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To cite this article: E Widyaningsih *et al* 2018 *J. Phys.: Conf. Ser.* **983** 012117

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Analysis of critical thinking ability of VII grade students based on the mathematical anxiety level through learning cycle 7E model

E Widyaningsih^{1,*}, S B Waluya¹ and A W Kurniasih¹

¹Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

*Corresponding author: ekowidyaningsihmath@gmail.com

Abstract. This study aims to know mastery learning of students' critical thinking ability with learning cycle 7E, determine whether the critical thinking ability of the students with learning cycle 7E is better than students' critical thinking ability with expository model, and describe the students' critical thinking phases based on the mathematical anxiety level. The method is mixed method with concurrent embedded. The population is VII grade students of SMP Negeri 3 Kebumen academic year 2016/2017. Subjects are determined by purposive sampling, selected two students from each level of mathematical anxiety. Data collection techniques include test, questionnaire, interview, and documentation. Quantitative data analysis techniques include mean test, proportion test, difference test of two means, difference test of two proportions and for qualitative data used Miles and Huberman model. The results show that: (1) students' critical thinking ability with learning cycle 7E achieve mastery learning; (2) students' critical thinking ability with learning cycle 7E is better than students' critical thinking ability with expository model; (3) description of students' critical thinking phases based on the mathematical anxiety level that is the lower the mathematical anxiety level, the subjects have been able to fulfil all of the indicators of clarification, assessment, inference, and strategies phases.

1. Introduction

According to Paul and Elder [1], critical thinking is the art of analyzing and evaluating thinking with a view to improving it. According to Adeyemi [2], critical thinking involves determining the meaning and significance of what is observed or expressed, or concerning a given inference or argument, determining whether there is adequate justification to accept the conclusion as true. Paul and Elder [1] stated that a person who thinks critically is able to generate vital questions and problems and formulate them clearly and precisely.

Richardson and Suinn defined mathematical anxiety as cited by Mahmood and Khatoon [3] as a feeling of tension and anxiety that interfere with the manipulation of mathematical problems in varied situations in ordinary as well as academic life. Mathematical anxiety can cause one to forget and lose one's self-confidence. According to Wells as cited by Furner and Gonzalez-DeHass [4] had identified anxiety as a major factor in blocking students' reasoning, memory, understanding of general concepts, and appreciation for mathematics. Mathematical anxiety can lead to the avoidance of mathematics and the decline of mathematical achievement. The research mathematical anxiety had been widely practiced by many researchers like Puteh and Khalin [5] and Arpin *et al.* [6]. The research by Puteh and Khalin [5] stated that mathematical anxiety is one of the factors that affect mathematical achievement. Mathematical anxiety has a negative relationship with student achievement.

Based on the research by Arpin *et al.* [6], mathematical anxiety negatively affect the students' critical thinking ability. Therefore, students' mathematical anxiety should be considered by teachers in mathematics learning. Thus, the knowledge absorbed by students becomes not maximal. By paying



attention to mathematical anxiety, it is expected to improve the ability to think critically in solving mathematical problems and find alternative solutions how to minimize mathematical anxiety in learning.

In the process of critical thinking there are several phases. According to Jacob and Sam [7], in the process of critical thinking there are four phases, namely clarification, assessment, inference, and strategies. Based on the students' critical thinking phases, it can be known that the quality of critical thinking varies from student to the others. According to Kurniasih [8], this difference is in the form of the characteristic phases of critical thinking raised by the students in the certain level of critical thinking. According to Kurniasih [8], the level of critical thinking ability consists of level 0 (not critical), level 1 (less critical), level 2 (quite critical), and level 3 (critical). In every level of critical thinking, there are critical thinking phases. Different phases of critical thinking effect on different level of critical thinking. Because of critical thinking and mathematical anxiety are negatively related, it is necessary to know how the critical thinking phases that students are raising on a certain level of mathematical anxiety.

Mathematical anxiety and lack of students' critical thinking abilities in solving math problems become a problem for SMP Negeri 3 Kebumen. Based on the interview with mathematics teacher of SMP Negeri 3 Kebumen, Ibu Suharti, S.Pd. on Saturday, March 18, 2017, obtained informations that the critical thinking ability of the students is still not optimal and the mathematical anxiety that is still experienced by students. This problems can be known from: (1) students are rarely given non-routine exercise; (2) the mastery of VII grade students in the field of geometry is still low; (3) students are afraid if the answer is wrong; (4) students' minds become empty when math exams; and (5) students feel unsure of their abilities in mathematics.

The students' critical thinking abilities that are not yet optimal are also known in the work of a preliminary test problem on the Lines and Angles material. Giving this problem aims to measure students' early critical thinking abilities. The analysis of the students' critical thinking ability level is based on the elements of thought and intellectual standards of thought by Paul and Elder. Many students of class VII F SMP Negeri 3 Kebumen academic year 2016/2017 who worked on the problem are 27 students. The results obtained are 9 students are not critical, 8 students are less critical, 6 students are quite critical, and 4 students is critical. Based on these results, it can be concluded that the critical thinking ability of the students is not optimal.

Based on the description above, it is needed the efforts to improve the critical thinking ability. One of them is learning model that can improve students' critical thinking abilities. The model is learning cycle 7E. According to Eisenkraft [9], learning cycle 7E model consists of seven learning phases: (1) elicit, (2) engage, (3) explore, (4) explain, (5) elaborate, (6) evaluate, and (7) extend. Elicit is the phase of eliciting a prior understanding of students by providing questions that will stimulate the initial knowledge of students. Engage is the phase of focusing students' attention, generating student motivation on the concepts to taught, and engaging students in group discussion activities. Explore is the phase where students work independently in small groups and try to solve problems. In this phase, teachers provide questions and inputs and also assess students' understanding. Explain is the phase where the teacher teaches a new scientific vocabulary, the students conclude and present the findings, and the teacher gives feedback on the conclusions raised by the students. Elaborate is the phase of giving students the opportunity to apply their knowledge to solve the problems about the material that has been taught. Evaluate is the phase where the teacher assesses students' understanding of the material they have learned. Extend is the phase where the teacher guides the students to apply the knowledge gained in the new context by relating it to the next material.

Critical thinking phases in this study are critical thinking phases of Jacob and Sam [7], that is clarification, assessment, inference, and strategies. In every phase, there are some indicators. The indicator of clarification used in this study is analyses, negotiates, or discusses the scope of the problem; indicator of assessment is gathers and assesses relevant information; indicator of inference is makes generalizations from relevant results; and indicator of strategies is propose specific steps to lead to the solution. Based on those indicators, it will be made the subindicators.

The lack of students' critical thinking ability is needed to study further to know how the critical thinking of each student based on the mathematical anxiety level. This study aims to determine whether the critical thinking ability of VII grade students with learning cycle 7E model achieve mastery learning, determine whether the critical thinking ability of VII grade students with learning

cycle 7E model is better than students' critical thinking ability with expository model, and describe the students' critical thinking phases based on the mathematical anxiety level.

2. Methods

The method in this study is mix method with the model is concurrent embedded where qualitative method as primary method and quantitative method as secondary method. Qualitative method is used as primary method because in the data processing qualitative method is more widely used than quantitative method. Qualitative data is the description of the students' critical thinking phases based on the mathematical anxiety level and the quantitative data is the critical thinking ability of VII grade students with learning cycle 7E model achieve mastery learning and better than the critical thinking ability of VII grade students with expository model.

The qualitative data is analyzed using Miles and Huberman model by the interview data and critical thinking test. The quantitative design used in this study is posttest-only control design. In this design there are two groups selected randomly from a population. The research is conducted in SMP Negeri 3 Kebumen which is located at Jl. Letjend. S. Parman 3 Kebumen. The population is VII grade students of SMP Negeri 3 Kebumen academic year 2016/2017 with the samples were class VII D as control class and VII F as experimental class. Sampling is random sampling technique. Quantitative data is obtained from the final test of critical thinking ability. It will be used to test hypothesis I and hypothesis II.

Hypothesis I test is conducted to determine whether the critical thinking ability of VII grade students with learning cycle 7E model achieve mastery learning. Mastery learning in this study are individual mastery and classical mastery. Minimum learning mastery standard is 75 and classical mastery is 75%. The criteria of individual mastery test is rejecting H_0 if $t_{\text{calculation}} \geq t_{(1-\alpha)}$, $t_{(1-\alpha)}$ is obtained from Student t distribution list with $df = (n-1)$ and probability $(1-\alpha)$ [10]. The criteria of classical mastery test is rejecting H_0 if $z_{\text{calculation}} \geq z_{0.5-\alpha}$, $z_{0.5-\alpha}$ is obtained from normal distribution with probability $(0.5-\alpha)$ [10].

Hypothesis II test aims to determine whether the critical thinking ability of VII grade students with learning cycle 7E model is better than students' critical thinking ability with expository model. To test Hypothesis II, it is conducted the difference test of two means and the difference test of two proportion. The criteria of the difference of two means test is rejecting H_0 if $t_{\text{calculation}} \geq t_{(1-\alpha)}$, $t_{(1-\alpha)}$ is obtained from Student t distribution list with $df = n_1 + n_2 - 2$ and probability $(1-\alpha)$ [10]. The criteria of the difference of two proportions test is rejecting H_0 if $z_{\text{calculation}} \geq z_{0.5-\alpha}$, $z_{0.5-\alpha}$ is obtained from normal distribution with probability $(0.5-\alpha)$ [10].

To know the description of the students' critical thinking phases based on the mathematical anxiety level, determined the subjects first by using purposive sampling technique. Subjects to be selected are known first of their characteristics after being given a mathematical anxiety questionnaire. Based on the analysis of questionnaire result, two students are selected in the middle of each level of mathematical anxiety that remained between before and after learning, that is two students from low level ($X \geq 92$), two students from medium level ($58 \leq X < 92$), and two students from high level ($X < 58$) where X is scores of mathematical anxiety obtained by the students. Six subjects are interviewed to find out the characteristics of their critical thinking phases.

3. Result and Discussion

3.1. Quantitative Analysis

Analysis of preliminary data is conducted to find out whether the sample in this study come from the initial condition or not. Analysis of preliminary data is conducted on preliminary test value data of critical thinking ability of control and experimental classes through normality test, homogeneity test, and the similarity test of two means. Testing of the data is conducted by using SPSS 24.0. It shows that data come from a population that is normally distributed, homogeneous, and has the same initial ability.

Research data is final test value of critical thinking ability and will be analysed by normality test, homogeneity test, hypothesis I test, and hypothesis II test. The preliminary test of final test value by

using SPSS 24.0 shows that data of the final test value is normally distributed and homogeneous so that the hypothesis test are conducted by parametric statistics.

3.1.1. Hypothesis I Test. Individual mastery test is conducted by mean test where $\mu_0=75$. Based on the calculation result, obtained $t_{\text{calculation}}=4.63$ and based on Student t distribution list obtained $t_{\text{table}}=1.70$. Since $t_{\text{calculation}} > t_{\text{table}}$, then H_0 is rejected. Therefore, the average of students' critical thinking abilities final test result using learning cycle 7E model is more than 75.

Classical mastery test is conducted by proportion test where $\pi_0=0.75$. Based on the calculation result, obtained $z_{\text{calculation}}=2.04$ and based on the normal distribution obtained $z_{\text{table}}=1.64$. Since $z_{\text{calculation}} > z_{\text{table}}$, then H_0 is rejected. Therefore, proportion of the students who completed in the class using learning cycle 7E model is more than 75%.

Based on the result analysis of individual and classical mastery tests above, it is concluded that the critical thinking ability of VII grade students using learning cycle 7E model achieve mastery learning. This is supported by the fact in the class that Elaborate phase of learning cycle 7E model, that is the phase of giving students the opportunity to apply their knowledge to solve the problem of the material that has been studied.

In this phase, students are accustomed to solve problems according to the phases of critical thinking. The existence of such habituation leads to the critical thinking phases of experimental class students getting better. This can be known from the appearance of the indicator of students' critical thinking phase from the first meeting to the fourth meeting at the time of learning. At the first meeting, students can only generate indicators from the clarification phase. By teacher guidance, the students can generate indicators from the assessment, inference, and strategies phases in the next meetings. It affects the critical thinking test results of the experimental class students so that many students in the experimental class can reach the minimum learning mastery standard specified in the study. It results proportion of students completed in the experimental class is more than 75%. The next test is hypothesis II test. It tests by using the difference test of two means and difference test of two proportions.

3.1.2. Hypothesis II Test. The difference test of two means uses right side test. Based on the calculation result, obtained $t_{\text{calculation}}=1.73$ and based on Student t distribution list obtained $t_{\text{table}}=1.67$. Since $t_{\text{calculation}} > t_{\text{table}}$, then H_0 is rejected. Therefore, the average of students' critical thinking abilities final test result using learning cycle 7E model is more than the average of students' critical thinking abilities final test result using expository model.

The difference test of two proportion uses right side test. Based on the calculation result, obtained $z_{\text{calculation}}=1.99$ and based on the normal distribution obtained $z_{\text{table}}=1.64$. Since $z_{\text{calculation}} > z_{\text{table}}$, then H_0 is rejected. Therefore, proportion of the students who completed in the class using learning cycle 7E model is more than proportion of the students who completed in the class using expository model.

Based on the tests of hypothesis II, it is concluded that the critical thinking ability of VII grade students using learning cycle 7E model is better than critical thinking ability of VII grade students using expository model. This is supported by the fact in the class that is: learning activity in the experimental class using the 7E learning cycle model is conducted by individual and group learning activities, and also learning together in the classroom so that the students who cannot learn individually can ask their friends when group discussion. If there is no solution in the group discussion then the students can discuss in a class during the presentation. It differs from the control class whose learning uses an expository model in which learning activity is more focused on the teacher as the informant (lesson material).

In addition, learning activities in the experimental class is begun by viewing motivational video, discussing, presenting, listening and responding to group presentations, noting what has been learned, and working on the quiz at the end of the lesson. The activities in the control class begins by viewing motivational videos, listening to teacher explanations about materials and sample questions, working on questions, and working on quizzes. Since they have obtained different learning variation than usual, then the students of the experimental class look more enthusiastic. Meanwhile, students' enthusiasm in the control class is less satisfactory when compared to the control class because the learning model they used is as same as they usually received. Due to the lack of enthusiasm, students

become less likely to notice when their friend write and explain the answers. Students of experimental class discuss actively so that classroom atmosphere also tend to be crowded, while control class students even though they do not do group discussion but they tend to be rowdy and difficult to set up so that their focus in following learning is not maximal. It also affects critical thinking test results because critical thinking problems require more attention and focus.

The result of this study are in accordance with the results of research [11] that applying of learning cycle 7E model is more effective in improving the mastery of concept and critical thinking skills of students than applying of conventional learning model. In addition, the results of this study also in accordance with research [12] that students' critical thinking ability with learning cycle 7E model exceeds the determined classical mastery. Classical mastery obtained is 79%, while the classical mastery determined is 75%.

3.2. Qualitative Analysis

3.2.1. Grouping Mathematical Anxiety Level. The results of mathematical anxiety questionnaires before and after learning are analyzed and grouped according to their level in Table 1. For mathematical anxiety questionnaire after learning, interviews are conducted before the students are grouped.

Table 1. Grouping of mathematical anxiety level

Level	Many Students		
	Before	After	Fixed
High	5	5	4
Medium	20	18	16
Low	7	9	6

3.2.2. Grouping Critical Thinking Ability Level. The result of written test of critical thinking is analyzed based on the appropriateness of students' answers with the rubric of critical thinking ability level according to [8] to obtain the grouping of critical thinking ability level in Table 2.

Table 2. Grouping of critical thinking ability

Level	Many Students
Level 0	1
Level 1	8
Level 2	17
Level 3	6

3.2.3. Determining Subjects. Based on the fixed level of mathematical anxiety before and after learning, selected two students at each mathematical anxiety level (high, medium, and low) whose position is at the mid of the mathematical anxiety level so that obtained six subjects as in the Table 3.

Table 3. List of research subjects

Student Code	Subject	Mathematical Anxiety Level	Critical Thinking Ability Level
E-05	S-01	Low	Level 3
E-21	S-02	Low	Level 3
E-02	S-03	Medium	Level 2+
E-25	S-04	Medium	Level 3
E-07	S-05	High	Level 1
E-10	S-06	High	Level 2

Note: Level 2+ is the level where the students' critical thinking ability reach level 2 but not reach level 3

3.2.4. Description of Critical Thinking Phases Based on The Mathematical Anxiety Level

3.2.4.1. *Clarification.* At the clarification phase, subjects at the low and medium mathematical anxiety level whose positions are critical thinking ability level 2+ (tend to critical) and level 3 (critical) have the same characteristics that is have been able to mention the known information on the problem, have been able to mention the asked information on the problem, and have been able to mention the other related information. Therefore, both of subjects at the low and medium mathematical anxiety level have been able to fulfil three subindicators of clarification phase.

Subjects at the high mathematical anxiety level whose positions are at critical thinking ability level 1 (less critical) and level 2 (quite critical) show the same characteristics that is have been able to mention the known information on the problem and have been able to mention the asked information on the problem. The difference of both subjects as on the third subindicator that is mention the other related information on the problem. Subject at level 1 (less critical) have not been able to mention the other related information on the problem, meanwhile subject at level 2 (quite critical) have been able to mention the other related information on the problem. Therefore, the lower the mathematical anxiety level, subjects have been able to mention the known information on the problem, have been able to mention the asked information on the problem, and have been able to mention the other related information.

At the clarification phase, subjects understand the problem. Teachers shall invite students to participate in finishing the task. At this phase, students have participated in finishing the problem by raising subindicators clarification phase, that is mention the known information on the problem, mention the asked information on the problem, and mention the other related information.

3.2.4.2. *Assessment.* At the assessment, subjects at the low mathematical anxiety level whose positions are at critical thinking ability level 3 have the same characteristics that is have been able to mention the concepts and ideas to solve the problem, have been able to connect the information on the problem with concepts and ideas to solve the problem, and have been able to assess the information made. Therefore, both of subjects at the low mathematical anxiety level have been able to fulfil three indicators of assessment phase.

Subject at the medium mathematical anxiety level whose positions is at the critical thinking ability level 2+ have characteristics tend to able to mention the concepts and ideas to solve the problem, tend to able to connect the information on the problem with concepts and ideas to solve the problem, and tend to able to assess the information made. While subject at the medium mathematical anxiety level whose positions are at level 3 showed the same characteristics with the subject at the low mathematical anxiety level.

Subject at the high mathematical anxiety level whose positions are at the critical thinking ability level 1 and level 2 show the same characteristics that is tend to able to mention the concepts and ideas to solve the problem. The difference of both subjects are at the second and the third subindicators. Subject at level 1 have not been able to connect the information on the problem with concepts and ideas to solve the problem, while subject at level 2 is tend to able to connect the information on the problem with concepts and ideas to solve the problem. In addition, subject at level 1 have not been able to assess the information made, while subject at level 2 is tend to able to assess the information made.

Based on that explanation, the lower the mathematical anxiety level, subjects have been able to mention the concepts and ideas to solve the problem, able to connect the information on the problem with concepts and ideas to solve the problem, and able to assess the information made. Furthermore, it is found out that the higher the critical thinking ability level, subjects have been able to mention the concepts and ideas to solve the problem, able to connect the information on the problem with concepts and ideas to solve the problem, and able to assess the information made.

Subindicators of assessment phase consist of mention the concepts and ideas to solve the problem, connect the information on the problem with concepts and ideas to solve the problem, and assess the information made. They correspond to Piaget's learning view that stated that when the students have reached formal operation phase he is able to devise a plan for problem solving and systematically examine the solution. The plan in this case can be the discovery of concepts and ideas to solve

problems, relate information on the problem with concepts and ideas to solve problems, and assess the information made.

Assessment phase can be grown by inviting students to give instructions or keywords, in this case the teacher lures students so that students can come up with concepts and ideas to solve problems. According to Bikmaz et al. [13], when students contribute their ideas on a topic or skill, teachers can add their ideas to guide the discussion. If the students' understanding is inappropriate or partially inappropriate, the teacher can revise it and provide an explanation based on what the student has gained during the discussion.

3.2.4.3. Inference. At the inference phase, subjects at the low and medium mathematical anxiety level whose positions are at critical thinking ability level 2+ and level 3 showed the same characteristics that is have been able to mention where concepts and ideas came to solve the problem, have been able to recognize the relationship, and have been able to mention the sequence of problem solving steps. Therefore, both of subjects at the low and medium mathematical anxiety level have been able to fulfil three subindicators of inference phase. Subjects at the high mathematical anxiety level whose positions are at critical thinking ability level 1 and level 2 show the same characteristics that is have been able to mention where concepts and ideas came to solve the problem. At level 1, subject do not recognize the relationship, while at level 2, subject have not been able to recognize the relationship. In addition, subject at the level 1 is not able to mention the sequence of problem solving steps, while subject at level 2 is tend to able to mention the sequence of problem solving steps. Based on that explanation, the lower the mathematical anxiety level, subjects have been able to mention where concepts and ideas come to solve the problem, have been able to recognize the relationship, and have been able to mention the sequence of problem solving steps coherently.

Students can be trained to fulfil the characteristics of inference phase by verification and clarification techniques of students' understandings. According to Kurniasih [13], after students gain experience on new knowledge, teachers need to assess students' understanding with sustainable and provide feedback. When students' sense of comprehension can be reasonably accepted, the teacher verifies it. But if the students' understanding is wrong, the teacher clarifies.

In this study, when the students try to mention where the concepts and idea came to solve the problem, recognize the relationship, and mention the sequence of problem solving steps coherently, the teacher confirms whether the student's opinion is true or false. It means that students learn to find concepts in order to gain meaningful learning. The students connect the information on the problem with the concepts they know so that they can determine the appropriate steps to solve the problem. Thus, it can be meaningful learning process.

3.2.4.4. Strategies. At the strategies, subject at the low mathematical anxiety level whose positions are at the critical thinking ability level 3 have the same characteristics that is explain the solution of the problem in a coherent and correct way based on the steps mentioned. Thus, both of subjects at the low mathematical anxiety level have been able to fulfil the subindicators of strategies phase.

Subject at the medium mathematical anxiety level whose positions are at level 2+ show the same character that is tend to able to explain the solution of the problem in a coherent and correct way based on the steps mentioned. Subject at level 3 show the same characteristics with subject at the the low mathematical anxiety level.

Subject at the high mathematical anxiety level whose positions are at the level 1 show the characteristic that is have not been able to explain the solution of the problem in a coherent and correct way based on the steps mentioned, while subject at level 2 show the characteristic tend to able to explain the solution of the problem in a coherent and correct way based on the steps mentioned. Based on that explanation, the lower the mathematical anxiety level, subjects have been able to explain the solution of the problem in a coherent and correct way based on the steps mentioned. Furthermore, it is found out that the higher the critical thinking ability level, subjects have been able to explain the solution of the problem in a coherent and correct way based on the steps mentioned.

Students' strategies phase can be trained by inviting students' participation technique. According to Kurniasih [13], teachers should invite students to participate in finishing the task. Students can participate by arguing or coming forward to contribute their ideas on the board. In this study, student

involvement in solving the problem occurred at the elaborate phase. Students discuss problem to solve it, argue in the group, then there are representatives of group to present the answer.

These results show that at the low mathematical anxiety level subjects are at the critical thinking ability level 3, at the medium mathematical anxiety level subjects were at the level 3 and level 2+, and at the high mathematical anxiety level subjects were at the level 1 and level 1. These result corresponds to the research of Arpin *et al.* [6] that stated the higher the mathematical anxiety level then the lower the critical thinking ability level.

4. Conclusion

Based on the results analysis of critical thinking ability of VII grade students based on the mathematical anxiety level through learning cycle 7E model, obtained the conclusions as follows: (1) critical thinking ability of VII grade students with learning cycle 7E model achieved mastery learning; (2) critical thinking ability of VII grade students with learning cycle 7E model was better than students' critical thinking ability with expository model; (3) description of the students' critical thinking phases based on the level of mathematical anxiety that is at the clarification phase subject at the high, medium, and low mathematical anxiety level had been able to mention the known information on the problem and had been able to mention the asked information on the problem. The lower the mathematical anxiety level, subjects had been able to mention the other related information.

At the assessment phase, the lower the mathematical anxiety level, subjects had been able to mention the concepts and ideas to solve the problem, had been able to connect the information on the problem with concepts and ideas to solve the problem, and had been able to assess the information made. At the inference phase, subjects are at the low, medium, and high mathematical anxiety level had been able to mention the concepts and ideas to solve the problem. The lower the mathematical anxiety level, subjects had been able to connect the information on the problem with concepts and ideas to solve the problem and also had been able to assess the information made. At the strategies phase, the lower the mathematical anxiety level, subjects had been able to explain the solution of the problem in a coherent and correct way based on the steps mentioned.

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