LOOKING WITHOUT SEEING: THE ROLE OF META-COGNITIVE BLINDNESS OF STUDENT WITH HIGH MATH ANXIETY

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ABSTRACT

This study aims to reveal how metacognitive failure occurs during problem-solving experienced by the pre-service teacher with mathematics anxiety. The data collected are in the form of words obtained through interviews, pictures of the results of the subject's work, and the results of the mathematics anxiety questionnaire as an instrument for selecting subjects. Description of data analysis and interpretation of the meaning of the findings apply text analysis. Analysis is conducted in all phases of problem-solving including the phase of understanding, analyzing, exploring, planning, implementing, and verifying. The presence of metacognitive blindness is identified through red flag, which is a warning sign to stop or retreat to the previous problem-solving phase and immediately take certain actions. Three types of red flag identified in this study include lack of progress (LP), error detection (ED), and anomalous results (AR). The results of the analysis show that students who experience math anxiety can experience metacognitive blindness during the problem-solving process. Red flag, which is dominant in metacognitive blindness, is error detection. This red flag occurs because subjects with mathematics anxiety pay less attention to the details of the problem, so they miss a lot of important information. The subjects see the problem only on the surface, based on the words they read in the problem presented.

1. INTRODUCTION

Students will internalize what and how their teachers teach, meaning that if they sense that their instructors do not enjoy being in the classroom, they will be less motivated to participate and learn (Jackson and Leffingwell, 1999). However, pre-service teachers' negative memories of their primary years can have a lasting effect, potentially up to 20 years or more when they serve as teachers. Based on the literature, pre-service teachers could perpetuate the negative cycle of mathematics anxiety in their students because of their own internal reaction to mathematics (Jackson and Leffingwell, 1999). Therefore, becoming aware of the prevalence of mathematics anxiety can be a vital step in providing a positive outcome towards mathematical performance in future generations.

Mathematics anxiety is the main factor

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that inhibits success in mathematical problem-solving (Guven and Cabakcor, 2013). Other studies have found that high levels of mathematics anxiety are associated with less efficient mathematical problem- solving (Hoffman, 2010).

The negative effects of mathematics anxiety on the success of mathematical problem-solving have been investigated by some experts (Carey, Hill, Devine, and Szücs, 2016). This is not surprising since problem- solving is at the core of mathematics learning (Cai and Lester, 2010). However, until now no research has been able to explain how this mechanism of mathematics anxiety interferes with the problem-solving process. In fact, information about this is needed for students who experience mathematics anxiety to improve their learning methods.

Problem-solving activity, one form of high-level thinking is closely related to metacognition (Faradiba, Sadijah, Parta and Rahardjo, 2019). The process of problem-solving is not enough if a student only has a lot of mathematical knowledge and facts, but must be accompanied with the ability to monitor and regulate the knowledge he/she has (Garofalo and Lester, 1985). This is in line with the framework of cognition-metacognition in problem-solving (Artz and Armour-Thomas, 1992).

Unfortunately, the metacognitive process cannot always go well. This is because the knowledge that is already owned cannot always be used optimally. Hoorfar and Taleb (2015) mention that mathematics anxiety makes students unable to use all of their metacognitive knowledge optimally. Another study identifies three types of metacognitive failures that are displayed by problem solvers as a reaction to red flag, namely metacognitive blindness, vandalism, and mirage (Goos, 2002).

In particular, there are two types of blindness when associated with attention (*inattentional blindness*), namely functional blindness and sighted blindness (Mack and Rock, 1998). Functional blindness is an activity of looking without seeing. This experience is most likely to occur when the subject lacks concentration and sensitivity to the condition of the environment. Conversely, sighted blindness occurs when the subject is involved in a very interesting conversation or when the subject is doing deep thoughts about something. This encourages the subject to look at things in more detail than others and pay more attention to things that are not really necessary.

The purpose of this study was to find out how metacognitive blindness occurs in pre-service teachers who experience mathematics anxiety. The results of this study are expected to provide input for the development of a mathematical learning model, considering that pre-service teachers have a very vital role in the success of future learning.

2. MATERIALS AND METHODS

This research applied qualitative approach with a case study design. The researcher ensured that the students had passed the Theory of Numbers course. This consideration is important to make sure that the prospective subjects have sufficient cognitive knowledge to solve the mathematical problems investigated in this study.

The mathematics anxiety score used in this study was adapted from MARS-R (Plake and Parker, 1982) and translated into Indonesian language. This instrument consists of 24 questions and given a score from 1 to 5 (1 shows no anxiety to 5 shows high anxiety). The items of the questionnaire were categorized into two factors. The first is anxiety factor that occurs when learning mathematics comprising of items that measure anxiety experienced during activities related to learning mathematics. The second is anxiety during the mathematics exam containing 8 items that measure the experience of anxiety when working on exam/test questions.

At this phase, two prospective subjects who had the highest math anxiety score were selected. The first subject (S1) got 70 in the first factor in mathematics anxiety score (considered high category) and 25 (considered moderate category) in the second factor. Therefore, it can be concluded that the source of anxiety experienced by the S1 was on the first factor. Meanwhile, the second subject (S2) got 48 in the first factor (considered moderate category) and 36 in the second factor (considered high category). Consequently, it can be said that the second factor was the main source of anxiety experienced by the S2.

The mathematical problem used in this study was adapted from Schoenfeld (1985). The initial problem presented by Schoenfeld is presented in Figure 1. Meanwhile, the problems, which are the results of adaptation used in this study, are presented in Figure 2.

Let G be a (9 × 12) rectangular grid, as illustrated to the right. How many different rectangles can be drawn on G, if the sides of the rectangles must be grid lines? (Squares are included, as are rectangles whose sides are on the boundaries of G.).

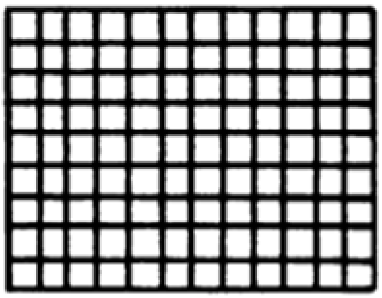

Figure 1. Mathematical Problem-Solving

There were several considerations in adapting mathematical problems. The first is the subject's background in the previous education level. Not all subjects have a mathematical background at high school level; some come from social sciences and linguistics. Therefore, the mathematical problem was simplified from a rectangle measuring 9 × 12 square units to a square measuring 8 × 8 square units. Because the sides of the square have the same size, it was expected to make it easier for the subjects to solve this mathematical problem. The second was by adding a different color to the square size of 8 × 8. This was done to attract the attention of the subject in order to give enough attention to solve this problem.

1. Determine how many squares have different color sizes and arrangements on an 8 × 8 square chessboard!
2. Determine how many squares you can find on an 8 × 8 chessboard!

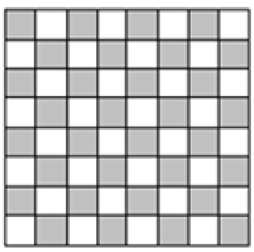

Figure 2. Adapted Mathematical Problem-Solving in this Research

The subjects then were asked to complete the problem-solving on a piece of paper. Next, an analysis was conducted based on the results of the students' work to determine whether the subjects could potentially experience red flag and metacognitive blindness during problem-solving process based on the description of metacognitive blindness in Table 1 to Table 6.

Table 1 describes metacognitive blindness which is caused by three types of *red flags, namely lack of progress* (LP), *error detection* (ED), and *anomalous results* (AR) that occurred in the process of understanding problem. The activity of understanding the problem is the activity to determine what is asked and to identify the information contained in the problem.

Table 1. Indicators of Metacognitive Blindness at the Phase of Understanding Problems

Red flag Types	Indicators of Metacognitive Blindness
LP1	The subjects do not realize that they have difficulty in determining what is asked.
ED1	The subjects do not realize that they made a mistake in the process of determining what is asked.
AR1	The subjects do not realize that the error/incongruity they find in solving the problem actually does not exist.

Furthermore, Table 2 contains a description of metacognitive blindness caused by *red flag* when the subjects analyze the problem. Analyzing the problem is the activity of thinking about material related to the problem and connecting the material with what is asked in the problem.

Table 2. Indicators of Metacognitive Blindness at the Phase of Analyzing Problems

Red flag Types	Indicators of Metacognitive Blindness
LP2	The subjects do not realize that they have difficulty in determining the relationship between what is known and what is asked.
ED2	The subjects do not realize that they make a mistake in the process of determining the relationship between what is known and what is asked in solving the problem.
AR2	The subjects do not realize that the error/incongruity that they find in the process of determining the relationship between what is known and what is asked in solving the problem actually does not exist.

Table 3 contains a description of metacognitive blindness caused by *red flag* when the subjects explore the problem. The activities in this phase are activities using relevant information from the previous two phases.

Table 3. Indicators of Metacognitive Blindness at the Phase of Exploring Problems

Red flag Types	Indicators of Metacognitive Blindness
LP3	The subjects do not realize that they have difficulty in determining information that is relevant to the method used.
ED3	The subjects do not realize that they make a mistake in the process of determining information that is relevant to the method used.
AR3	The subjects do not realize that the error/incongruity that they find in the process of determining relevant information in the way it is actually used does not exist.

After the phase of exploring the problem, the subjects then plan to solve the problem. At this phase, the subjects think of an approach that can be used to find a solution. Indicators of metacognitive blindness at this phase can be seen in Table 4.

Table 4. Indicators of Metacognitive Blindness at the Planning Phase for Problem-Solving

Red flag Types	Indicators of Metacognitive Blindness
LP4	The subjects do not realize that they have difficulty in determining various approaches to solve the problems.
ED4	The subjects do not realize that they made a mistake in the process of determining various approaches to solve the problem.
AR4	The subjects do not realize that the errors/incongruities that they found in the process of determining various approaches to solve the problem actually do not exist

In the fifth phase, the subjects carry out a problem-solving plan. Here the subjects apply the chosen approach and combine several approaches. Indicators of metacognitive blindness at this phase can be seen in Table 5.

Table 5. Indicators of Metacognitive Blindness at the Phase of Implementing a Problem-Solving Plan

Red flag Types	Indicators of Metacognitive Blindness
LP5	The subjects do not realize that they have difficulty in determining the steps of implementing the chosen strategy.
ED5	The subjects do not realize that they make a mistake in the process of determining the steps of implementing the chosen strategy.
AR5	The subjects do not realize that the error/incongruity they find in the process of determining the steps for implementing the chosen strategy is actually nonexistent.

The final phase is verification. At this phase, the subjects evaluate activities related to approaches, methods, strategies, calculation procedures and the final results. Indicators of metacognitive blindness at this phase is in Table 6.

Table 6. Indicators of Metacognitive Blindness at the Verification Phase

Red flag Types	Indicators of Metacognitive Blindness
LP6	The subjects do not realize that they have difficulty in the process of checking the suitability of the solution that has been produced.
ED6	The subjects do not realize that they made a mistake in the process of checking the suitability of the solution that has been produced.
AR6	The subjects do not realize that the error/incongruity they found in the process of checking the real solution does not exist.

3. RESULTS

3.1. Description of the Problem-Solving Process by Subject 1 (S1)

S1 described a square size of 1 × 1 by means of shading. In this case, shading represents a square on a black chess board. Whereas it can be seen on the chess board that there is also a white square besides the black square. Therefore, it can be concluded that the information collected by S1 at the phase of understanding the problem is incomplete. The results of the S1 work for the first problem is shown in Figure 3.

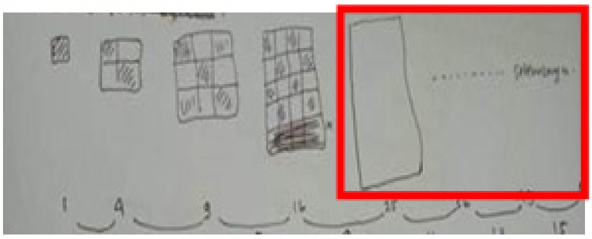

Figure 3. The Mathematics Anxiety Indicator Experienced by S1 in Resolving Problem 1

S1 also had difficulty in determining what was actually asked in the first problem. *Red flag* that occurs in this phase is ED1. This can be seen when S1 calculated the number of squares in each picture he made that is actually not asked in the problem. This is indicated by the numbers written at the bottom of each square made by S1. In square size 1 × 1, it is written 1 showing that the number of square units in square size 1 × 1 is 1. In square size 2 × 2, it is written number 4 indicating that the square size 2 × 2 is formed from 4 square units. In square size 3 × 3, S1 wrote number 9, indicating that square size 3 × 3 is formed by 9 square units. Finally, at the bottom of the square the size of 4 × 4, S1 wrote number 16, meaning that there are 16 square units forming a square size of 4 × 4. For a square size of 5 × 5, S1 did not make the picture sketch. Sketching for a 5 × 5 square is avoided by the S1 because he felt anxious about the results of the sketches that did not form a square, but rather a rectangle. This was shown in the dialogue between I(7) and S1(8). However, he started to understand the pattern of the number of square unit from the four squares he made earlier that is 1, 4, 9, 16; therefore, S1 continued this pattern to be 1, 4, 9, 16, 25, 36, 49 and so forth.

The difficulties in identifying what is asked in solving problems done by S1 is supported by the results of the following interviews between interviewer (I) and subject 1 (S1).

I (1) : "What do these numbers mean?" (Pointing to the number written below the picture)

S1(2): "These numbers show the number of unit squares in each of the square above it."

I (3): "So, how many different squares are there on the chess board?"

S1(4): "Because the chess board is 8 × 8 square unit, the number of squares is 64."

I (5): "Are you sure that is what is asked in this problem?"

S1(6): "yes"

I(7): "What about the 5 × 5 of a chess board? Why did not you make a sketch? "

S1(8): "I am not sure with the sketch I made because the shape is no longer square, but a rectangle"

Dialogues I(3) to S1(6) indicate that S1 failed in determining what was asked in solving problems, but he did not realize it and felt confident in the answer. In this case, S1 only saw that the chess board has 64 square units. However, S1 could not realize that the first problem asked about how many different squares. The word *different* means square color differences on chess board (black and white) and different square sizes that might be formed from a chess board. S1 only glanced at it and did not observe well the illustrations given on the first problem.

In the phase of analyzing problem, S1 also experienced *red flag* when identifying material related to problem-solving. *Red flag* that occurred at this phase is LP2. S1 only mentioned one material about the concept of square. This is shown from dialogues I(9) until S1(14) of the interview transcription as follows.

I (9): "What material is related to solving this problem?"
S1(10): "Square Concept"
I (11): "Can you explain more specifically what kind of square concept do you mean?"
S1(12): "Square has 4 equal sides. because the unit in solving this problem is using a unit square, a square can be formed from a square arrangement of units that has a size of 1 × 1, 2 × 2 and so on to 8 × 8."
I (13): "Besides the concept of square, is there any other material related to solving this problem?"
S1(14): "there is no"

The next phase is exploring the problem; S1 experienced LP3 in gathering information that is relevant to the strategies used in problem-solving. This can be seen from the failure of S1 to identify color differences on the chess board. This can be seen in Figure 3 showing that S1 showed only a black (shaded) 1 × 1 chess board. S1 ignored the white 1 × 1 square, which is actually also on the chess board.

The fourth phase is planning problem-solving. At this phase, *red flag* that occurs is shown by the presence LP4. It occurs when S1 determined the right strategy to solve problem-solving. Actually, there are three strategies can be used: using the formula for the number of *n terms* in a series, using a pattern, and counting directly through drawing sketches. However, to solve problem number 1, a combination of strategies is needed. S1 did not realize that the strategy he chose must be combined to produce the correct solution.

In the fifth phase, implementing a problem-solving plan, S1 experienced AR5. S1 only used one last strategy – using a pattern. Sketching images made by S1 only served as a basis for making patterns. However, after the pattern appeared, the sketch of the image was not used anymore. This can be seen in Figure 3 showing that S1 only sketched images for square size 1 × 1, 2 × 2, 3 × 3, and 4 × 4. S1 intentionally avoided the combination of other strategies because he felt there was an error in sketching for a 5 × 5 square size. In fact, this error actually does not exist. This error is caused by sketches produced by S1 using a unit square not exactly the same size so as to produce a square with a side length that seems not to be the same length. This can be seen from the dialogue S1(18).

I(15): "Why didn't you continue sketching the 5 × 5 square image?"
S1(16): "I'm still confused"
I (17): "What difficulties did you experience when sketching a 5 × 5 square image?"
S1(18): "It should be the same length and width as the square, but it is not in my sketch. There must be something wrong."

In the final phase, verifying the solution that has been produced, S1 took evasive actions. S1 did not check his answers. This can be seen in the transcription of S1(34). In addition, S1 also experienced ED6 because he was not aware of errors existing in the solutions he produced.

I(19): "Have you reviewed the solution before collecting?"
S1(20): "No"
I (21): "Why didn't you do it?"
S1(22): "Yes, actually there was still time to check, but I want to finish quickly so that it can be collected soon."
I (23): "Are you sure the solution you produced is correct?"
S1(24): "Yes"

Furthermore, the solution to the second problem is described in Figure 4. In this problem, the subject was asked to calculate the number of all squares on the chess board measuring 8 × 8. In Figure 4, it appears that S2 described a square of size 1 × 1, 2 × 2 and so on to 8 × 8 regardless of color differences. Therefore, the final answer obtained by S1 is 8 square.

Figure 4 shows the process of resolving the second problem carried out by the S1 indicates mathematics anxiety. This can be seen from the results of the observation of S1 during mathematical problem-solving. S1 sketched a chess board of size 1 × 1, 2 × 2 then jumped directly to the chess board size 4 × 4, 5 × 5, and 6 × 6. S1 paused for a while. Furthermore, S1 calculated the number of sketches of the chess board that had been made–they were five, while he wrote the size of the last chess board made was 6 × 6. Then, S1 realized that the sketch for the 3 × 3 chess board was skipped and immediately drew it, followed by sketches for chess board of 7 × 7 and 8 × 8.

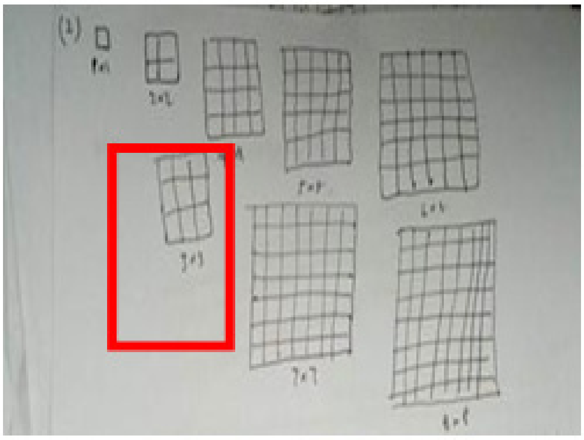

Figure 4. The Mathematics Anxiety Indicator Experienced by S1 in Resolving Problem 2

In the early phase, S1 experienced ED1. S1 made a mistake in determining what was asked, but he did not realize the mistake. This can be seen in the interview transcription of S1(38).

I(25): "Can you retell what is asked in problem number two?"

S1(26): "Determining how many squares on the 8 × 8 chess board"

I(27): "How do you do that?"

S1(28): "As far as I know the number of squares on the chess board can be counted directly because there are 8 square rows as many as 8 columns, so there are 8 square"

I(29): "Are you sure that's what is asked in the question?"

S1(30): "Yes, sure. This can also be done by observing the pattern, square size 1 × 1, square size 2 × 2, and so on. The maximum is only up to 8 × 8 square, so there are 8 squares on the 8 × 8 chess board"

In analyzing the problem, it can be seen that S1 experienced ED2. This is based on the interview transcription of S1(28). S1 was not aware of errors in determining the number of squares. S1 only showed that a chess board of size 8 × 8 could be formed by a square size of 1 × 1, 2 × 2, 3 × 3, 4 × 4, 5 × 5, 6 × 6, 7 × 7 and 8 × 8 as many as one each square. S1 did not realize that there were 64 squares on an 8 × 8 chess board.

In the phase of exploring problems, S1 experienced LP3. Not only being failed to realize the number of squares size of 1 × 1 on the 8 × 8 chess board in the previous troubleshooting phase, he also did not realize that a square size of 2 × 2 on a chess board is more than 16. S1 forgot the fact that there is a unit square that intersect on a chess board. This is shown in the dialogue transcription of S1(44) as follows.

I (31): "How many squares with size of 2 × 2 are on the chess board?"

S1(32): "If there are 2 × 2, there are 16 with 4 squares sideways, and 4 squares down because the size of the chess board is 8 × 8 square unit."

I(33): "Then why is the solution that you produced only written 1 for square size 2 × 2?"

S1(34): "Based on my understanding it is enough to be represented by just one; it's the same size of 2 × 2"

In the phase of planning problem-solving, again the S1 experienced LP4. In this case, S1 only used one solution, sketching of an image, whereas in solving this problem, S1 is required to be able to combine sketches of images and patterns of numbers produced. This can be seen in the dialogues I(35) and S1(36) in the following.

I (35): "In addition to sketching square drawings like this, what other strategies do you think to solve this problem?"

S1(36): "I think this problem can only be solved with images like this because it makes it easier to imagine the actual chess board conditions"

In the phase of implementing the problem-solving plan, red flag experienced by S1 is ED5. S1 did not realize that there is no square of the chess board having the same color as the sketch of the image he made as in Figure 3.

The final phase in problem-solving is the verification. In this phase, S1 also experienced ED6. This *red flag* is a result of *red flag* in the previous phase. S1 verified that the answer was appropriate. According to S1, there are 8 squares produced, square size 1 × 1 to 8 × 8 each number 1.

3.2 Description of the Problem-Solving Process by Subject 2 (S2)

In the phase of understanding the problem, S2 failed to find what was asked in the problem. This can be seen in the interview transcription S2(44) that S2 experienced ED1.

I (37): "What is asked in the first problem?"
S2(38): "Finding the number of different squares on the chess board."
I(39): "What do you mean by different?"
S2(40): "Different means not the same."
I(41): "Well, if I have an 8 × 8 chess board, how many different squares size of 1 × 1 on the chess board?"
S2(42): "32 white and 32 black"
I(43): "32? Isn't this the same square, both white and equal size 1 × 1? "
S2(44): "Different, even though the size and color are the same, this is a square located on the first row, while the other square is located on the second row."

Furthermore, in analyzing the problem, S2 experienced ED2. S2 described white squares of size 1 × 1 on a chess board as many as 32. In addition, S2 described the number of black squares measuring 1 × 1 on a chess board as many as 32. Errors made by S2 in this case are to assume that the 32 square units are different squares (location), but actually they are the same (in size and color). ED2 that occurred when S2 analyzed the problem was a result of ED1.

In the phase of exploring the problem, S2 experienced an AR3. S2 described a square size of 2 × 2 as many as 16. This was in consideration that a square size of 4 × 4 has 4 rows and 4 columns in a square size of 8 × 8 (chess board). The process of sketching a square of size 3 × 3 was not done because the square arrangement of size 3 × 3 cannot form an 8 × 8 square, whereas it actually can, because there are 3 × 3 square sections that intersect each other. This is shown in dialogues S2(48) as follows.

I(45): "Why didn't you draw 3 × 3 square?"
S2(46): "Because a square of size 3 × 3 cannot close a square of size 8 × 8 perfectly, remaining two columns and these two lines"
I(47): "What about the size of a 4 × 4 square units?
S2(48): "Because the chess board is 8 × 8, it's a 4 × 4 square right to cover it, and it takes 4 square 4 × 4 to cover the 8 × 8 chess board. This is the largest square, 5 × 5 and so on, it can't be cover anymore."

The next step is to plan problem-solving. S2 experienced LP4 because the information collected in the previous phase was wrong; the error resulted in the same *red flag* in this phase. S2 was not able to use the pattern to find a solution to the problem number 1 because based on the information gathered in the previous phase, S2 did not apply the chosen strategy to all unit square sizes, only on square sizes 1 × 1, 2 × 2, 4 × 4. In this case, S2 did not realize that the difficulty he experienced in representing other sizes of squares actually did not exist because the unit square can intersect with each other. At this phase, S2 tried to understand the existing pattern but eventually failed and decided to work on the strategy only.

In the phase of implementing a problem-solving plan, S2 completed the problem for a 4 × 4 square unit of 4 squares. This is obtained from a 4 × 4 square arrangement in an 8 × 8 square forming 2 rows and 2 columns. At this phase, S2 experienced LP5. Initially S2 doubted whether the 3 × 3 square was included in the solution or not. This is indicated by the scribbling on the results of his work on a square image below a 2 × 2 square. S2 had difficulty in representing a 3 × 3 square unit size on the chess board. Also in this phase, the indication of mathematics anxiety can be found. After S2 sketched a 2 × 2 chess board, S2 tried sketching another square size with a larger size. However, the sketch he made was a rectangular instead of a square. In addition, S2 shaded the adjacent square (top-bottom), whereas the square arrangement should be alternating (black followed by white and vice versa). This sketch can be seen in Figure 5.

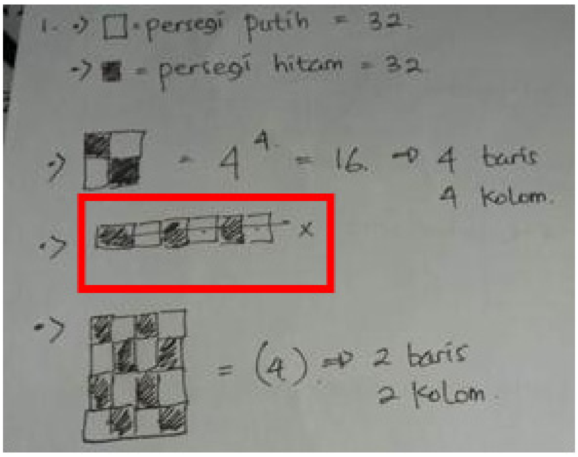

Figure 5. The Mathematics Anxiety Indicator Experienced by S2 in Resolving Problem 1

At the end, S2 re-checked the answers that had been generated to ensure there were no miscalculations. At this phase, S2 did not realize that he had not added the total square. In the previous phase, S2 wrote the solution as 32 + 32 + 16 + 4 + 1 as shown in Figure 6. So, it can be concluded that S2 to experienced ED6.

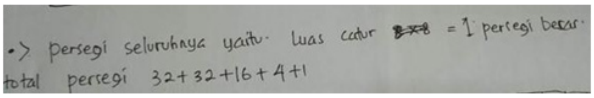

Figure 6. The Final Solution to Problem Number 1 by S2

The same thing was done by S2 in question number 2. In the phase of understanding the problem, S2 did not realize that there were two possibilities for unit square colors. For example, in a unit square measuring 1 × 1, S1 only described it in black, not in white. Therefore, it can be concluded that in this phase S2 experienced ED1.

Furthermore, in analyzing the problem, S2 assumed that the square unit of size 1 × 1 was in a 2 × 2 square unit and so on. Therefore, S2 would use the strategy by reducing the number of squares on the pattern he made with the previous square. S2 was not aware of this mistake, so it can be concluded S2 experienced ED2.

Next, in exploring the problem, S2 experienced an LP3. S2 calculated the number of squares in the sketch of the picture he made. In a square of size 1 × 1 there is 1 square, on the size side of 2 × 2 there are 4 squares so on until the square size 8 × 8 is a chess board. S2 had an overlap; a square calculated on a square of a larger size has actually been calculated before working with a smaller square.

The next step is to plan problem- solving. In this case, S2 did not realize that the way he used to answer what is asked was not right. S2 experienced ED4; this is indicated by the attitude of the S2 who continued using the method he chose. S2 tried to find a number pattern but in an inappropriate way.

In the phase of implementing the problem-solving plan, S2 was asked to determine how many squares were in the chess board without regarding the color differences. To produce a solution to this problem, S2 made a 1 × 1 square, followed by a 2 × 2 square and so on to square size 8 × 8. Numbers below the square show the number of square units that are in each square. While the numbers in the second row show the difference from the number of units that are written in the first row as in Figure 7. The *red flag* that occurs in this phase is ED5.

In the phase of implementing the problem, the indication of mathematics anxiety experienced by the S2 can be found when solving the second problem. In this case, S2 calculated the number of square units on a 2 × 2 chess board 4, a chess board of size 3 × 3 as many as 9, and so on until a 8 × 8 chess board of 64. In this case, S1 skipped the chess board of size 1 × 1 consisting of 1 square unit. As a result, in the next calculation process, S1 calculated the deviation in the number of square units of chess board size 3 × 3 (as many as 9 square units) and 2 × 2 (as many as 4 square units), namely 9 - 4 = 5. But in fact, when it was following this pattern actually the first calculation is the deviation in unit square on a chess board of size 2 × 2 (as many as 4 square units) with a chess board of size 1 × 1 (as many as 1 square unit), namely 4 - 1 = 3.

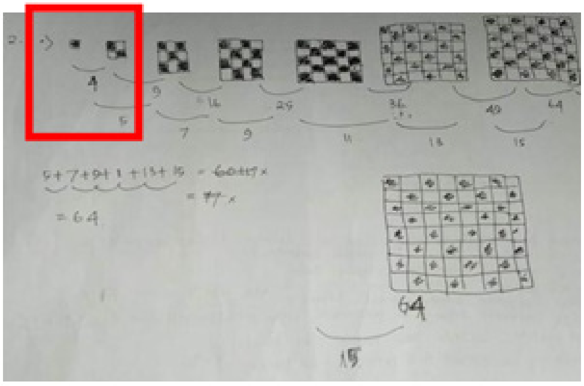

Figure 7. The Mathematics Anxiety Indicator Experienced by S2 in Resolving Problem 2

At the final phase, the verification phase, S2 also experienced ED6. This can be seen when S2 wrote the final result of the answer as 5 + 7 + 9 + 11 + 13 +15 = 60. However, S2 wrote it as 64. In general, the process of metacognitive blindness that occurs in subject 1 and subject 2 can be seen in the Table 7.

Table 7. Redflag of S1 and S2

Phase	S1 Problem 1	S1 Problem 2	S2 Problem 1	S2 Problem 2
1	ED1	ED1	ED1	ED1
2	LP2	ED2	ED2	ED2
3	LP3	LP3	AR3	LP3
4	LP4	LP4	LP4	ED4
5	AR5	ED5	LP5	ED5
6	ED6	ED6	ED6	ED6

4. DISCUSSIONS

Mathematics is built on several cognitive abilities (Geary, 2011), is implemented by neural networks in the brain (Goswami and Szűcs, 2011; Fias, Menon, and Szucs, 2013), and is influenced by emotional aspects (such as feelings of fear, dislike, tension, worry, frustration, and fear) experienced when solving mathematical problems, known as mathematics anxiety. Regarding the relationship between mathematics anxiety and cognitive processes, previous studies have shown that individuals with limited working memory capacity have difficulty in regulating their anxiety levels (Hofmann, Smits, Asnaani, Gutner, and Otto, 2011). In addition, anxiety can reduce working memory resources (Mammarella, Hill, Devine, Caviola, and Szucs, 2015). It is common knowledge that cognitive skills such as working memory, processing speed, attention and obstacles are important in regulating the difficulty of learning mathematics (Fletcher, J. M. at al, 2007). In line with these findings, mathematics anxiety causes disruption of the subject's ability to maintain his attention capacity (Ramirez, Gunderson, Levine, and Beilock, 2013). From the description above, it can be traced that metacognitive blindness is one type of metacognitive failure caused by the lack of attention of the subject in the problem-solving process, which is derived from the existence of mathematics anxiety. Meanwhile, metacognitive mirages are part of metacognitive failure originating from the subject's excess attention to a problem. The impact of excess attention is that the subject becomes aware of things that are not really necessary. This causes the subject to always feel there is something wrong/incongruity.

In the process of solving mathematical problems, there may be difficulties, process errors, or results. *Red flag* is a sign of difficulties, process errors, or errors in the results of problem-solving (Goos, 2002; Goos, Galbraith and Renshaw, 2000). *Red flag* is a trigger for metacognitive activity when a person is aware of certain difficulties (Stillman, 2004). *Red flag* occurs in problem-solving when someone experiences LP, ED, or AR.

LP is a condition when a person experiences obstacles or *deadlock* in the problem-solving process (Goos, 2002). In his research, Goos (2002) states that LP occurs in the exploration phase (the third phase) which demands to reanalyze the problem and reassess the chosen strategy, and then assess understanding and seek new information or strategies. However, in this study LP does not only occur in the third phase of problem-solving, but it also appears in the third phase. LP also exists in the second and fourth phases of the S1, and the fourth and fifth phases in S2.

Meanwhile, Goos, Galbrait, and Renshaw, 2000 state that *error detection* is a warning when someone experiences a process error at the implementation/ application phase requiring someone to check and correct errors. ED is a *red flag* that dominates the problem-solving process performed by both subjects. Furthermore, Abdullah, Abidin, and Ali (2015) explain that several errors can occur in the phases of the problem-solving process.

First is *reading error*, an error in reading problems. Reading is the initial phase of problem-solving and is included in the cognitive domain; therefore, it is not discussed further in this study. This is done by considering the condition of the subjects as pre-service teachers who certainly do not experience obstacles in reading the problem.

The second is *comprehension errors*, which occur in the phase of understanding the problem and when someone misunderstands what is needed/known and what is asked. Students who experience mathematics anxiety need to have metacognitive therapy in the form of giving four types of questions; one of them is comprehension questions (Faradiba, Sadijah, Parta, and Rahardjo, 2019). Comprehension question provides a new appearance for the treatment of psychological disorders by underlining the significance of how a person thinks, rather than simply focusing on the content of his cognition.

The third is *transformation error*, an error in interpreting and identifying the appropriate mathematical operations to solve the problem. Transformation error occurs in the second and third phases of problem- solving. An error in this phase will always be followed by LP in the next phase. This is not surprising because the subject experienced a lack of information to keep going to the next phase.

The next is process skill error, an error in applying the work procedure. Process skill error occurs in the fourth and fifth phase of problem-solving. The error that occurs in this phase is the result of the previous error.

The last is encoding error, an error in writing the final answer. Encoding error occurs at the end of the problem-solving phase. This error can be single (only appears at the end of the problem solving phase), or not (as an effect of the error in the previous phase).

Each phase of problem-solving is expected to produce appropriate results, but in reality, this may not be the case. AR is an odd/unusual result that can happen; a lot of the results obtained is strange (strange results) or odd (anomalous results) (Goos, Galbrait, and Renshaw, 2000; Goos, 2002; Stillman, 2004).

Mathematics anxiety causes worse mathematical performance. This happens because of the temporary reduction in cognitive resources needed in solving mathematical problems. The cognitive resources referred to here are working memory (WM). WM is a short-term memory system that controls, regulates, and actively maintains a number of information that is relevant to the problem at hand (Engle, Tuholski, Laughlin, and Conway, 1999). In line with this opinion, anxious subjects tend to be slow in processing information. This is due to the consideration to the reduced capacity of WM so that seeking information strategies tend to take place partially, not thoroughly (Leon, 1989). Therefore, the process of gaining information during the effort of problem-solving is incomplete. The incompleteness that occurs is not because the subject is incapable, but it is merely because the attention of the subject is limited due to the mathematics anxiety. In this study, it can be seen in Figures 3, 4, 5, and 7. In Figure 3, it appears that S1 skips sketching the chess board of size 5 × 5, 6 × 6, 7 × 7, and 8 × 8 even though S1 has been sketched chess board measuring 1 × 1, 2 × 2, 3 × 3, and 4 × 4. In Figure 4, it appears that S1 skips drawing process of a 3 × 3 chess board size, even though he has been sketched chees boards of size 1 × 1, 2 × 2, 4 × 4, 5 × 5, and 6 × 6. In Figure 5, S2 sketches a chess board that is not square and with the same color arrangement adjacent to each other (instead of alternating colors; adjacent squares have different colors), surprisingly the previous sketch made earlier, which is a 2 × 2 chess board, is square and has an alternating color arrangement. In Figure 7, S2 skips the unit square calculation on a chess board measuring 1 × 1, even though S1 calculates the number of unit squares for all other chess board sizes.

In this case, S1 and S2 experience total metacognitive blindness because they experience a red flag in each phase of problem-solving. Further research is needed to examine whether it is possible to solve the red flag that occurs on the pre-service teacher in several phases of problem-solving. Metacognitive blindness occurs when the subject is not aware of errors in the problem-solving process (Goos, 2002). This can be seen from the attitude of the subject who survives with the wrong strategy or ignores calculation errors. Other metacognitive failures are metacognitive mirage and metacognitive vandalism (Goos, 2002). Metacognitive mirage occurs when the subject feels there is an error/incongruity during the problem solving process, but actually there is no error/incongruity. In this case, the subject mistakenly leaves a useful strategy, changes the calculation that is not wrong, or rejects the correct answer. Meanwhile, the subject is said to experience vandalism if he takes destructive action to overcome the impasse. It is when the subject can change the problem by imposing an inappropriate conceptual structure to enable them to apply the knowledge that is already available in their thinking scheme. In other words, there are two possibilities for the flow of metacognitive failure experienced by the subject that leads to metacognitive destruction. First, metacognitive blindness is followed by metacognitive destruction. Second, metacognitive mirages are followed by metacognitive destruction.

5. CONCLUSIONS

Mathematics anxiety causes metacognitive blindness experienced by the pre-service teacher. This metacognitive blindness is caused by the presence of a red flag in each phase of problem-solving. The dominant type of red flag is ED. This result is very surprising because the ED that occurs actually starts from the first phase of problem-solving. Considering that the subjects are the pre-service teachers, they should have no difficulty in understanding the problem. In other words, metacognitive blindness that occurs is caused by subjects who only read the problem at first glance at the beginning of the problem-solving process and less deeply explore the meaning. Mathematics anxiety limits the pre-service teachers' ability to struggle with mathematics. Therefore, it is necessary to further study the metacognitive process in the phase of understanding the problem.

This study also finds that S1 and S2 have different problem-solving processes. S1 experiences mathematics anxiety dominant in the first factor which is the incompleteness of processing information in the first stage of understanding the problem in learning mathematics. Meanwhile, S2 experiences mathematics anxiety dominant in the second factor, namely the anxiety in facing the mathematics exam. S2 has incomplete information processing at the stage of implementing problem-solving plan. It means that the effect of mathematics anxiety on subject who has dominant anxiety in the first factor is higher than the subject who is dominant in the second factor. In other words, metacognitive blindness experienced by subject whose dominant source of anxiety originates from anxiety while learning mathematics occurs early and gradually settles down to the end of the problem- solving process. Meanwhile, metacognitive blindness that occurs in subject whose source of anxiety is dominant in anxiety during the mathematics exam only takes place in the middle of the problem-solving process.

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Conflict of interests

The authors declare no conflict of interest.

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