Students' Creative Thinking Ability on Problems of Mathematics Literacy

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One of the skills that we are expected to have now and in the future is the ability to think creatively and demonstrate literacy. This article explores the field of qualitative descriptive research, with a focus on evaluating students' proficiency in creatively approaching challenges related to mathematical literacy. Data collection was carried out by means of tests and interviews, and the four subjects were students at Indraprasta PGRI University. The research results show that there are five components in measuring a person's creative thinking ability in mathematical literacy problems, namely fluency, flexibility, originality, elaboration and communication. Mathematical communication here is related to how students can understand, comprehend and solve mathematical problems presented in the form of narratives, tables, pictures or graphs of data.

Keywords: creative thinking, mathematics literacy

INTRODUCTION

The ability to think creatively is the ability to come up with something new, both in form of idea and work, and that is completely different from existing solutions. Common sense thinking is used to find the right solution. Common sense thinking involves rational and systematic processes that enable verification to form a valid conclusion. Divergent reasoning generates many ideas focused on flexibility, fluency, and originality in solving mathematics ("math") problems (problem solving and problem posing). Thinking creatively is a combination of lateral and vertical thinking, where each compliments the other. Lateral thinking refers to an invention of new ways of thinking in finding ideas, whereas vertical thinking is related to the development of ideas and reexamination of objective criteria.

"Literacy for All" is a slogan pronounced by the United Nations Educational, Scientific, and Cultural Organization (UNESCO)—an international organization that works in education, confirming that every

individual is entitled to become "literate" as their asset to face the future. Literacy has a multiplier effect, namely, to eliminate poverty, reduce infant mortality, control population growth, achieve gender equality, and ensure sustainable development, peace, and democracy (Rahmawati & Mahdiansyah, 2014). Math literacy or math awareness in the PISA framework draft assessment 2012 is described as an individual's ability to formulate, apply, and interpret math in different contexts, including the ability to perform mathematical analyses as well as use concept, procedure, facts, and mathematics tools to describe, explain, or forecast phenomena/incidents (Buyung & Dwijanto, 2017). In general, literacy is related to language and how it is used, whereas written language is characteristically secondary. Language development and use cannot be parted from culture; therefore, the definition of literacy must include aspects that cover language, namely, socio-cultural situation (Rahmawati & Mahdiansyah, 2014). Mathematics literacy is a basic skill and is as important as language literacy. The reason behind the importance of literacy for students is the belief that the goal of all teachers is to create content that makes it easier for students to read and write in their field (Draper & Siebert, 2004). It is therefore imperative that one study more to understand the function of literacy in each level of education (Huizinga et al., 2009). For this reason, the math school curriculum needs to aim at developing math literacy and improve every student's ability to use and apply their math knowledge in solving problems or situations in real life (Sumirattana et al., 2017). Math literacy is a knowledge that needs to be understood when basic math is practiced in daily life (Nitasari et al., 2018). One's math literacy can help them understand rules that use math as a reference to real life as well as make judgements and decisions needed by constructing, applying, and reflecting on one's self as a member of the community (Kuswidyanarko et al., 2017). A student will be able to understand math if their analysis skills are good and they are able to communicate mathematically; i.e., math symbols have better meaning (Sumpter & Hedefalk, 2015). This concept of communication is in line with the first seven basic competencies in mathematics according to PISA.

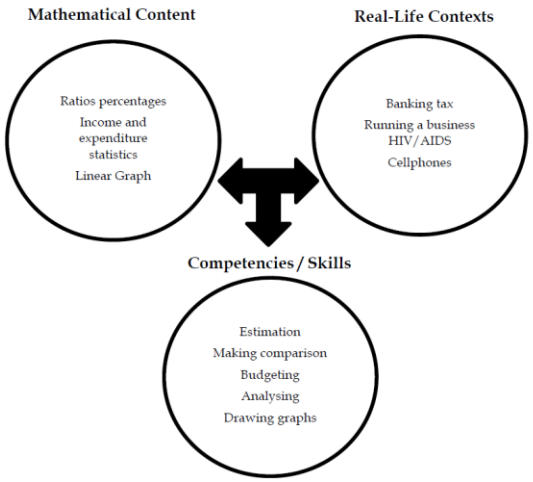
THEORETICAL OVERVIEW

Indonesia is ranked 64th of 72 countries. Besides the rank in PISA, Indonesia's rank in education is relatively far behind other countries at 57th of 65 countries (World's Education Rank, published by the Organization for Economic Co-operation and Development). The OECD ranks countries according to educational development, especially in terms of reading, mathematics, and science (Wahyudi et al., 2018).

Math skills and math literacy are needed to solve problems in our daily life; thus, it is important to help students understand the purpose of math in daily life. Math literacy is a person's ability to think mathematically and to formulate, apply, and interpret clues in solving problem at various contexts in real life. The Curriculum and Assessment Policy Statement (German & Randel, 2013) states that mathematics is a subject that develops competence by giving students the opportunity to understand, participate, and contribute in 21st century society in different ways. This competence includes the ability to analyze, make decisions, solve problems, manage resources, interpret information, and set targets as well as use and implement technology (Machaba, 2018).

Literacy in the context of mathematics is the strength to use math to solve daily challenges and to be ready to face life challenges. Thinking involves a problem solving mindset, common sense analysis, communication, and explanation (Stacey & Turner, 2015). Bernstein stated that there is a difference in knowledge structure between mathematics and mathematics literacy, which is supported by knowledge classification and pedagogic practice. Pedagogic practice is defined as a form of communication (interaction) in the pedagogical knowledge acquiring process (Machaba, 2018).

FIGURE 1
INTERACTION BETWEEN CONTENT, CONTEXTS, AND SKILLS IN PROBLEM SOLVING IN MATHEMATICS LITERACY



(German & Randel, 2013)

TABLE 1
COMPARISON OF MATHEMATICS AND MATHEMATICS LITERACY

Topics	Mathematics	Mathematics Literacy
Pedagogical practices	Prescribed algorithms and a focus on symbolic manipulation deprived of meaning	Teachers integrate content and/or skill in solving problems in the teaching of mathematics literacy; teachers provide learners with opportunities to develop and practice decision making and communication skills
	Teaching includes discussion about contexts, but this must be balanced with revisiting math concepts and learning new math concepts in new ways	Exploring context to deepen the understanding of mathematics and to deepen understanding of that context as mathematics literacy should not be taught in the absence of everyday context
	Whenever appropriate, teachers ensure that they draw from learners' everyday experiences	Teachers ensure that they draw from authentic (genuine and realistic) contexts such as cellphone pricing packages
	Everyday context is used as a vehicle to access the learning of mathematics	Teachers draw from contexts that are both familiar and unfamiliar to learners
	Teaching approaches are mainly teacher-centered	Teachers integrate content and/or skills in solving problems; teachers provide learners with opportunities to develop and practice decision making and communication skills

Topics	Mathematics	Mathematics Literacy
Pedagogical practices	Teaching entails the multifaceted tasks of observing, representing, and investigating patterns, necessitating the active engagement of students' cognitive faculties, which are enriched through the cultivation of logical thinking, critical reasoning, and precision.	Exploring context so as to deepen the understanding of mathematics and deepen understanding of that context; Math literacy should not be taught in the absence of everyday context
	Teaching that monitors and extends learners' thinking, and identifies learners' misconceptions	Teachers draw from authentic (i.e., genuine and realistic) contexts such as cellphone pricing packages
	Prescribed algorithms and a focus on symbolic manipulation deprived of meaning	Teachers draw from contexts that are both familiar and unfamiliar to learners; teachers use elementary mathematical content

(Machaba, 2018)

There are four indicators of math literacy: (1) Formulate concrete problem, (2) Apply mathematics concept, (3) Interpret solution, and (4) Evaluate solution. Based on the results of a survey conducted by the Program for International Student Assessment, Indonesian students' math literacy skill is relatively low and lies below the international average. Moreover, the majority of students are only able to solve problems below level two. These facts indicate that Indonesian students' math literacy skills need to be improved (OECD, 2021). Steen, researching in the United States, used a concept similar to math literacy, called "quantitative literacy," aimed at developing students' ability with a flexible range that can be applied in various contexts (Machaba, 2018). In solving a daily life-related math problems, a student is also expected to have good communication ability/skill (Teledahl, 2017; Otoo et al., 2018). Communication ability is an important asset for students in order to solve a mathematics problem, especially ones related to daily life. This is the reason for the importance of communication skills in solving math problems. Based on prior research, Indonesian students' communication skill is also low in IMO and PISA (Yuanita et al., 2018). Efforts to improve students' communication skills have become the main objective in math teaching at school as it is viewed that this skill is the primary process in building understanding (Huang et al., 2005). Problem solving and mathematical communication is a skill students need in studying math (Ahdhianto et al., 2020).

One aspect that supports fluency in math learning and thinking, among others, is the ability to think in a mathematically creative manner. The ability to think creatively about math problems needs to be developed or improved in studying mathematics in college (Murni et al., 2020). This skill is crucial in solving complex problems (Ambar, 2019). Mathematical creative thinking refers to the combination of common sense and divergent thinking based on intuition and with a purposeful target. Creative thinking is related to common sense thinking and intuitive thinking (Herayani et al., 2015).

According to Vally et al. (2019) creative outcomes can be expressed in various component parts, namely, fluency (or number of relevant response and ideas), flexibility (numbers of different categories of ideas), originality (level of idea subtlety), and elaboration (level of specification of ideas) with unique ideas (Csikszentmihalyi & Getzels, 1971; Kettner, Guilford, & Christensen, 1959; Scott et al., 2004; Torrance, 1999). The result of Ziegler and Kapur's (2018) research showed that there is a connection between creativity and making mistakes. Mistakes may have direct disadvantage effect but not in long-term learning, whereas creativity positively impacts leaning in the long term. Creativity is not only in creating a product but also in thinking, including mathematical creative thinking (Wahyudi et al., 2019). The process of creative thinking is considered important in learning math (Maftukhah et al., 2017). Mathematical creativity refers to the application (cognitive behavior) of known concepts in order to improve or broaden one's correct understanding about math. Mathematical creativity increases when the teacher creates a longer

dialog in class and in an open interdisciplinary lesson with an open learning objective (Willemsen et al., 2019).

As for development, creative thinking expands when there is an evaluation or assessment to follow up with the development of the learning and to formulate an evaluation (Kusuma et al., 2019). Students' creativity basically does not appear on its own. Indeed, it needs training and to be applied as a habit (Permata et al., 2017). In general, thinking creatively can be triggered through the presentation of a challenging problem (Jaenudin et al., 2020). Students' inability to think creatively through their lessons results in low ability in solving math problems (Saironi & Sukestiyarno, 2017).

MATERIALS AND METHODS

This study was conducted at the University of Indraprasta PGRI Jakarta, using a qualitative research design. The participants in this research are 24 students from the Mathematics Education Program. This number was narrowed down to four students selected based on their creative thinking skill level. Mathematical creative thinking was observed and described in its entirety using four creative thinking indicators—*fluency, flexibility, originality*, and *elaboration*—as observed against the seven basic mathematical competencies according to PISA (2018): *Communication, Mathematizing, Representation, Reasoning and Argument, Devising Strategies for Solving Problems, Using Symbolic, Formal and Technical Language and Operation,* and *Using Mathematical Tools* (Echazarra & Schwabe, 2019). The data comprise the results of a mathematical creative thinking test, the interview guide, and observational annotations for triangulation purposes. The four participants were each presented with exam problems requiring creative thinking based on the seven mathematical basic competencies according to PISA (2018) listed in Table 3. In order to test each indicator, the researcher made an initial assessment. The scoring system is presented as Table 2.

TABLE 2
STANDARD OF CREATIVE THINKING TEST

No.	Note	Score
1	Does not answer	0
2	Does not answer accurately and does not explain or elaborate answers for the problems	1
3	Answers accurately and does not elaborate on the answer	2
4	Answers accurately and elaborates on the answer	3

(Ahmad, 2020) modified

TABLE 3
MATHEMATICS BASIC COMPETENCIES ACCORDING TO PISA

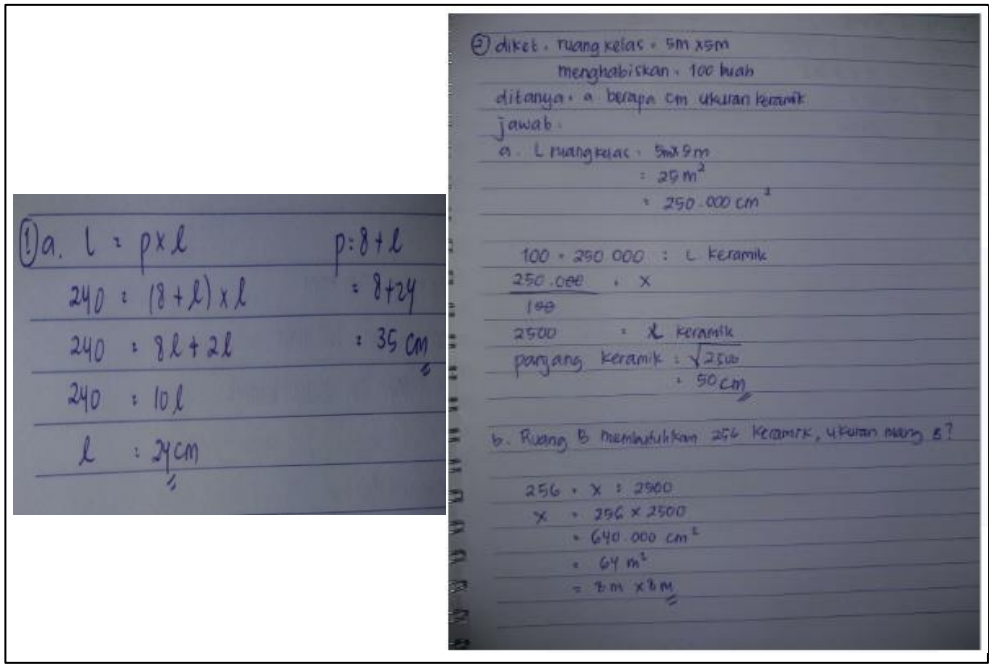
Number	Mathematics Basic Competence	Achievement Form
1	Communication	• Able to communicate in reading, describing, and interpreting statements, questions, tasks, or objects • Able to make a mental model of a situation in an effort to understand, clarify, and formulate a problem
2	Mathematizing	• Able to transform real problems into mathematical form (making structures, conceptualizations, assumptions, formulating a model, interpreting/assessing mathematical results or mathematical models related to the initial problem)

Number	Mathematics Basic Competence	Achievement Form
3	Representation	◦ Able to select, interpret, translate, and use various representations in understanding a situation, interacting with a problem, or to express one's work (including graphs, tables, diagrams, pictures, equations, formulas and concrete objects
4	Reasoning and Argument	◦ Able to think logically, explore and connect parts of the problem to make conclusions, and check answers given or provide justification for reports/solutions obtained
5	Devising Strategies for Solving Problems	◦ Able to involve a series of critical control processes to identify, formulate, and solve problems effectively ◦ Be able to choose or design a plan/strategy to use mathematics in solving problems that arise from the task/context and guide its implementation.
6	Using Symbolic, Formal and Technical Language and Operations	◦ Able to understand, interpret, manipulate, and make symbol expressions in a mathematical context (including expressions of mathematical operations) ◦ Able to involve understanding and utilizing formal forms based on definitions, rules, and formal systems as well as the use of algorithms
7	Using Mathematical Tools	◦ Able to take advantage of and find out the weaknesses of mathematical tools such as measuring instruments, calculators, and computers that can help mathematical activities

RESULT AND DISCUSSION

Subject 1 (S1)

FIGURE 2
ANSWER S1



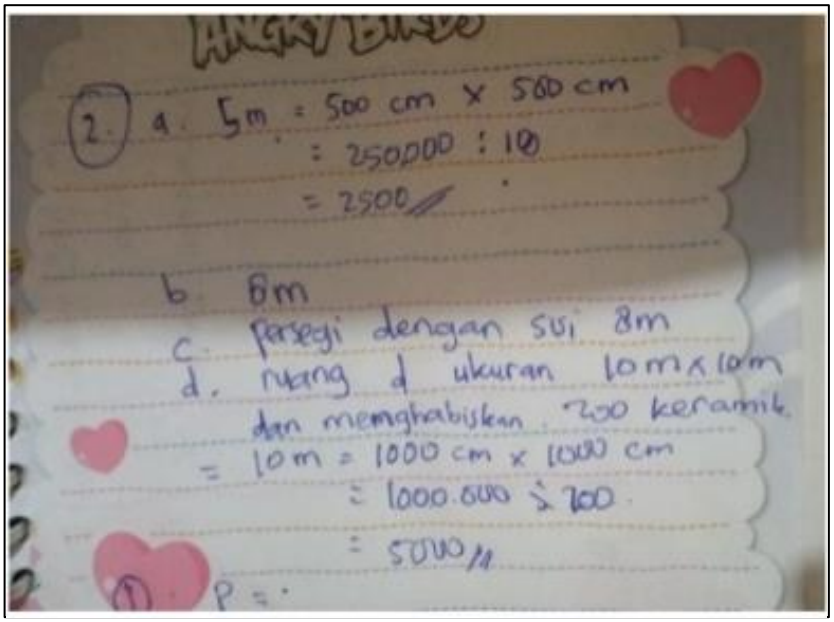
The following is from an interview with Subject 1 (S1):

Interviewer:	"What comes to mind the first time you see this problem?"
Subject 1:	"What is this problem, Ma'am? I looked at it for a while because I wasn't sure how to answer."
Interviewer:	"Have you ever seen a problem like this before?"
Subject 1:	"Yes, I have, Ma'am. In Junior High, but it was easier than this."
Interviewer:	"There are several points on the problems. Can you understand them all?"
Subject 1:	"I can answer problem number 1a Ma'am, but I don't understand 1b and 1c, and cannot answer it, and I only know that one formula for number 1d."
Interviewer:	"What about problem number 2?"
Subject 1:	"I can do problem number 2a and 2b, although I can only give one answer to number 2b and I ran out of time when I was trying to answer number 2c, and I don't understand number 2d, Ma'am."

S1 successfully answered questions 1 and 2. Both questions were successfully solved using common sense. At the first encounter, S1 was uncertain on how to solve the problem because they were not familiar with the style of the problem. S 1 needed to repeat reading the problem to understand how to solve it. S1 managed to work on question 1. S1 finished one part of question 1a but the answer was not correct. S1 could answer question 2. S1 solved questions 2a, 2b, and 2d with a total score of 10 for the creative thinking test with one fluency component (manage to produce ideas that correspond with the question task) fulfilled; hence, S1 is categorized as a "creative student."

Subject 2 (S2)

IMAGE 3
ANSWER S2



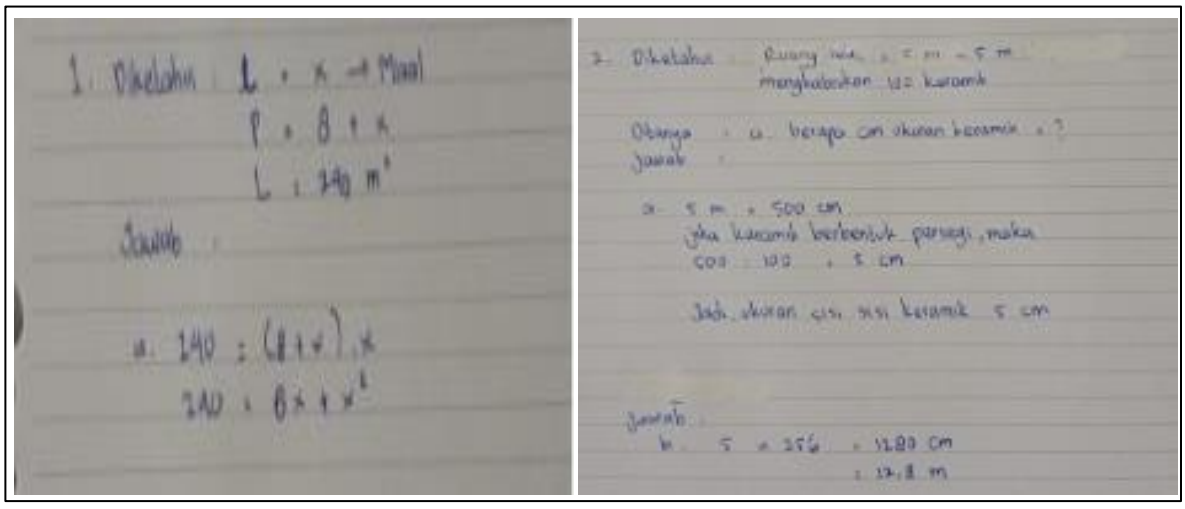
The following is from an interview with Subject 2 (S2):

Interviewer:	"What came to mind when you got these problems?"
Subject 2:	"I was confused…."
Interviewer:	"What made you confused? Was it the sentence or something else?"
Subject 2:	"I wasn't warmed up, Ma'am, so when I got this problem, I was surprised plus the condition around me wasn't supportive enough. It could've been answered using common sense, can it?"
Interviewer:	"What held you from solving the problem?"
Subject 2:	"My surrounding was noisy. When I started working on the problem, I couldn't focus and there was a time limit."
Interviewer:	"Why did you go straight to question number 2 and skip number 1?"
Subject 2:	"As I mentioned before, my surrounding was noisy when I was trying to work on question 1. I could focus when working on question 2 because it got quiet then."
Interviewer:	"What other difficulty did you face apart from trying to focus?"
Subject 2:	"I didn't know how to answer them, Ma'am. So, I simply use my common sense to solve it."

S2 could not solve problem 1 due to their environment, i.e., S2's surroundings were not conducive to focus due to the noise of a blender in the background. Because they could not focus on question 1, S2 went directly to question 2. Questions 2a, 2b, 2c, and 2d were answered well by S2. Question 2a was answered but not entirely; 2b was answered without any explanation on the steps; 2c was answered but not accurately; and the answer for question 2d was not correct. After further interview questions, S2 revealed how they failed to understand what the question expected and answered only using common sense; the answers were what S2 could think of in the moment. However, when the question was represented during the interview, S2 managed to provide a more accurate and structured answer. The total score for S2 is 6, with inaccurate answers. Therefore, there were components of creative thinking that were not fulfilled so S2 is categorized as "not a creative student." The other difficulty according to S2 is that they had never received questions like those given during the test, besides that basic education before studying for S2 comes from a social class that only gets basic math lessons and not in depth.

Subject 3 (S3)

FIGURE 4
ANSWER S3



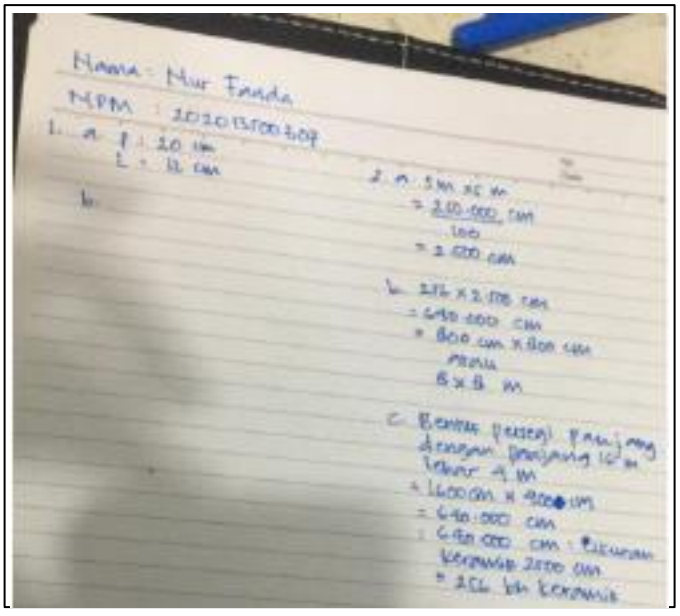
The following is from an interview with Subject 3 (S3):

Interviewer:	"What did you do when you got this question?"
Subject 3:	"Panic, Ma'am. I got nervous and not knowing what to do."
Interviewer:	"Was the problem I gave you clear enough?"
Subject 3:	"Yes, it was Ma'am. It's just that I needed to read and reread to understand what I am expected to do."
Interview:	"Why did you fail to answer question 1?"
Subject 3:	"It took me too long to read and understand the question because I panicked, Ma'am. So I kept rereading it and the time ran out."
Interviewer:	"Did you not understand the question?"
Subject 3:	"After going through it enough, insyaAllah I did, Ma'am."
Interviewer:	"What was the mathematical model you could think of to finish this problem?"
Subject 3:	"I spontaneously used common sense and previous knowledge that I could remember, Ma'am."

S3 managed to work well on questions 1 and 2 regardless of their panic and nervousness at the beginning. As soon as S3 looked at question 1, they figured out what the question expected and what concept was needed to solve question 1a. S3 stopped because they got confused. During interview, S3 felt they should have been able to answer question 1, but panic prevented them from finishing the work. Later, S3 went on to question 2. They were able to present the question in a mathematical formula as can be seen from the order/steps taken to finish the problem. S3 started solving by writing down what was known from the problem, writing down what was asked, then answering the question. However, S3 made a mistake when working on questions 2a and 2b due to panic, which made S3 fail to concentrate. S3 appears to be a superior student; however, because S3 only managed to get a score of 4 on the test with the creative thinking component that was fulfilled was fluency. Therefore, S3 can be categorized as a "fairly creative student."

Subject 4 (S4)

FIGURE 5
ANSWER S4



The following is from an interview with Subject 4 (S4):

Interviewer:	"What did you do when you came across these problems?"
Subject 4:	"Surprised, Ma'am, because usually the questions are not very far different from the example given."
Interviewer:	"Did you think of solutions to solve them?"
Subject 4:	"I just use common sense, Ma'am, what I remembered when working on question 2 but I got stuck in question 1, I couldn't answer."
Interviewer:	"What operation and solution model did you use to solve the problem I gave you?"
Subject 4:	"Trial and error, Ma'am, I simply used my common sense because I cannot think of using a particular formula."
Interviewer:	"What things hold you off from these problems apart from being not accustomed to the question?"
Subject 4:	"I found it difficult because it is made into an illustration, so I had to try to figure out what the question actually expects. I am accustomed to questions that are straightforward, questions that are explained in detail."

S4 was surprised by the questions as they are accustomed to working on problems that are not very different from the example given in the lesson. S4 was also not accustomed to face problems in application form as given in the test. According to S4, they were able to solve question 1 by simply using common sense. In answering question 1a, S4 realized a correct answer but made some trials and errors to get the answer; hence, there was no explanation on the steps to get the answer. On facing questions 1b, 1c and 1d, S4 got confused. S4 continued working on question 2 and it is shown that S4 managed to answer questions 2a, 2b, and 2c correctly. S4 successfully answered using the expected concept, with a total score 11. S4 fulfilled two components in the creative thinking indicators: fluency and flexibility. It can be concluded that S4 is "quite creative." The basic math competencies of S4 are communication, mathematization, representation, and formulation of strategy in solving problems while other competencies were not evident.

CONCLUSIONS

Based on the results and discussion, there are five components that we can use to measure students' ability to think creatively on math problems using the concepts of numeric literacy through self-efficacy, i.e., communication, fluency, flexibility, originality, and elaboration. *Communication* is shown in a person's ability in processing/managing information according to the given task. *Fluency* is shown when one is able to produce ideas that correspond with the task. *Flexibility* is shown through one's ability to produce ideas that are used and *originality* is shown through one's ability in coming up with new idea. *Elaboration* is shown by one's ability to explain in detail the answer he/she comes up with. Thus, students' ability to think creatively through problems of mathematics with literacy concept will be shown when the communication component is present.

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