Is It True That Mathematics Anxiety Has A Bad Impact On Problem-Solving Skills?

Surya Sari Faradiba, Alifiani, Abdul Halim Fathani, Ganjar Setyo Widodo, Siti Nurul Hasana, Sikky El Walida, Isbadar Nursit, Anies Fuady

Abstract: This study aimed to examine how students who experience high mathematics anxiety solve mathematical word problems. This research involved 40 math students of Universitas Islam Malang from 26 out of 34 provinces in Indonesia. From the 40 populations, five subjects were selected on the basis of their high score in Mathematics Anxiety Scale (MAS) questionnaire. Furthermore, these five subjects worked on problem-solving problems. The answers of the five subjects were analysed based on DOTS (Detect, Organize, Transform, and Solve) problem-solving criteria. The results of this study indicate there are two types of problem solving done by the subjects. First, four subjects solved the problem by doing DOTS steps. In this case, the subjects can detect the problem structure, but they have difficulties in applying arithmetic operations both in numerical and algebraic expressions. Interestingly, one of the four subjects can organize the information, but she misapplies commutative as well as associative properties when carrying out subtractions/divisions and fails to use distributive property of multiplication over addition. Meanwhile, the other one subject can do the DOTS steps at the same time. From these five subjects, it can be seen that mathematics anxiety does not always lead to failure in problem-solving. This can be seen in the fifth subject that shows good performance on problem-solving and goes through the DOTS steps at the same time.

Index Terms: DOTS, MAS, mathematics anxiety, problem-solving.

1. INTRODUCTION

MATHEMATICS document is a anxiety is a feeling of tension, worry, and fear experienced by students when they are in situations involving mathematical-related activities [1]. The relationship between mathematics anxiety and mathematical cognition has often been investigated. The negative relationship between the two has been proven in various domains of mathematics learning ranging from simple calculations [2] to complex mathematics as in problem-solving [3]. When Low achievement and low participation in mathematics are matters of concern in many countries. In international comparative studies, such as Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA), Indonesian students performed below than most other participating countries [4,5]. Recent PISA data indicated that Indonesia has a history of underachieving students in mathematics and the gap between high and low school achievers.

- *Surya Sari Faradiba, Universitas Islam Malang, Indonesia, E-mail: suryasarifaradiba@unisma.ac.id*
- *Alifiani, Universitas Islam Malang, Indonesia, E-mail: alifiani@unisma.ac.id*
- *Abdul Halim Fathani, Universitas Islam Malang, Indonesia E-mail: fathani@unisma.ac.id*
- *Ganjar Setyo Widodo, Universitas Islam Malang, Indonesia, E-mail: ganjarsetyow@unisma.ac.id*
- *Siti Nurul Hasana, Universitas Islam Malang, Indonesia, E-Mail: s.nurulhasana@unisma.ac.id*
- *Sikky El Walida, Universitas Negeri Malang, Indonesia, E-mail: sikkywalida@gmail.com*
- *Isbadar Nursit, Universitas Negeri Malang, Indonesia, E-mail: isbadar.nursit.1603119@students.um.ac.id*
- *Anies Fuady, Universitas Negeri Malang, Indonesia, E-mail: anies.fuady.1503119@students.um.ac.*id

Moreover, students in Indonesia demonstrate low levels of perseverance in math, and results showed that more than three-quarters of Indonesian students did not reach the baseline Level 2, which means they could only answer tasks that have familiar contexts and present all relevant information. The low performance of math students in Indonesia is primarily associated with inability to learn math and difficulties in learning math. Mathematical learning disabilities and learning difficulties associated with persistent low achievement in mathematics are universal and not attributable to intelligence [6]. These individuals have an identification number and memory delays and deficits that appear to be specific to mathematics learning. The most promising intervention for those problems is by directly overcoming the specific deficits. Therefore, for children with mathematics learning disabilities intervention must be specifically on their low working memory capacity. Unfortunately, teachers in practice cannot specifically identify the factors causing the students' difficulties. The teachers often generalize the students' condition due to limitation in time to observe and deeply understand the students' problem one by one. The thing generally ignored is the fact that mathematical difficulties are seen not only in the student with specific mathematical learning disorders but also with emotional issues, namely mathematics anxiety [7]. Again, time limit to do observation and understand the students' condition becomes a critical problem. Moreover, most classes in Indonesian context are large classes (more than 30 students in class). The previous studies have shown that individuals with mathematics anxiety have increasing difficulty with the increasing demand of the mathematical problem. A negative loop is generated in which these individuals often perform poorly on standardized math tests, avoid arithmetic courses [8], and develop negative beliefs regarding their own math abilities [9], and thus experience even greater mathematics anxiety and avoidance. Since mathematics anxiety has long-term damaging effects, it is essential to understand how it affects mathematics achievement. Anxiety is a state of arousal that surfaces through bodily, emotional, and mental changes, which an individual experiences when faced with the stimulus [10]. Many symptoms include but are not limited to the feelings of helplessness, panic, difficult breathing, shame, inability to cope with problems, sweaty palms, nervous stomach, andloss of concentration. The other symptoms, including tension, nervousness, worrying, edginess, impatience, confusion, fear, and developing a mental block [11]. There are two main focuses of mathematics anxiety. The specific mathematics anxiety occurs when a person is anxious about a particular mathematics situation, such as being fearful of fractions. Global mathematics anxiety is when a person is stressed in all mathematical situations regardless of the type of problem [12]. Some aspects of mathematics appear to be cognitively tricky for many people to acquire, and some people have moderate or severe specific mathematical learning disabilities [13]. However, not all mathematical disabilities result from cognitive difficulties. Children and adults have mathematics anxiety, which may severely disrupt their mathematical learning and performance, both by causing avoidance of mathematical activities and by overloading and disrupting working memory during mathematical tasks. Problem-solving is cognitive processing directed at achieving a goal when no solution method is visible to the problem-solver [14]. As an essential component of mathematical problem-solving, word problem-solving (WPS) involves knowledge about semantic construction and mathematical relations as well as knowledge of necessary numerical skills and strategies [15]. Learning how to solve word problems is difficult for students and has gained attention in the field of mathematical development [16]. Word problem-solving requires affective and cognitive aspects [17]. Mathematics anxiety is one of the first useful features which were systematically investigated in the mathematics learning domain [18]. Mathematics anxiety involves tension feelings that interfere with the numbers and the mathematical problems manipulation in a wide variety of ordinary life and academic situations. Mathematics anxiety is an essential factor that impedes one's mathematical problem-solving success [19]. High levels of anxiety were found to be related to less efficient mathematical problem solving [17]. Many students fear and despise the mathematics word problems that they encounter in their classes and could use a few word problem strategies to help solve the problems. Mathematics anxiety is a real- life experience and is usually made worse by the thought of having to solve a word problem. The truth is that life itself is made up of a long series of word problems, and those that require the use of our mathematics skills to solve are not tricky once a few simple strategies are learned. This study aims to examine how students who experience high mathematics anxiety solve mathematical word problems. By understanding this phenomenon, an illustration of the effects of mathematics anxiety on problem-solving will be obtained.

2 MATERIALS AND METHODS

2.1 Research Subjects

This research is a descriptive qualitative case study in nature [20]. The subjects of his study were selected on the basis of purposive sampling. The sample consisted of 40 undergraduate students (10 students of the first semester, 10 students of the third semester, 10 students of the fifth semester, and 10 students of the sixth semester) from the Department of Mathematics Education, Universitas Islam Malang. Those four levels of proficiency were enough to obtain a generalization for overall level of mathematics anxiety. Universitas Islam Malang was chosen because the researcher is a lecturer at the university so that data retrieval can be done in a sufficient period. Also, researchers have a close relationship with the subjects of research so it is possible to investigate information regarding the problem-solving process maximally. Another thing that is considered in choosing a sample is the cultural condition of students at Universitas Islam Malang which is quite heterogeneous, consisting of various provinces in Indonesia so that it can generalize the math anxiety of Indonesian students.

2.2 Instruments

The two instruments in this study are Mathematics Anxiety Scale (MAS) Questionnaire and problem-solving tasks. Mathematics Anxiety Scale (MAS) questionnaire adopted from Betz [21] is used to measure mathematics anxiety experienced by the subjects. Meanwhile, the problem-solving task is used to reveal how the problem-solving process is carried out by the chosen subjects.MAS is a 10-item scale with five items positively worded and five items negatively worded. The questions require self-assessment of respondents' experiences of and feelings about studying mathematics, both in class and on tests. Responses are given on a 5-point Likert-type scale with responses ranging from 1 (strongly agree), 2 (agree), 3 (undecided), 4 (disagree) to 5 (strongly disagree). Half of the questions are reversed scored and a higher score indicates higher levels of mathematics anxiety [21]. The task given to students were two samples of the problem in mathematics that had to be solved, as shown below:

a. A rectangle has a width 6 cm shorter than its length. If the perimeter is 44 cm, find the length and width!
b. Ani and Wati bought flour to make cake. Ani bought 0.5 kg of flour A and 0.75 kg of flour B, while Wati bought 1.5 kg of flour A and 0.25 kg of flour B. If Ani had to pay Rp. 13.000 for the groceries and Wati paid Rp 15.000, set the price per kg of flour A and flour B!

The problems required the student to incorporate their knowledge of mathematics, specifically magnitude relationships, in scenarios that would have been familiar with their daily lives. Participants were asked to compute each problem and given two pieces of scratch paper to begin. Participants had free access to the scratch paper, and they could use more if needed. The students had 45 minutes to solve the problems.

2.3 Data collection

In this research, the data were collected from task and observation. Observations were made during the learning process by several observers utilizing an observation sheet. The observation sheet was based on learning activities and consisted of questions concerning the implementation of learning. The data could include photos of events, videos, and field notes of the observer during the learning process.

2.4 Validity and reliability test

Validity and reliability tests were performed by triangulation through the display of data from the video and compared them with the students' written test data [22]. The videos of each interview were recorded. The interview was conducted with selected students who met following criteria: (1) they represented one of the five levels based on questionnaire results, (2) they had good communication, (3) and they had an adequate score of mathematics anxiety. In this research, the problem solving process was analyzed based on the four steps of DOTS (Detect, Organize, Transform, and Solve) [23]. In the first step, the subjects identified the types of the problems, whether addition, subtraction, multiplication, division, or the combination of some of those basic math operations. The second step, the subjects organize information by representing the relationship between among variables. In the first problem, the subjects represented the sentence stating that plane figure which is shorter than 6 cm from the length as p – 6 where p shows the length of the rectangle in the second problem. Meanwhile, the subjects organized similar and dissimilar variables. The appropriate organization will ease the next step, to make equality. In the third stage, the subjects made meaningful equalities. Finally, the subjects solve the problems through equality manipulation in the step four. Besides, the subjects were assigned to check their answers to make sure that their answers are logic.

3 RESULTS AND DISCUSSIONS

3.1 Characteristics of subject 1 (S1)

Figure 1 shows a written result of the S1 who did not recognize the problem structure in both questions. The evident is this student represented the information existing in the problem in a wrong equality. She stated that quadrilateral is a multiplication of width by the length in the first question. Meanwhile, she did not answer the second question. When solving the first problem, S1 sketched a rectangle and shaded the area inside showing the concept of the area of the rectangle. S1 seemed confused in identifying the concepts of area of rectangle and circumference of the rectangle. This indicates that S1 did the steps of DOTS separately. S1 seemed to detect problem by sketching the picture of rectangle. Next, S1 organization stage by stating that quadrilateral as the length multiplied with width. However, the stages of transform and solve did not appear.

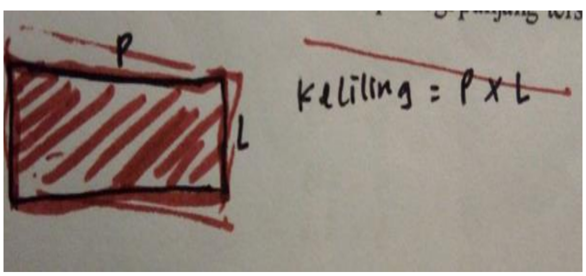

Figure 1. *The answer of S1 for the first problem*

3.2 Characteristics of subject 2 (S2)

The same thing also happens in S2 when solving problem. As seen in Figure 2, S2 did the stages of DOTS separately. It can be seen from how she made the equality that is k = 2 (p × l). In this sense, S2 was inconsistently in stating the multiplication. In the stage of ‘detect’, she used multiplication symbol in the form of x and without any symbol after the number 2 and before the opening bracket. In the next line, S2 stated multiplication as a dot. In this case, S2 did all the stages; detect, organize, transform, and solve. However, the stage of ‘solve’ was not done completely. Figure 2 shows the written result of the subject who could recognize the problem structure at the first question but could not organize the information using conceptual model diagrams. This can be seen with the equality written “44 = 2 (p. p - 6) not 44 = 2 (p + (p - 6))”.

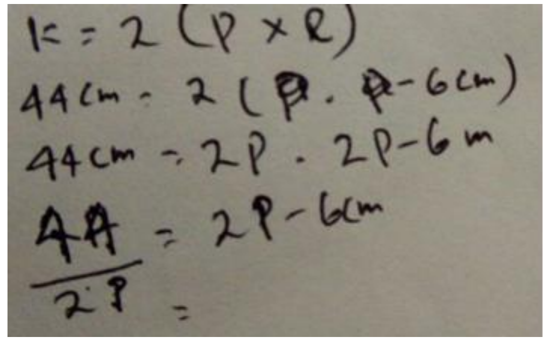

Figure 2. *The answer of S2 for the first problem*

In the second problem, S2 only organized, without detecting, transforming, and solving the problem. S2 only categorized similar variables without representing them. As shown in Figure 3, for the second question, S2 could recognize the structure of the problem by dumping the data based on its variables, namely variable A (the amount of A flour purchased), variable B (the amount of flour B being bought), and variable C (money paid). However, the student was unable to organize it so that it is possible to determine the relationships among variables.

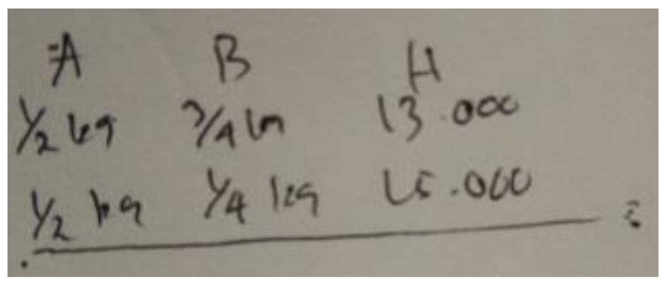

Figure 3. *The answer of S2 for the second problem.*

3.3 Characteristics of subject 3 (S3)

S3 also did the stages of DOTS separately. She started with detecting problem, organizing information, transforming, and solving problem. However, S3 found difficulties in the transformation stage. S3 wrote 44 = 2p + 2p – 6 equivalent to 50 = 4p. Figure 4 shows the written results of S3 who could detect the structure of problem well at the first question.

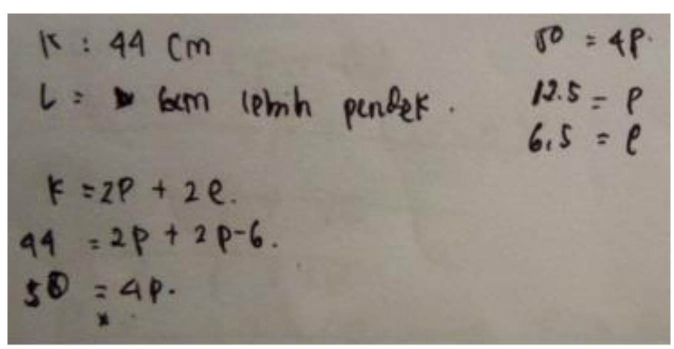

Figure 4. *The answer of S3 student for the first problem*

Figure 5 show S3 could detect the structure of the problem well. However, the students were not really careful. It can be seen from the equation made by the student 0.5 a + 0.75 b =

13,000, which is correct, whereas another equation of 1.5 a + 0.75 b = 12,000 is incorrect. It should have been 15,000 as written on the second problem. In addition, the first equation was written "× 3". This form is inappropriate because it means 13,000 × 3, while the other numbers before equal symbol were not multiplied with 3.

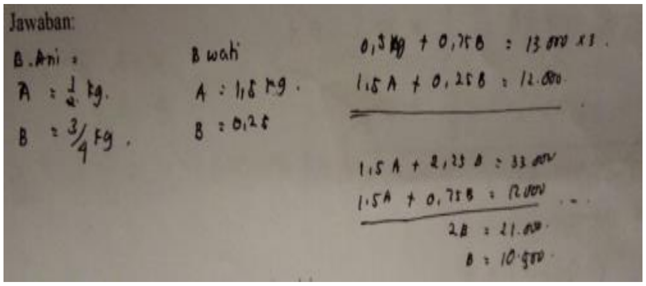

Figure 5. *The answer of S3 for the second problem*

3.4 Characteristics of subject 4 (S4)

Different from S1, S2, dan S3, in the case of S4 did the stages of DOTS at the same time. It is shown from the first line of what she wrote Kll = 2p + 2l. In this case, Kll means quadrilateral. Next, the width of the rectangle directly transformed into p – 6. Then S4 solved the equality she made until finding out the solution. Figure 6 shows the results of S4 who made an unconscious error in the first question. This was revealed as unconscious error since the student wrote "44 = 2 (p + (6 - p))" but the next calculation was "44 = 2p + 12 – p" (the true answer was 44 = 2 (p + (6 – p)). Moreover, the student wrote the length was 32 cm while the true answer was 8 cm.

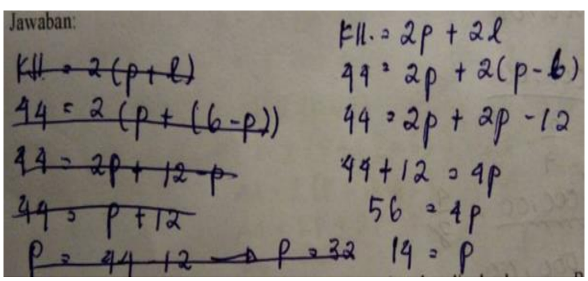

Figure 6. *The answer of S4 for the first problem*

However, when solving the second problem, S4 performed the stages of DOTS separately. It appears in the first line that is by making notation that flour A is represented by x and flour B as y. Figure 7 shows the results of the second question that S4 seemed to solve the problem less effectively. S4 multiplied the first equation by 3/2, and the second equation by 1/2. Two multiplication processes were performed to produce the same coefficient x, namely 3/4 x). With the same coefficient, it is expected to be eliminated. However, the student could eliminate it by a one-time multiplication process; for example, the student multiplied the first equation with 3, so that the coefficient of x for the first equation is 3/2, where the coefficient for the second equation is also 3/2 (without going through multiplication process).

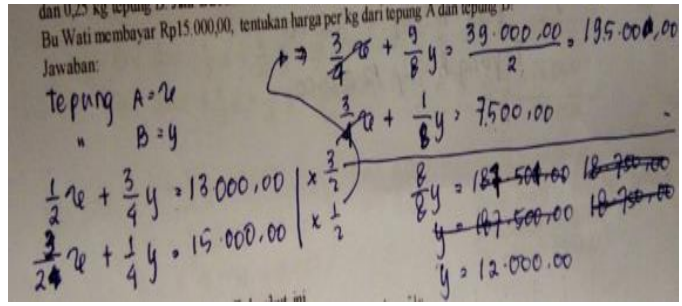

Figure 7*. The answer of S4 for the second problem*

3.5 Characteristics of subject 5 (S5)

S5 performed the stages of DOTS at the same time. Figure 8 and 9 show the results of the first and the second questions for S5. The answers were correct for both the first and second questions. In the first question, the student looked for rectangle length first. Furthermore, she did not forget to look for the width of the rectangle. Concerning the second question, she solved the problem in a very efficient manner. To get a clear picture of the problem solving process done by S5, an interview with the subjects was conducted. The result of the interview can be seen in the following transcription.

I : "How do you deal with this word problem-solving?"
S5 : "I read it carefully, paid attention to every detail in the problem, and made equality to make it easier to solve it".
I : "What difficulties did you face when dealing with this word problem-solving?"
S5 : "Hmm, when making the equality, I needed time to decide the appropriate equality to represent the width of 6 cm shorter that the length, so I was stuck in k = 2 (p +l)"
I : "So, what did you do to solve that problem?"
S5 : "I had to find out the relationship between the length (p) and the width (l). I paid a serious attention to the problem and focused on the sentence stating that the width is 6 cm shorter than the length. At first, I represented it as p + 6, but finally I realized that my fault and I then concluded that the width could be represented as p – 6"

The result of S5 which previously stating width as p + 6 change into p – 6 as indicated in the red box in Figure 9. In that box, the symbol "+" (bolded) changed into "–".

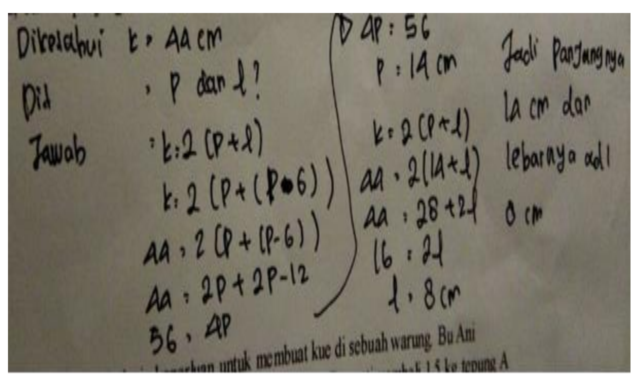

Figure 8. *The answer of S5 for the first problem*

Meanwhile, in solving the second problem, S5 did not get any difficulties. It is indicated in Figure 10. S5 did the stages of 'detect, organize, transform, and solve' all together at the same time.

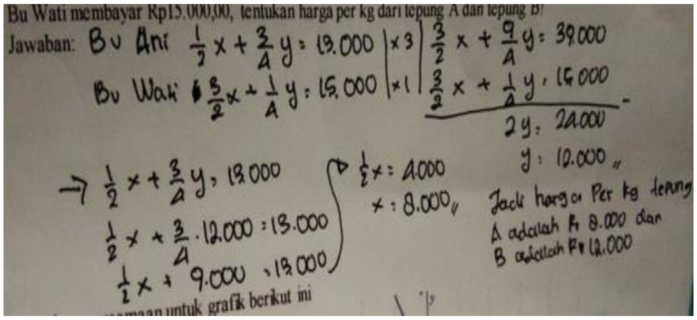

Fig 9. *The answer of S5 for the second problem*

4 DISCUSSIONS

In this study, S1 experienced mathematics anxiety and thus failed in solving simple mathematical problems though the problems are categorized as lower level problems. The results of previous studies found the same thing. Hoffman [17] states that "problem solving success is contingent upon the interactive effects between self-beliefs and optimal strategy use as a means to avoid anxiety." Arem [24] explains the existence of a negative relationship between anxiety and problem-solving ability through the process of mathematical anxiety. The process of solving the problem for someone with high anxiety does not work well so that it can reduce the ability of problem solving. S2 demonstrates difficulty in algebra mathematization that consists of horizontal and vertical mathematization. The difficulty in horizontal mathematics concerns students' difficulty in going from the world of real phenomena to the world of symbols and vice versa, whereas the difficulty in vertical mathematization concerns students' difficulty in dealing with the process of moving within the symbolic world [25]. These are called as 'mathematics difficulties'. Based on the results of the interview, the student had no idea what to write to solve this problem. Moreover, the student did not work at all on the second question. S2 is unable to organize variables, making it difficult to solve the next problem. In this case, the student failed to add or subtract algebraic terms and sometimes detached symbolic expressions from the operations [26]. Altogether, we summarize these as difficulties in applying arithmetic operations both in numerical and algebraic expressions. Concerning the literal symbols, S2 has difficulties to distinguish a literal symbol as a variable that plays the role of a placeholder, a generalized number, an unknown, or a varying quantity. These difficulties are called 'difficulties in understanding the notion of the variable.' The student was also unable to understand the function of the equal sign. In arithmetic, the equal sign often invites carrying out a calculation and writing down a numerical answer, whereas, in algebra, it usually means 'is algebraically equivalent to' [27]. In this study, this difficulty is called 'difficulty in understanding the different meanings of the equal sign.' During the interview, the student described difficulties in understanding the algebraic equation of the second problem because of the differences in units of variables, namely kilograms (unit weight) and rupiah (currency). However, in this present study, S3 had not been able to solve the equations that have been made correctly. The student summed up the equation 44 = 2p + 2p - 6 to 44 = 4p - 6 and finally writes 50 = 4p with p = 12.5. The student paid less attention to this form of equation which should be 44 = 2p + 2 (p - 6). In this case, the students also misapplied commutative as well as associative properties when carrying out subtractions or divisions [28] and failed to use the distributive property of multiplication over addition [29]. Meanwhile, S4 resolves the problem in a less effective way. Historically, choosing and implementing the appropriate arithmetic operations for a solution is very important for successful problem solving. However, according to Jonassen [30] conceptual understanding of the problem of a story must first exist before finding a solution. In particular, a conceptual model that recognizes and rearranges the deep structure of a problem needs to be built before planning a solution. Besides, the conceptual model must encourage the development of solutions that involve the selection and application of appropriate arithmetic operations [31]. The most interesting part of this research is about S5. S5 experiences high mathematics anxiety but she can solve mathematical problems well and efficiently. Specifically, mathematics anxiety may not universally interfere with the development of mathematical abilities [32], and clinical efforts aimed only at reducing the level of mathematics anxiety may not prove effective for all students [33]. These findings indicate that mathematics anxiety can also be beneficial rather than detrimental to the subject. Therefore, it might be better for some students to maintain their level of mathematics anxiety, with teacher monitoring to ensure that learning and testing material is quite challenging. The combination of moderate mathematics anxiety and high intrinsic motivation can help encourage students to work harder in learning mathematics and enjoy the fun in this process at the same time [33]. The phenomenon experienced by S5 is not surprising. Arnsten [34] and Diamond, et al. [35] have shown that moderatemathematics anxiety can even help focus and improve working memory. Meanwhile, the high or the low level of mathematics anxiety frequently affects insufficient cognitive source, so it hampers students to work on mathematics tasks. Along the same line, Wang, et al. [33] also revealed that high motivation level and moderate level of mathematics anxiety can support performance in solving mathematical problems. However, with individual with low level of motivation, anxiety consistently has a weakening effect on mathematical performance. This pattern potentially shows the importance of motivation in regulating the cognitive source and manage the negative effect during problem solving. This finding is consistent with the finding in contemporary functional MRI highlighting the relationship between brain activation involving in motivating behavior and control cognitive in improving the performance of adult experiencing mathematics anxiety [32]. Students with high motivation might be able to solve mathematical challenges through active approach [36]. Therefore, there is always a possibility that students with high motivation will have moderate anxiety level. It is because the difficulty they face will challenge them to be better from time to time gradually [37]. In contrast, those who do not have motivation will tend to avoid difficulties so that they cannot improve their mathematical performance [36]. This possibility is in line with the previous research findings which report that the effect of students' response to the difficulties determine their mathematical performance [38].

5 CONCLUSIONS

The results of this study indicate that there are two types of problem solving performed by the subjects of this study. First, four subjects solved the problem by performing the stages of DOTS. In this case, the subjects can detect the structure of the problem, but they have difficulties in applying arithmetic operations both in numerical and algebraic expressions. Something interesting is that one of the four subjects can organize information, but she misapplies commutative as well as associative properties when carrying out subtractions or divisions and fails to use distributive property of multiplication over addition. Meanwhile, the other one subject can do the stages of DOTS altogether at the same time. From these five subjects, it can be seen that mathematics anxiety does not always lead to failure in problem-solving. This can be seen in the fifth subject that shows good performance on problem-solving and goes through the stages of DOTS at the same time.

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