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Students' Thinking Process in Solving Mathematical Literacy Problems in Islamic Contexts

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Abstract

Islamic contexts help stimulate students' mathematical abilities and develop their religious thinking. Therefore, this research aims to describe students' thinking process in solving mathematical literacy problems adapted from PISA questions using Islamic contexts. This research is qualitative-descriptive in nature with the purposive sampling technique used to select the three best teams competing on the National Mathematics Olympiad organized by the Mathematics Education Study Program of UIN Syarif Hidayatullah Jakarta in 2018. Each school level (Islamic elementary school (MI), Islamic junior high school (MTs), and Islamic senior high school (MA)) was represented by a team of 3 students. Data were collected through tests of mathematical literacy in Islamic contexts that matched PISA contexts and through interviews. Then, the data collected were analysed using triangulation techniques. The results showed that the students' thinking process in solving mathematical literacy problems in Islamic contexts was in accordance with Bayer’s thinking process theory. In general, the students already engaged in a thought process starting from information processing to decision-making. In fact, some MTs students had reached the thinking level of analysing relationships, synthesising problems or arguments, and conducting evaluations using several criteria suitable for the MA level. So it can be concluded that he Islamic contexts used in mathematical literacy questions tend to draw students' attention to the problems and help them solve those problems.

Keywords: Mathematical Literacy in Islamic Contexts, Mathematical Thinking Process, High-Level Mathematics Skills

Abstrak

Konteks Islam membantu merangsang kemampuan matematika siswa dan mengembangkan pemikiran keagamaan mereka. Oleh karena itu, penelitian ini bertujuan untuk mendeskripsikan proses berpikir siswa dalam menyelesaikan soal literasi matematis yang diadaptasi dari soal-soal PISA menggunakan konteks keislaman. Penelitian ini merupakan penelitian deskriptif kualitatif dengan teknik purposive sampling yang digunakan untuk memilih tiga tim terbaik dari olimpiade matematika tingkat nasional yang diselenggarakan oleh Program Studi Pendidikan Matematika UIN Syarif Hidayatullah Jakarta tahun 2018. Setiap jenjang pendidikan yaitu Madrasah Ibtidaiyah (MI), Madrasah Tsanawiyah (MTs) dan Madrasah Aliyah (MA) diwakili oleh tim yang terdiri dari 3 orang siswa. Pengumpulan data dilakukan melalui tes literasi matematis dengan konteks keislaman yang disesuaikan dengan konteks PISA dan wawancara. Kemudian, data yang terkumpul dianalisis melalui teknik triangulasi. Hasil penelitian menunjukkan bahwa proses berpikir siswa dalam menyelesaikan soal literasi matematis dengan konteks keislaman sesuai dengan teori proses berpikir Bayer. Pada umumnya siswa sudah memiliki proses berpikir mulai dari tahap pengolahan informasi sampai tahap strategi pengambilan keputusan. Bahkan, beberapa siswa MTs sudah sampai pada tahap berpikir menganalisis hubungan, mensintesis masalah atau argumentasi dan melakukan evaluasi dengan menggunakan beberapa kriteria yang sesuai dengan tingkat MA. Sehingga dapat disimpulkan bahwa konteks keislaman dalam soal literasi matematis cenderung membangkitkan perhatian siswa terhadap masalah dan membantu mereka dalam menyelesaikannya.

Kata kunci: Literasi Matematis Konteks Keislaman, Proses Berpikir Matematis, Kemampuan Matematika Tingkat Tinggi

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INTRODUCTION

Literacy is a popular topic among the international community. It is little wonder that numerous countries are aggressively conducting literacy assessments and looking for ways to enhance their people's skills. According to Arslan & Yavuz (2012), as well as Pamungkas & Franita (2019), literacy is critical to overcoming various state-related economic, social, and cultural problems. The higher the level of literacy understanding of a nation, the faster and more precise the policies issued (Akyüz, 2014; Mujulifah, Sugiatno, & Hamdani, 2015). Mathematical literacy abilities need to be developed in the 21st century for everyone to be able to face various problems related to work or tasks in daily life (Kusumah, 2012; OECD, 2019). It is all the truer as mathematical literacy is also relevant to attempts to solve challenges in the current era that involve collaborations and innovations (Anwar, Pujiastuti, & Mutaqin, 2019).

Indonesia is one of the countries that are currently paying serious attention to literacy due to its unsatisfactory position globally, as shown by its PISA scores. Some of the components associated with this problem are content, process, and context (Thomson, 2013). PISA focuses on literacy abilities, emphasizing the skills and competencies obtained by students from schools and used in everyday life to solve various problems (Johar, 2012). These PISA test results were confirmed by the results of the Progress in International Reading Literacy Study (PIRLS) in 2016, according to which the mathematical literacy abilities of students in Indonesia were still relatively low (Kurniawati, Miftah, Kadir & Muin, 2021).

Students' low mathematical literacy ability has been unveiled by, among other things, how they solved PISA questions (Edo, Hartono, & Putri, 2013; Mahdiansyah & Rahmawati, 2014). Contexts play an essential role in mathematics learning and assessment as they allow students to prepare for future challenges. Therefore, it is important that they be introduced to various contexts covering various aspects of daily life (Freudenthal, 1968; Gravemeijer, 1994; De Corte, Greer & Verschaffel, 1996; Stacey, 2011). As stated by Zulkardi, Meryansumayeka, Ilma, Putri, Alwi, Nusantara, Ambarita, Maharani, & Puspitasari (2020), the use of contexts in mathematical problems aims to stimulate students in learning mathematics. This tends to bring students to recall the concepts they have learned, connect with existing problems, and formulate solutions that fit the given contexts. Another cause of low mathematical literacy is that students are less trained in working on PISA-characterised questions that require higher-order thinking processes (Budiman & Jailani, 2014). Therefore, Zulkardi (2010) suggested designing PISA-like math problems and using them in mathematics learning in the classroom.

According to St. Clair (2018), contexts relevant to mathematical tools should be used in classroom learning. Mathematical literacy questions can be developed using various contexts. For example, some have been developed in the contexts of Indonesian natural and cultural heritages and of football and tennis matches at the 2018 Asian Games (Oktiningrum, Zulkardi & Hartono, 2016; Efriani, Putri, & Hapizah, 2019; Nizar, Putri & Zulkardi, 2018). The use of a certain context in a mathematical literacy problem allows students to develop familiarity with problems presented in PISA and encourages them to apply the solutions to such problems in everyday life (Masjaya & Wardono, 2018).

One of the focuses of mathematics learning is the development of affective aspects, including religiosity (Mardhiyana, 2015). Islamic contexts, as an aspect of religiosity, can be integrated into mathematics learning, especially in developing mathematical literacy test instruments (Lutfianto & Sari, 2017). The integration of Islamic contexts into math literacy questions for Islamic school students aims to (1) adapt to the situation and condition faced by students who receive Islamic materials every day at school, (2) indirectly make students learn Islam through mathematical literacy questions, (3) strengthen their belief in Islam through a mathematical approach, and (4) eliminate the paradigm that mathematics is a general subject matter distant from religion (Kurniawati et al., 2021).

The Islamic contexts integrated into mathematical literacy problems fall to either of the following domains: *Al-Qurán*, *Al-Hadits*, *Sirah Nabawiyyah*, and *Yaumiyyah* (daily life). Figure 1 shows how PISA contexts are related to Islamic contexts (Kurniawati et al., 2021). Teachers need to look into students' thought process in solving math problems (Pitriani & Afriansyah, 2017). This is because good thinking skills will increase students’ ability to easily understand the mathematical concepts they are learning (Yanti & Syazali, 2016).

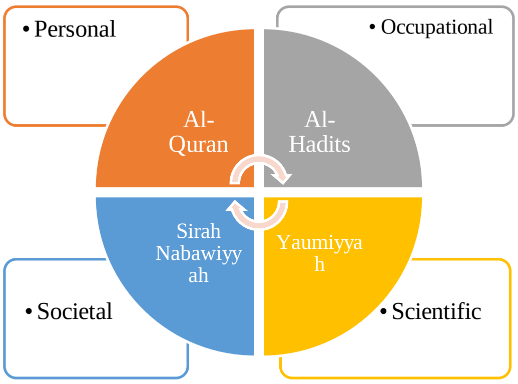


Figure 1. Relationship between PISA and Islamic contexts

It is important for students to develop mathematical thinking to meet their needs in every field (Uyangör, 2019). A variety of mathematical thinking definitions have been widely expressed by experts, and all of them generally consist of such components as abstraction, synthesis, generalisation, modelling, problem-solving, and verification (Hudson, Henderson, & Hudson, 2015; Çelik, 2020; D. Tall, 2002; Liu, 2015; Mason, Burton, & Stacey, 2010). Henderson, Riedesel, Hamer, & Hitchner (2003) defined mathematical thinking as the direct or indirect use of techniques, concepts, and methods in the problem-solving process. Individuals use mathematical thinking skills in solving the events and phenomena they encounter at every stage of their life. According to Gravemeijer (1998), students' level of thinking starts with a specific context, a model, and a strategy, which refer to the situation described in a problem. The focus of mathematics is on mastering strategies that refer to contexts, working with conventional procedures, and notation. Later, students apply the concepts obtained to new problems in different contexts. Pöhler, B., and Prediger (2014) specifically distinguished informal and formal thinking level of seventh grade students. At this level, students no longer depend on the contexts provided. Rather, they are able to abstract the solution to a problem using the right concept. According to Bayer (1988), students' thinking abilities, i.e., information processing and critical thinking, are determined by their educational level, from elementary school to high school level.

Some of the tasks in teaching are to form thinking concepts, establish mental attitudes, and touch the deepest affections from the core humanity of students (Sopian, 2016). According to Yanti & Syazali (2016), teachers' ability to understand students' varying thinking processes helps track their position and types of mistakes. Therefore, teachers must understand the various thinking processes that students undergo because any inaccuracy in the thinking process will hinder students' understanding of the mathematical concepts they are studying. Muhtarom, Murtianto, & Sutrisno (2017) stated that students' thinking processes in solving mathematical problems need further researching in various subjects. Studies related to students' thinking process in solving mathematical literacy problems in Islamic contexts are scarce. Previous research by Kurniawati et al. (2021), for example, found that the mathematical literacy abilities of MI, MTs, and MA students in Indonesia in Islamic contexts were still low. However, the research has yet to specifically discuss what causes students' mathematical literacy abilities to be low and how students' thinking processes in solving mathematical literacy questions in the Islamic context go.

Therefore, this research aims to describe the mathematical thinking processes of Islamic elementary school (MI), Islamic junior high school (MTs), and Islamic senior high school (MA) students in solving mathematical literacy problems adapted from PISA questions using Islamic contexts. The Islamic contexts used in this study pertained to *Al-Qur'an*, *Al-Hadith*, *Sirah Nabawiyyah*, and *Yaumiyyah*.

METHODS

This research used a qualitative descriptive approach to reveal the incidence of symptoms emerging from the subjects. It was used to formulate students' thought processes in solving mathematical literacy problems in Islamic contexts. Data were collected from the answers of Islamic school students to mathematical literacy questions in Islamic contexts posed at the 2018 National Mathematics Olympiad (OPTIKA). This event was organized by the Mathematics Education Study Program of UIN Syarif Hidayatullah Jakarta. The contestants (n = 3,285) came from 231 Islamic elementary schools (MI), 167 Islamic junior high schools (MTs), and 203 Islamic senior high schools (MA) across 34 provinces of Indonesia.

The purposive sampling technique was used to select the 3 best teams in the first stage of this competition. The three best teams in this competition showed that they were highly capable and were the best of all contestants at the MI, MTs, and MA levels. This was intended to confirm Indonesian students' relatively low PISA test results and to figure out the thought processes of the best students of Islamic schools when solving mathematical literacy questions in Islamic contexts. These subjects were chosen based on the consideration of their potential in their mathematical literacy thinking processes. Data were not collected from students with low success rates because mathematical thinking is characterized by the attainment of new knowledge or concepts through estimation, generalisation, guesswork and testing, abstraction, reasoning, and proving (Uyangör, 2019). The subjects selected for the MI level were students from SD Islam Atthirah Makassar, MIN 9 Jakarta, and SD Muhammadiyah 12 Pamulang. The subjects selected from the MTs level were students from SMP Islam Atthirah Makassar, SMP Internat Al-Kautsar Jabar, and MTs Pembangunan UIN Jakarta. The subjects selected from the MA level were students from MAN 2 Sleman, MAN 2 Pekanbaru, and SMAIT As-Syifa Boarding School, West Java.

The procedure in this research was as follows: (1) administering a mathematical literacy test in Islamic contexts on the students; (2) analysing the students' answers to identify their thinking processes according to Bayer (1988), (3) categorising the students based on their levels of thinking in solving mathematical literacy problems in Islamic contexts, (4) conducting interviews with the students, and (5) analysing the interview results. The instruments used in this research were 9 mathematical literacy questions in Islamic contexts for all education levels adapting level 4 PISA questions. These questions were first tested for validity by experts engaged in the fields of mathematics education and Islamic religious sciences. Data were collected from students' work in solving the mathematical literacy questions in Islamic contexts and interviews as a triangulation technique to determine their credibility. Table 1 shows a map of education levels, student codes, question codes, composition of PISA questions, and Islamic contexts.

Table 1. Composition of mathematical literacy questions based on PISA and Islamic context

Levels	Student Codes	Problem Codes	Composition of the Question			
			Context	Content	Process	Islamic Contexts
MI	A1, A2, A3	MI-1	Occupational	Quantity	Connection	*Al-Qur'an*
		MI-2	Social	Change and Relationships	Connection	*Yaumiyyah*
		MI-3	Social	Quantity	Reflection	*Sirah Nabawiyyah*
MTs	B1, B2, B3	MTS-1	Scientific	Space and Form	Reflection	*Al-Hadits*
		MTS-2	Occupational	Change and Relationships	Reflection	*Yaumiyyah*
		MTS-3	Social	Quantity	Connection	*Al-Qur'an*
MA	C1, C2, C3	MA-1	Social	Quantity	Connection	*Al-Hadits*
		MA-2	Scientific	Change and Relationships	Reflection	*Al-Hadits*
		MA-3	Scientific	Change and Relationships	Reflection	*Al-Hadits*

In this study, the analysis was conducted using a qualitative descriptive technique through the following stages: (1) data reduction, (2) data presentation, and (3) conclusion drawing (Basrowi & Suwandi, 2008). The data were obtained by observation, interview, and documentation methods. The researcher conducted data reduction from students' answers to the mathematical literacy questions in Islamic contexts. Then, the data were presented for easy reading and conclusion drawing. The data were also verified, in which case the meaning that emerged from the data was tested for its validity and suitability, indicating guaranteed validity. At this level, the researcher reviewed the data at hand repeatedly, collected what had formed, and reported the results of the research in full.

According to Bayer (1988), students' thinking level goes according to their order of thought and educational level from elementary school to senior high school. (1) At level I, information processing is the most basic thinking operation, which is relatively simple in terms of the procedures involved or rules applied. Students use information processing abilities repeatedly in a variety of combinations to implement more complex level II and level III abilities and strategies. (2) At level II, students perform critical thinking, which is not a process in the same sense as a level I strategy. Rather, it is a different set of mental operations used to determine the value or accuracy of something, as well as a set of dispositions that guide its use and execution. This operation combines analysis and evaluation and is repeatedly used in the various stages of a level I thinking strategy. (3) At level III, students engage in strategy thinking, which refers to broad, inclusive, and complex operations such as problem-solving, decision-making, and conceptualisation. Table 2 shows students' thinking levels from elementary school all the way to senior high school.

Table 2. The thinking processes of students from elementary school to senior high school levels

Thinking Processes	Elementary School	Junior High School	Senior High School
Information Processing Skills	(1) Identify (2) Classify (3) Compare	(1) Provide concept examples (2) Identify common problems (3) Classify the problems (4) Connect the problems with one another	(1) Identify concept examples (2) Identifies common problems (3) Classify the problems (4) Connect the problems with one another (5) Determine the most important issues
Problem-Solving Strategies	(1) Identify problems (2) Choose a solution plan (3) Carry out the plan (4) Check answers	(1) Identify problems (2) Represent the problems (3) Plan and choose solutions (4) Carry out the plan (5) Check answers/plans	(1) Identify problems (2) Organise data (3) Represent the problems (4) Plan and choose solutions (5) Carry out the plan (6) Check answers/plans

Thinking Processes	Elementary School	Junior High School	Senior High School
Critical Thinking Operations	(1) Determine correct facts and sources (2) Make arguments from conclusions	(1) Identify the sequence of arguments (2) Detect irrelevant problems (3) Identify unstated assumptions (4) Identify logical errors	(1) Assess the strength of arguments (2) Identify logical errors (3) Identify logical inconsistencies
Analysis, Synthesis, and Evaluation	(1) Analyse part of the whole (2) Synthesise problems (3) Conduct an evaluation using given criteria	(1) Analyse part of the whole (2) Synthesise problems (3) Conduct an evaluation using self-found criteria	(1) Analyse relationships (2) Synthesise problems or arguments (3) Conduct an evaluation using several criteria
Decision Making Strategies	Grade 6 and above (1) Set goals (2) Identify options (3) Analyse the options (4) Choose the best option	(1) Set goals (2) Identify options (3) Analyse the options (4) Choice ranking (5) Choose the best option	(1) Set goals (2) Identify options (3) Analyse the options (4) Choice ranking (5) Top selection evaluation (6) Choose the best option

Note. Adapted from Developing a Scope and Sequence for Thinking Skills Instruction by Bayer (1988)

RESULTS AND DISCUSSION

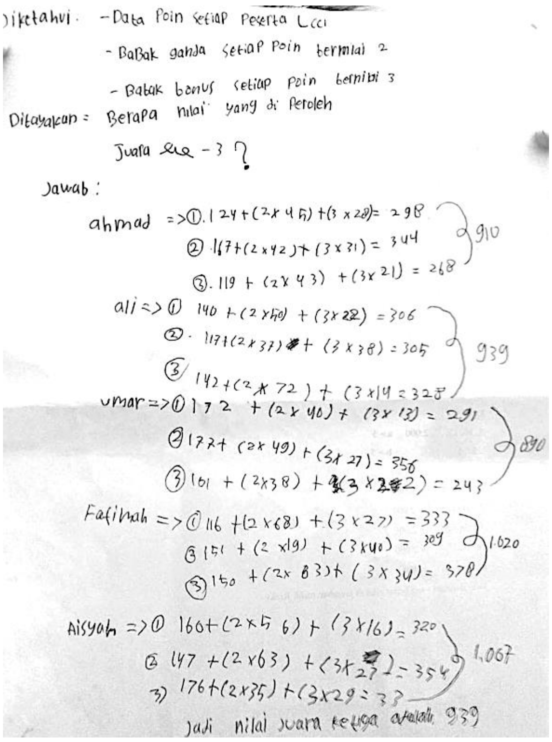
This study aims to describe the thinking processes of students of different levels of education (MI, MTs, and MA) in solving mathematical literacy questions in Islamic contexts. Each level of education was represented by one school, which was represented by the 3 best students who won the National Mathematics Olympiad for Islamic schools. The levels of students' thinking processes referred to Bayer (1988). This research helps find out the strengths and weaknesses of students' thinking process in solving mathematical literacy questions in the Islamic context and provides recommendations for mathematics teachers in schools who are to improve students' mathematical literacy skills in Islamic contexts.

Information Processing Skills

MI Students

Question MI-1 relates to the context of the Islamic Themed Quiz Competition (LCCI). In this question, students were asked to determine the participant likely to win the 3rd place in the LCCI. From student answers (Figure 2), it was known that students A1, A2, and A3 were able to identify the participants' points and classify the participants based on the calculation in each session by considering the weighting rules assigned to the questions. Furthermore, the students compared their results and finally stated that the participant who won the 3rd place in the LCCI was Ali, who earned a score of 939. This indicates that all MI students had the ability to identify, classify, and compare information at the first thinking level correctly, showing that they possessed excellent information processing skills. A1, in particular, was able to relate problems to one another, showing the thinking processes of those at the MTs level.

Based on the interview results, it was found that students paid considerable attention to the information that they obtained from the question as support for their completion. The contexts of competition and Islam were contributing factors. When new information is linked to the understanding structure that someone already has in the cognitive structure, learning will be meaningful (Salsabila, 2016).


Diketahui: - Data Poin setiap Peserta LCCI
- Babak ganda setiap Poin bernilai 2
- Babak bonus setiap poin bernilai 3
Ditanyakan: Berapa nilai yang di Peroleh Juara ke - 3 ?
Jawab:
ahmad => ①. 124+(2×45)+(3×28) = 298
② 167+(2×42)+(3×31) = 344 910
③. 119 + (2×43) + (3×21) = 268
ali => ① 140 + (2×50) + (3×22) = 306
②. 117+(2×37)+(3×38) = 305 939
③ 142+(2×72) + (3×14) = 328
umar => ① 172 + (2×40) + (3×13) = 291
② 177+(2×49)+(3×27) = 356 890
③ 101 + (2×38) + (3×22) = 243
Fatimah => ① 116 + (2×68) + (3×27) = 333
② 151 + (2×19) + (3×40) = 309 1.020
③ 150 + (2×83) + (3×34) = 378
Aisyah => ① 160+(2×56)+(3×16) = 320
② 147 + (2×63) + (3×27) = 354 1.007
③ 176+(2×35)+(3×29) = 33
Jadi nilai juara ketiga adalah 939

Translated into English:

Given:
- ⇨ Point data for each LCCI participant
- ⇨ Each point in the doubles round is valued 2
- ⇨ Each point in the bonus round is valued 3

Asked: What score would the third place winner get?
Answer:

Ahmad = (1). $124 + (2 \times 45) + (3 \times 28) = 298$
(2). $167 + (2 \times 42) + (3 \times 31) = 344$ — 910
(3). $119 + (2 \times 43) + (3 \times 21) = 268$

Ali = (1). $140 + (2 \times 50) + (3 \times 22) = 306$
(2). $117 + (2 \times 37) + (3 \times 38) = 305$ — 939
(3). $142 + (2 \times 72) + (3 \times 14) = 328$

Umar = (1). $172 + (2 \times 40) + (3 \times 13) = 291$
(2). $177 + (2 \times 49) + (3 \times 27) = 356$ — 890
(3). $101 + (2 \times 38) + (3 \times 22) = 243$

Fatimah= (1). $116 + (2 \times 68) + (3 \times 27) = 333$
(2). $151 + (2 \times 19) + (3 \times 40) = 309$ — 1.020
(3). $150 + (2 \times 83) + (3 \times 34) = 378$

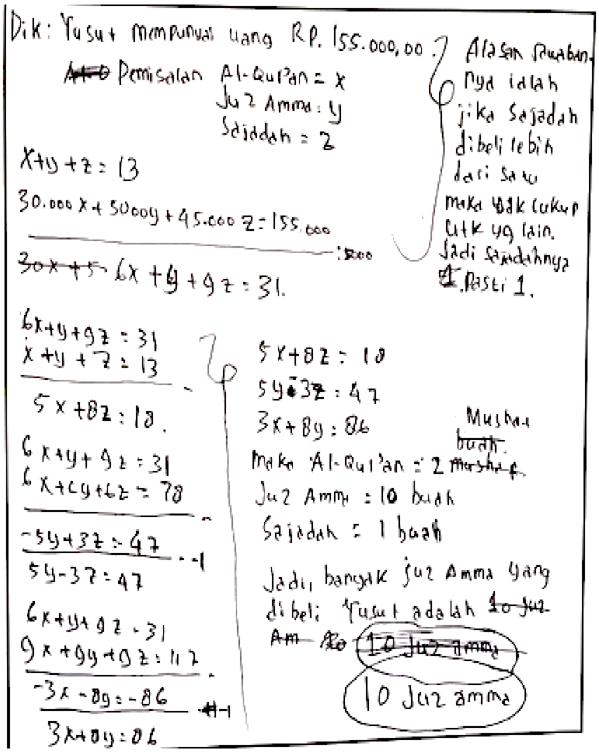
Aisyah = (1). $160 + (2 \times 56) + (3 \times 163) = 320$
(2). $147 + (2 \times 63) + (3 \times 27) = 354$ — 1.007
(3). $176 + (2 \times 35) + (3 \times 29) = 333$

So, the third place winner would earn a score of 939

Figure 2. Student A1's answer to question MTS-1

MTs Students

MTs-1 question relates to the concept of three-variable linear equation systems. In this question, students were asked to determine the number of *Juz Amma* books purchased by Yusuf based on the information provided. Students B1, B2, and B3 were able to identify important information, classify a given problem, and compare the information as part of their problem-solving process with an assumption that *Al-Qur'an* book*, Juz 'Amma* book, and prayer mat, each denoted by x, y, and z, are three variables in a linear equation. The students were able to generate the correct equation and find out that the variables x, y, and z are each valued 2, 1, and 2. From their calculation, they found out that Yusuf purchased 10 *Juz 'Amma* books. This indicates that the MTs students already had a complete mastery of information processing. As stated by Yeigh (2014), any information processing is mediated by categorizing and using concepts. Therefore, information processing determines the formation of meaning in a person, which results in a change in attitude. Student B1's answer to this question is presented in Figure 3.



Translated into English:

Given: Yusuf has Rp155,000.00
Suppose: *Al-Qur'an* = *x*
Juz 'Amma = *y*
Prayer mat = *z*

When more than one prayer mat is bought, it is not enough for others. Therefore, the prayer mat must be 1.

$x + y + z = 13$
$30{,}000x + 5{,}000y + 45{,}000z = 155{,}000$
$6x + y + 9z = 31$

$6x + y + 9z = 31$
$x + y + z = 13$ -
$5x + 8z = 18$

$6x + y + 9z = 31$
$6x + 6y + 6z = 78$ -
$-5y + 3z = -47$ × (-1)
$5y - 3z = 47$

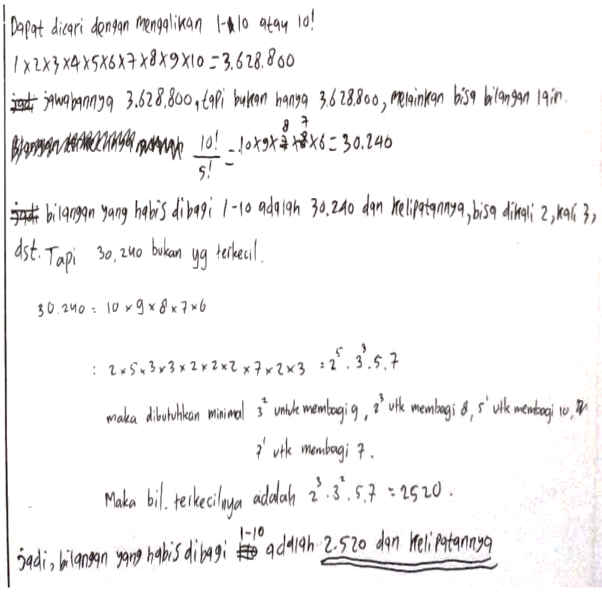
$6x + y + 9z = 31$
$9x + 9y + 9z = 117$ -
$-3y - 8y = -86$ × (-1)
$3x + 8y = 86$

$5x + 82 = 18$
5y - 3z = 42
3x + y = 86
Then,
Al-Qur'an = 2 mushafs
Juz 'Amma = 10 pieces
Prayer mat = 1 piece
So, Yusuf bought 10 pieces of *Juz 'Amma*

Figure 3. Student B1's answer to question MTs-1

MA Students

The thought process of information processing in MA students is higher in complexity than those in MI and MTs students. In general, MA students are able to identify, classify, and connect problems with each other and analyse examples of concepts. For instance, student C1 was able to reveal the use of factorial concepts as a problem-solving strategy. C1 used 10! in calculating a number that is divisible by 1–10 even though this is not a minimal number. C1 concluded that the minimum number divisible by 1 to 10 is $2^3 \times 3^2 \times 5 \times 7 = 2.520$ (see Figure 4). This indicates that the thinking process of MA students involves connecting problems and determining the most important ones based on the outlined questions. This is certainly influenced by memory and cognition, including students' intelligence, which tends to determine the amount of information processed, and the surrounding stimulus. Frishammar (2002) stated that the smarter a person is, the more able he/she is to examine the error of an argument and the higher his/her interest is.



Translated into English:

Can be found by multiplying 1-10 or 10!

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 \times 9 \times 10 = 3{,}628{,}800$$

The answer is 3.628.800, but not only restricted to it. Another number can be correct too.

$$\frac{10!}{5!} = 10 \times 9 \times 8 \times 7 \times 6 = 30{,}240$$

A number that is divisible by 1-10 is 30,240 and its multiples. It can be multiplied by 2, 3, and so on. But 30.240 isn't the smallest.

$30.240 = 10 \times 9 \times 8 \times 7 \times 6$

$= 2 \times 5 \times 3 \times 2 \times 2 \times 7 \times 2 \times 3 = 2^5 \times 3^3 \times 5 \times 7$

Then, it takes a minimum of 3^2 to split 9, 2^3 to split 8, 5^1 to split 10, and 7^1 to split 7.

So, the smallest number is $2^3 \times 3^2 \times 5 \times 7 = 2{,}520$

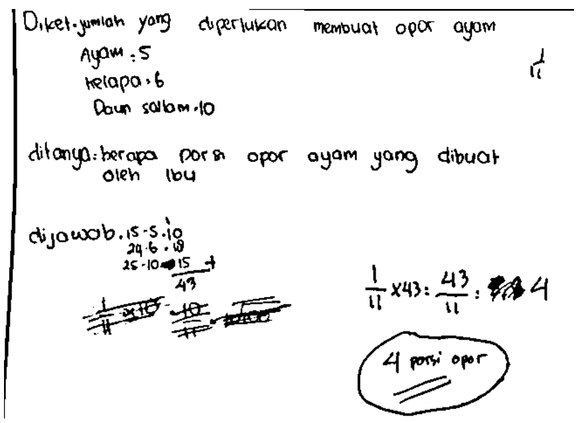
So, the number that is divisible by 1-10 is 2.520 and its multiples.

Figure 4. Student C1's answer to question MA-1

Problem-Solving Strategies

MI Students

Question MI-2 relates to food preparation to be served on *Eid al-Fitr* and is solved using the comparison concept. All students understood the context of the question and found a strategy to solve the question, which was by carrying out a comparative analysis on chicken, coconut, and bay leaves. Based on student answers, it was found that the students examined their completion work by stating that the chicken made 10 servings. Student A3 only wrote down the numbers of chickens, coconuts, and bay leaves without understanding the comparison concept in the question. Furthermore, they used the subtraction concept to solve the problem instead of the comparison concept, hence wrong answers (see Figure 5).



Translated into English:

Given:
The required amount to make opor ayam
Chicken = 5
Coconut = 6
Bay leaf = 10
Asked: How many servings of opor ayam did your mother make?
Answer:

$15 - 5 = 10$
$24 - 6 = 18$
$25 - 10 = 15$ +
43

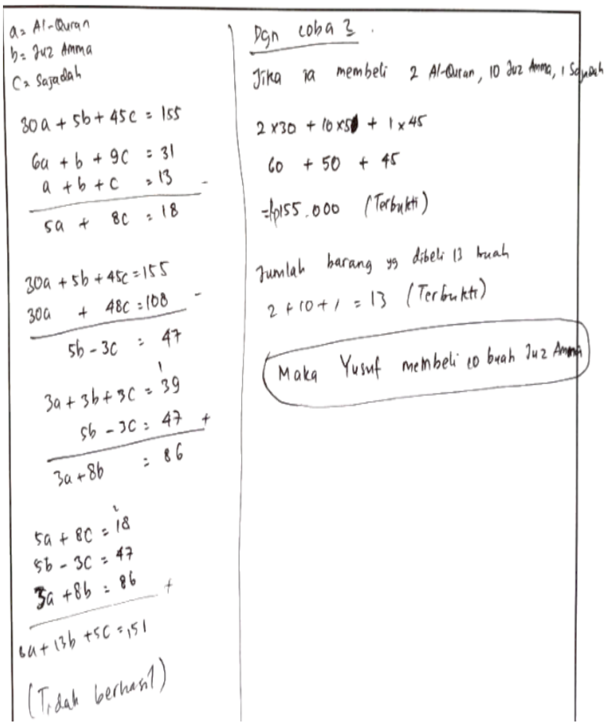
$$\frac{1}{11} \times 43 = \frac{43}{11} = 4$$

4 servings

Figure 5. Student A3's answer to question MI-2

MTs Students

All the MTs students were already in the problem-solving level of thinking process. However, B2 developed a unique strategy when they were unable to make the expected solution with the elimination method (see Figure 6). B2 failed to make a solution using this method due to an error in combining equations. Therefore, B2 switched to the "trial and error" strategy. B1 assumed that Yusuf bought 2 *Al-Qur'an* books, 10 *Juz ‘Amma* books, and 1 prayer mat. When substitution was performed to the equations that they developed, the answer given turned out to be correct.



Translated into English:

a = *Al-qur’an*
b = *Juz amma*
c = *Prayer mat*
$30a + 5b + 45c = 155$

$6a + b + 9c = 31$
$a + b + c = 13$ $-$
$5a + 8c = 18$

$30a + 5b + 45c = 155$
$30a + 48c = 108$ $-$
$5b - 3c = 47$

$3a + 3b + 3c = 39$
$5b - 3c = 47$ $+$
$3a + 8c = 86$

$5a + 8c = 18$
$5b - 3c = 47$
$3a + 8b = 86$ $+$
$8a + 13b + 5c = 51$
(not successful)

By trial and error
If he buys 2 *Al-Qur'an* books, 10 *Juz Amma* books, and 1 prayer mat
$2 \times 30 + 10 \times 5 + 1 \times 45$
$60 + 50 + 45$
= Rp155,000 (proven)

The number of items purchased 13 pieces
$2 + 10 + 1 = 13$
(proven)

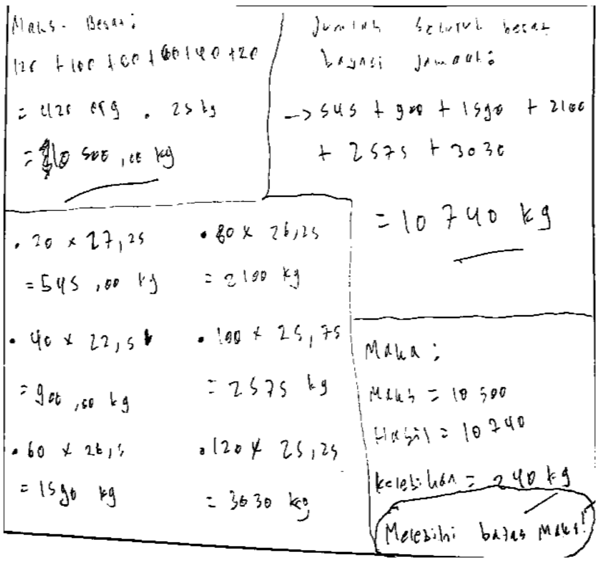
So, Yusuf bought 10 *Juz Amma* books

Figure 6. Student B2’s answer to question MTs-1

MA Students

Question MA-2 asks students to determine whether the baggage weight of *umrah* pilgrims exceeds a maximum limit. Data are presented in a histogram along with the condition that each *umrah* pilgrim is only allowed to carry baggage weighing 25 kg at most on flights. All students answered this question correctly and identified the problem, organised data, represented the problem, implemented a plan, and obtained a solution to the problem. However, like MI and MTs students, MA students did not re-check their answers or plans.

C1 used a unique strategy to solve this problem (see Figure 7). In obtaining the total weight of baggage carried by the *umrah* pilgrims, C1 multiplied all the frequencies by the weight of the baggage to finally get 10,740 kg. Furthermore, C1 compared it with the maximum baggage weight obtained from the sum of the frequencies to acquire 10,500 kg. C1 found that the baggage weight of the pilgrims is in excess of 240 kg. Meanwhile, C3 answered in a simpler manner using statistical concepts with negative skewedness of the baggage weight data, which means that the mode is above the median and empirical average. Therefore, the baggage weight tends to be higher.



Translated into English:

Maximum weight
$120 + 100 + 80 + 60 + 40 + 20$
$= 420$ person $\times 25$ kg
$= 42$

⇨ $20 \times 27.25 = 545$ kg
⇨ $40 \times 22.5 = 900$ kg
⇨ $60 \times 26.5 = 1{,}590$ kg
⇨ $80 \times 26.25 = 2{,}100$ kg
⇨ $100 \times 25.75 = 2{,}575$ kg
⇨ $120 \times 25.25 = 3{,}030$ kg

The total weight of the pilgrim's baggage:
$545 + 900 + 1{,}590 + 2{,}100 + 2{,}575 + 3{,}030 = 10{,}740$

So,
Maximum = 10.500
Results = 10.740
Excess = 240 kg

"Exceeded the maximum limit"

Figure 7. Student C3's answer to question MA-2

Critical Thinking

MI Students

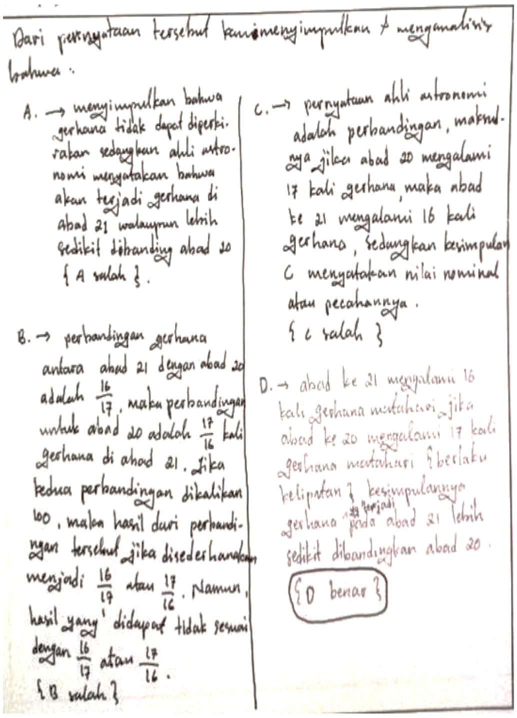
In solving question MI-2, A1 and A2 were able to make correct conclusions and provide arguments. Meanwhile, A3 made incorrect conclusions due to misunderstanding of the facts or information provided in the question. This error compromised the student's precision in developing a problem-solving strategy.

MTs Students

In solving question MTs-1, B1, B2, and B3 engaged in an excellent thinking process. B1 was able to identify the sequence of arguments by providing a logical reason for the answer given (in saying *"when more than one prayer mat is bought, it is not enough for others. Therefore, the prayer mat must be 1"*). Such an argument shows that the student had good critical thinking skills and tended to consider possibilities as when considering what would happen if Yusuf purchased more than one prayer mat. Furthermore, the student was also able to detect irrelevant problems, identify unstated assumptions, and identify logical errors.

MA students

Question MA-3 asks students to determine the truth of four astronomical statements on the prediction that in the 21st century 16/17 solar eclipses are to occur as in the 20th century. C1 provided an argument for each of the astronomical statements and considered that statement (d) is true (see Figure 8). C1 argued that the 21st century will experience 16 solar eclipses supposing that the 20th century did 17 (multiples apply). In conclusion, there are fewer solar eclipses that will occur in the 21st century than there were in the 20th century. Figure 8 shows C1's answer to question MA-3.


Dari pernyataan tersebut kami menyimpulkan & menganalisis bahwa :

A. → menyimpulkan bahwa gerhana tidak dapat diperkirakan sedangkan ahli astronomi menyatakan bahwa akan terjadi gerhana di abad 21 walaupun lebih sedikit dibanding abad 20 {A salah}.

B. → perbandingan gerhana antara abad 21 dengan abad 20 adalah $\frac{16}{17}$, maka perbandingan untuk abad 20 adalah $\frac{17}{16}$ kali gerhana di abad 21. Jika kedua perbandingan dikalikan 100, maka hasil dari perbandingan tersebut jika disederhanakan menjadi $\frac{16}{17}$ atau $\frac{17}{16}$. Namun, hasil yang didapat tidak sesuai dengan $\frac{16}{17}$ atau $\frac{17}{16}$. {B salah}

C. → pernyataan ahli astronomi adalah perbandingan, maksudnya jika abad 20 mengalami 17 kali gerhana, maka abad ke 21 mengalami 16 kali gerhana, sedangkan kesimpulan C menyatakan nilai nominal atau pecahannya. {C salah}

D. → abad ke 21 mengalami 16 kali gerhana matahari jika abad ke 20 mengalami 17 kali gerhana matahari {berlaku kelipatan} kesimpulannya gerhana terjadi pada abad 21 lebih sedikit dibandingkan abad 20. {D benar}

Translated into English :

From these statements, it is concluded and analysed as follows:

A => Concludes that eclipses cannot be predicted, while astronomers claim that there will be eclipses in the 21st century although in a smaller number than the 20th century (A is wrong).

B => The ratio of eclipses in the 21st century to eclipses in the 20th century is $\frac{16}{17}$, so in the 20th century there were $\frac{17}{16}$ times more eclipses than the eclipses in the 21st century. If both ratios are multiplied by 100, the result of the comparison is simplified to $\frac{16}{17}$ or $\frac{17}{16}$. However, the result obtained matched neither $\frac{16}{17}$ nor $\frac{17}{16}$. (B is wrong).

C => The statements of the astronomers are comparative. That is, if the 20th century experienced 17 eclipses, the 21st century will experience 16 eclipses. Meanwhile, conclusion C states the nominal value or fraction (C is wrong).

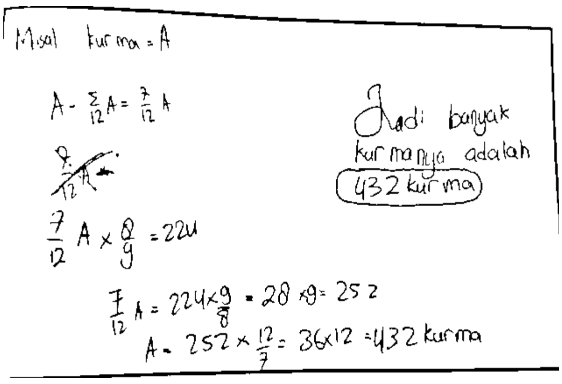
D => The 21st century will experience 16 solar eclipses. If the 20th century experienced 17 solar eclipses (multiples apply), the conclusion is that there will be fewer eclipses in the 21st century than there were in the 20th century (D is correct).

Figure 8. Student C1's answer to question MA-3

Analysis, Synthesis, and Evaluation

MI Students

In question MI-3, students were asked to understand the context of *zakat*, obligatory to every Muslim, using the fraction operation concept. A1 and A2 were able to provide the right answers (see Figure 9). Student A1 equated $A - \frac{15}{12}A = \frac{7}{12}A$ as a mathematical expression of "$\frac{15}{12}$ *parts of all the dates that bear fruit on Monday"*. Furthermore, $\frac{7}{12}A \times \frac{8}{9} = 224$ for $\frac{1}{9}$ of the rest bear fruit on Tuesday, while 224 bear none. This equation shows that A1 was able to conclude that there are 432 dates in the plantation. In other words, A1 was able to analyse parts of the whole, synthesise a problems, and carry out an evaluation using given criteria.



Translated into English:

Given:
Date = A

$A - \frac{5}{12}A = \frac{7}{12}A$

$\frac{7}{12}A \times \frac{8}{9} = 224$

$\frac{7}{12}A = 224 \text{ kg} \times \frac{9}{8} = 28 \times 9 = 252$

$A = 252 \times \frac{12}{7} = 36 \times 12 = 432$ date

So, there are 432 dates.

Figure 9. Student A1's answer to question MI-3

MTs Students

Question MTs-2 asks students to determine the height of *hilal* (x) in degrees to determine the beginning of the month of Ramadhan. Figure 10 is a pictorial representation of binoculars fixed at an angle.

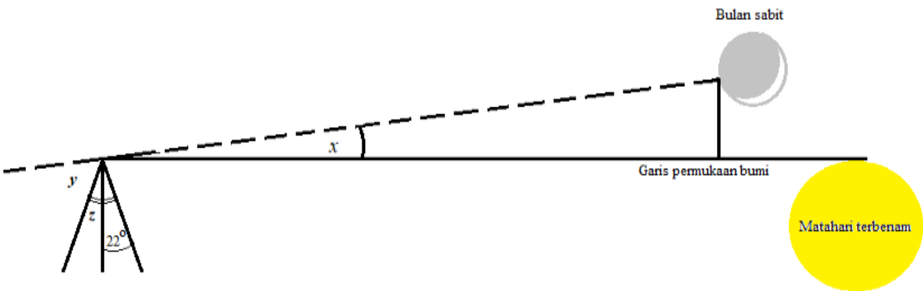
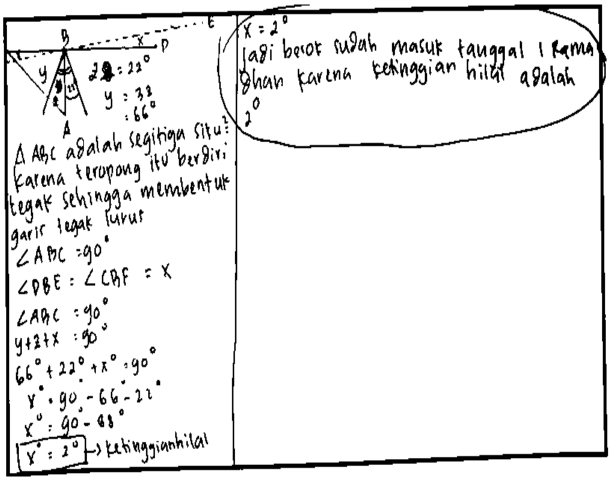


Figure 10. Binoculars positioning for determining the height of *Hilal*

Only B1 and B2 answered this question correctly by describing and summarising important information to clearly determine the right problem-solving strategy. B1 also carried out an evaluation after obtaining a solution. Figure 11 shows that B1 had the ability to determine the magnitude of angle z = 22°. Furthermore, B1 understood the concept of angular congruence by looking at the congruent sign at z = 22°. The equation y = 3z was evaluated to obtain y = 66°. This shows that B1 had the ability to analyse the problem, synthesise it to determine the hidden concepts, and evaluate the results. Furthermore, B1 also evaluated the completion of this question using various criteria, such as the concepts of angles, right triangles, and angular congruence.



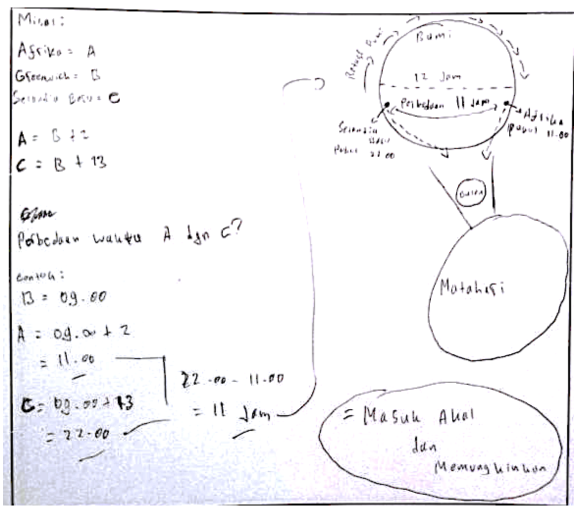
Translated into English:

ABC is a right triangle
Because it is cut standing upright so that it forms a perpendicular line
$< ABC = 90°$
$< DBE = < CBF = x$
$< ABC = 90°$
$y + z + x = 90°$
$66° + 22° + x° = 90°$
$x° = 90° - 88°$
$x° = 2°$
So, tomorrow is the 1st of Ramadhan because the height of the moon reaches 2 degrees.

Figure 11. Student B1's answer to question MTs-2

MA Students

Question MA-4 asks students to analyse the time difference information on the occurrence of a solar eclipse on September 25, 2012, in South Africa and New Zealand. Only student C1 correctly answered the question with an illustration of sun's, moon's, and earth's positions, while C2 and C3 were unable to solve the problem correctly in every level of thinking process they went through. As shown in Figure 12, C2 presupposed GMT at 09.00. Hence, it is 11 a.m. and 10 p.m. in South Africa and New Zealand, respectively, with the equation A = B + 2. Based on the interview, it was identified that C2 made an error in placing South Africa and New Zealand at noon. C2 focused on the 11 hours of time difference between South Africa and New Zealand, disregarding whether it is day or night time. Thus, C2 was unsuccessful in conducting analysis, synthesis, and evaluation of the question.



Translated into English:

For example:
Africa = A
Greenwich = B
New Zealand = C
$A = B + 2$
$C = B + 13$
The time difference between A and C?

Example:
$B = 09.00$
$A = 09.00 + 2$
$= 11.00$
$C = 09.00 + 13$
$= 22.00$
$22.00 - 11.00 = 11$

Reasonable and Possible

Figure 12. Student C2's answer to question MA-4

Decision-Making

MI Students

Only student A1 was able to make a good decision, as reflected in their answer to question MI-1. A1 was able to determine the score earned by the third-place winner, as well as the score earned by each of the other contestants, by considering the rules set for the problem. Furthermore, A1 identified possible choices and analysed them before finally becoming clear that Ali was the third-place winner with a score of 939. A1 was able to determine the problem-solving objective, marked by their answer to the question, identify and analyse options, and finally choose the best solution to the problem presented.

MTs Students

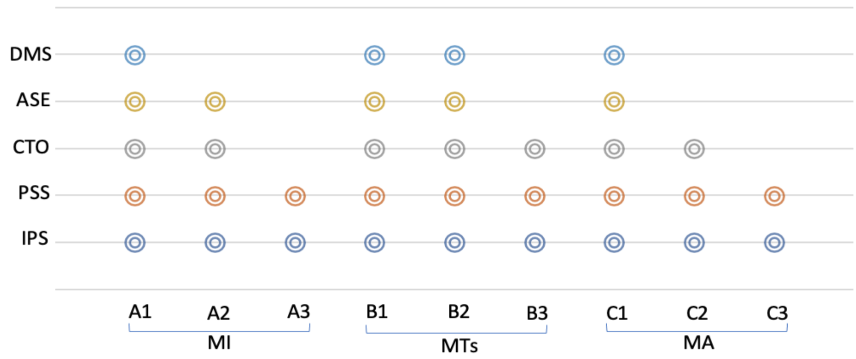
Students B1 and B2 were able to make good decisions, as shown by their answers to questions MTs-1 and MTs-2. They were also able to determine the problem-solving objectives, as seen from their ability to provide answers to the questions, identify problems by writing important things, analyse the problems, and choose the best solutions to make decisions.

MA Students

Question MA-2 was designed to explore students' thinking processes in making decisions. Only C1 answered this question properly, showing that they were able to determine the objective to be carried out, as well as identify, analyse, rate, evaluate, and choose the best option.

Based on Figure 13, MI, MTs, and MA students have different thought processes. This is consistent with the opinion of Masriyah & Firmansyah (2017) that the thinking processes of students are different. It was figured out that the thinking processes of Islamic school students in Indonesia in solving mathematical literacy problems in Islamic contexts had reached all thinking levels according to Bayer (1988). Furthermore, in solving mathematical literacy questions in Islamic contexts, all MI students already reached the information processing and problem-solving levels of thinking process. However, almost all students failed in the re-examination process in writing during problem-solving. Only A1 and A2 reached the levels of critical thinking and analysis, synthesis, and evaluation. Meanwhile, in decision-making, only A1 was able to carry out an analysis properly.

At the MTs level, students B1, B2, and B3 were in the thinking levels of information processing, problem-solving, and critical thinking. Students B1 and B2 even went as far as the thinking levels of analysis, synthesis, and evaluation and of decision-making. Meanwhile, at the MA level, students C1, C2, and C3 were at the thinking levels of information processing and problem-solving. C1 and C2 were additionally at the critical thinking level. Only C3 was at the analysis, synthesis, and evaluation and decision-making levels. At the problem-solving level, in particular, almost all students of every school level failed to carry out the written re-examination process. By and large, the thinking level of decision-making was the most difficult to MI, MTs, and MA students. Figure 13 represents students' achievements in their thinking processes when solving mathematical literacy problems in Islamic contexts.



Note. IPS: Information Processing Skill, PSS: Problem-Solving Strategies, CTO: Critical Thinking Operations, ASE: Analysis, Synthesis, and Evaluation, DMS: Decision-Making Strategies

Figure 13. Students' achievements in their thinking processes when solving mathematical literacy problems in Islamic contexts

As shown in Figure 13, the thinking processes of students differ at each level of education. The lowest achievement in the thinking process of each level of education was at the level of developing problem-solving strategies. However, none of the students re-checked their work. Sabaniatun, Febrilia, and Juliangkary (2019) found that in working on questions, students will only work until they get their desired results, and they will not write their conclusions, let alone re-check their work. The results of this study also showed that all students from all levels of education were able to process the information provided. This is in contrast to Azizurrohim, Nissa, and Kinasih's finding (2014) that most students are unable to read the data and information provided on problems and use mathematical concepts accurately.

CONCLUSION

In general, the thinking processes of Islamic school students in Indonesia in solving mathematical literacy problems in Islamic contexts had reached all levels of thinking according to Bayer. In solving mathematical literacy questions in the Islamic context, MI students were already able to process information and develop problem-solving strategies. However, almost all students did not re-check their written work during the problem-solving process. MI students could also think critically as well as analyse, synthesise, and evaluate, but the decision-making process was still not optimal.

At the MTs level, all students had information-processing skills, problem-solving strategies, and critical thinking abilities. However, not all students were capable of analysis, synthesis, and evaluation and of decision-making. At the MA level, all students had the skills to process information and solve problems. However, not all students reached the critical thinking level. Only one student was able to reach the levels of analytical thinking, synthesis, and evaluation and decision-making. Particularly to the problem-solving level, almost all students at every education level failed to carry out the written review process. From these results, it can be concluded that decision-making was the most difficult to MI, MTs, and MA students.

The use of Islamic contexts in mathematical literacy questions can draw students' attention to the problems and improve their thinking processes in solving problems. It was found in this study that MI students reached the MTs level in information processing by connecting one problem to another. Likewise, MTs students evaluated various criteria in the analysis, synthesis, and evaluation level of thinking process as that of the MA level. It is concluded that MI, MTs, and MA students were able to solve level 4 PISA-type questions well.

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