based on gender

The results also indicate that some students do not choose any category. Their number is quite large, 36.5% for males and 13.5% for females. They are students who can not answer some of the questions tested, so the answer sheet is left empty. Students who do not know the theory or matter to answer questions tend to empty the answer sheet or fill out the potluck, which is not necessarily the correct answer.

Based on Figure 1, by excluding the number of students who did not choose a decision-making category, it can be seen that both female and male students tend to use their intuition more than their learning experience, theory, and rationale. Followed by the rational category and a combination of intuition - and rationality. However, the percentage of the three ways of decision-making is more significant for female students than male students. This is because more male students did not answer the questions than female students.

Students' Decision-Making at Each School

Figure 2 shows the category of decision-making at each school. Based on that figure, it shows that students from S01 and S03 who use single categories tend to use rational categories; S02, S04, and S05 tend to use intuition categories; and S06 tend to be many who do not choose any category of decision-making or abstain. Students from S02, S05, and S06 were the most abstinent. This happens because they cannot answer the question.

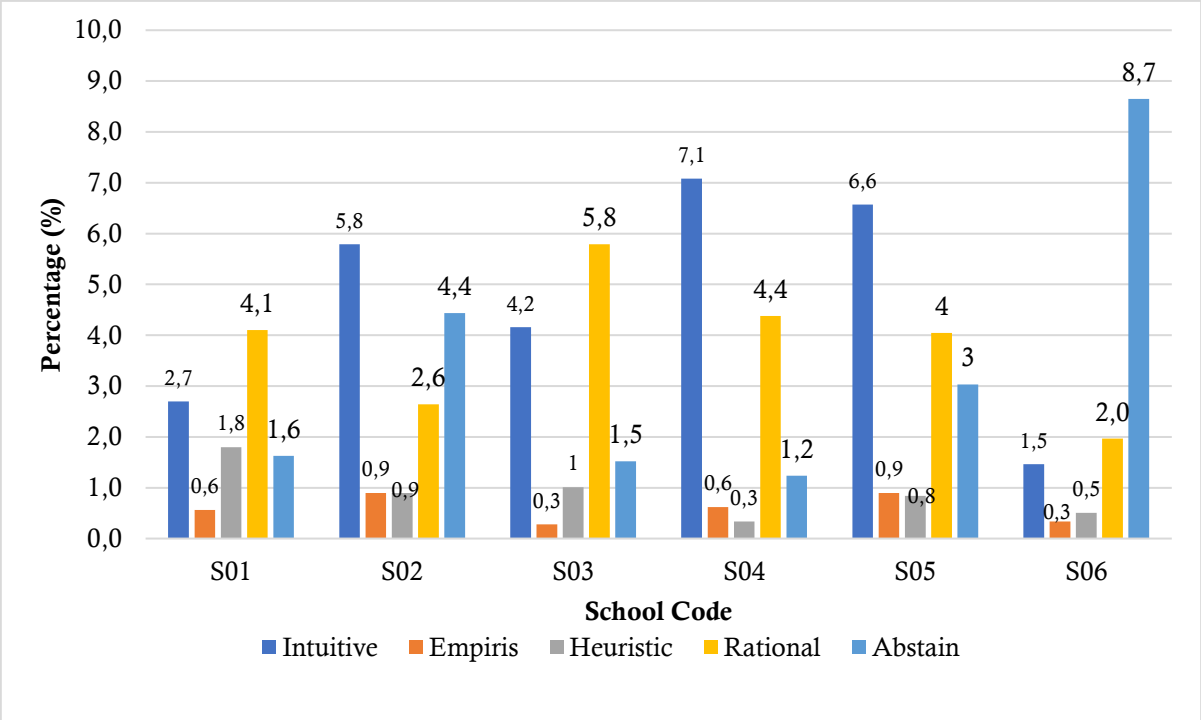

Figure 2. Category of students' decision-making at each school

The decision-making process involves the evaluation of information as well as reasoning (Wu & Tsai, 2011). Students must know and process information related to the problem and use logic to answer the questions presented. The use of feelings or intuition is the weakest way to make decisions. This is consistent with the findings in this study. Many students answer the problem wrongly than students who answer the question correctly when using their intuition to answer questions. Intuitive cognition in decision-making is often done but does not guarantee the reasoning is used appropriately. Decision-making using intuition can lead to a strong bias of judgment and decision (Albert & Steinberg, 2011). Bias in students who use their intuition to answer questions can cause the answer to be wrong.

On the other hand, students who use the rational category decision-making methods answer the questions correctly and incorrectly. Decisions resulting from rational decision-making are objective, logical, and more consistent. Students who answer the question wrongly, even though they have used the rational category, can be caused by a misconception of the concept they use when answering the question. The errors of this concept include intuitive conceptions, false theories, spontaneous reasoning, inaccurate previous knowledge, and unscientific ideas.

While the number of students who do not choose the category of any decision-making almost entirely answers the problem incorrectly, the number is more dominant because students do not answer the question, so they do not choose the category of any decision-making. The results showed that many students still can not answer the problem or answer the problem wrongly. This is because the problem of cognitive domains of reasoning requires students to use their reasoning to analyze data and other information, draw conclusions, and broaden their understanding of the new situation. So, if students do not have the capability required to answer the matter of reasoning, then they can not answer the question correctly or even cannot answer the question.

Based on the study results, some students use the combination category. One of the most commonly used combination categories of students is a combination of intuition and rationale. The use of such combinations may be due to the students having an advanced analysis of their

intuition using logic. Intuition can be the basis for further analysis. Intuition can enable analytical thinking in decision-making (Grace et al., 2015).

The learning process can influence students' decision-making when answering evaluation questions. Students can answer questions based on their own learning experiences. These experiences can make students answer evaluation questions based on empirical or heuristic categories. Nevertheless, there is little in this study. The number of students who answer the question using intuition or rationale is more than those who answer the problem using the category of empirical or heuristic. Some of the TIMSS science reasoning questions tested on students relate to the experiment. Students can answer the questions by using their experience (empirical) if they ever do or based on theory because they know the linkage of experiment with the theory. Based on the results obtained, it turns out that few students answered the problem by using the category of empirical or heuristic.

This study investigated the decision-making strategies employed by 178 eighth-grade students in Bandung, Indonesia, when tackling TIMSS science reasoning questions. The analysis revealed several key findings: 1) Decision-Making Categories: Students utilized a variety of decision-making categories when answering the questions. The most frequently used categories were intuition (I) and rational (R), followed by a combination of intuition and rational (IR). Many students also did not select any decision-making category, indicating unanswered questions. 2) Gender Differences: While both genders preferred intuition, a slightly higher percentage of female students used a combination of intuition and rational approaches compared to males. This finding requires further investigation in future studies. 3) School-Level Variations: Decision-making patterns varied across schools. Schools S01 and S03 had a higher proportion of students using the rational category, while schools S02, S04, and S05 leaned towards intuition. School S06 had the highest number of students who did not select any category.

The dominance of intuition in student decision-making during science reasoning tasks aligns with previous research by Kristjánsson, who suggests an inherent human tendency to rely on intuition before engaging in logical reasoning (Kristjánsson, 2022). This highlights the need for educational interventions that explicitly encourage students to develop critical thinking and analytical skills alongside their existing knowledge base (Kong, 2014). The limited use of empirical (learning experience) and heuristic (theory-based) categories suggests potential shortcomings in connecting classroom learning to real-world applications and scientific principles (Hora & Hunter, 2014). A possible explanation, supported by findings from Kapici (2022), could be a lack of emphasis on inquiry-based learning and scientific reasoning within the curriculum (Kapici et al., 2022).

Students who did not select any decision-making category likely faced challenges comprehending the questions or lacked the necessary scientific knowledge (Yacoubian, 2018). This aligns with the observation that a significant portion of students answered incorrectly. As highlighted by Kuhn (2012), mastering scientific reasoning requires practice analyzing data, concluding, and applying knowledge to new situations (Janoušková et al., 2023). Educational strategies emphasizing these aspects could improve student performance in science reasoning tasks. Interestingly, some students utilized a combination of intuition and rational approaches (Garrecht et al., 2018). While Grace et al. (2015) suggest intuition can be a springboard for analytical thinking, further research is needed to understand how students integrate these seemingly contrasting approaches (Larsson & Tibell, 2015).

This study is limited by its focus on a single city in Indonesia. Future research could explore decision-making patterns in a wider geographical context. Additionally, the study relied on self-reported decision-making categories, which could be prone to bias. Employing think-aloud protocols or interviews could provide richer insights into students' thought processes. This study

contributes to a deeper understanding of student decision-making during science reasoning tasks. The findings highlight the prevalence of intuition and the need for educational interventions that cultivate critical thinking, scientific reasoning, and the application of knowledge to real-world scenarios. Future research should explore these areas further and investigate the effectiveness of targeted interventions to bolster student performance in science reasoning.

4. Conclusion

This study shows an overview of the decision-making of junior high school students in Bandung in completing the TIMSS science reasoning questions. Both male and female students are more likely to use a single category than a combination category. The most widely used decision-making categories are intuition, rational, and combination intuition-rational, and many students cannot answer the questions, so they do not choose any category. For future research to see how students carry out the decision-making process, different test instruments, such as literacy and numeracy questions or socioscientific issues questions, can be used to see students' higher-order thinking skills.

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