Artikel 3

by Novi Prayekti

CRITICAL THINKING ABILITY OF HIGH SCHOOL STUDENTS IN SOLVING A QUADRATIC EQUATION PROBLEM

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ABSTRACT: This study aims to describe the categories of critical thinking skills of high school students in solving quadratic equation problems. The data in this study are the results of student work related to tests of critical thinking skills and the results of researchers' interviews with students. Data analysis will be carried out after giving the action and all data collected. Data analysis techniques in this study include data reduction activities, data presentation, and drawing conclusions and verification. The results of the critical thinking category show that there are three levels in critical thinking, namely students with "critical" levels of thinking, students with "less critical" levels of thinking, and students with "uncritical" levels of thinking.

KEYWORDS: Students' Ability, Critical Thinking, Quadratic Equations

INTRODUCTION

The quadratic equation is one of the material in mathematics that has been taught starting in junior high school and is often unwittingly used in everyday life. Activities or movements of objects which have a parabolic trajectory can be calculated every movement with accurate results using quadratic equations. Also, many problems that arise in everyday life can be solved by quadratic equations. Quadratic equation material is important because it makes it possible to establish relationships between various other mathematical material such as linear equations, functions, and polynomials (Sağlam & Alacacı, 2012). According to the research of Didis & Erbas (2011), the material of quadratic equations plays a very important role in helping students think mathematically in preparing the steps of problem-solving related to quadratic equations. According to Lithner (2008), teachers need to design learning and teaching environments that can actively promote mathematical thinking by focusing on reasoning on rote learning and algorithmic reasoning.

Quadratic equations have become a fundamental topic, not only in the mathematics curriculum in secondary schools but also in the development of algebra. According to Katz & Barton (2007), various approaches to solving quadratic equations are used at different stages including; through representations including arithmetic or numerical, algebraic or symbolic, and visual or geometric. Equation squares are representations used in the disciplines of science others, such as physics, engineering, and design, because of its usefulness in completing various types of problems and is useful for modeling realistic or real-life situations (Sağlam & Alacacı, 2012). Vaiyavutjamai & Clement (2006) argues that very little attention is given to the material in quadratic equations in the mathematics education literature, and also that few do research on teaching and learning on quadratic equation material. Most of the students think that the quadratic equation can create challenges in a variety of ways completion Kotsopoulos, 2007). Allaire & Bradley (2001); Bosse & Nandakumar (2005) stated that teachers should be aware that solving the quadratic equation is not only based on the procedures and rules but trying to find alternative ways of teaching right quadratic equation. Also, students must be allowed to explore various situations in which they are asked to construct, interpret, and then solve quadratic equations.

Slameto (2003) states that in solving problems, a person will use knowledge concepts, and rules that he had before. Duron, et al. (2006) define, critical thinking as the ability to analyze and make evaluations of information. Krulik, & Milou (2003) defines critical thinking as the ability to analyze problems, examine the completeness of data to solve problems, decide whether there is additional information in the problem and analyze the situation. Ennis (1993) defines think critically is reflective thinking that is logical concerning the decision about what people believe and do. Some of these opinions indicate that critical thinking is always associated with judgments that are used as reference material in deciding to solve a problem. This is as stated by Kondalkar (2007), stating that ability is the capacity of students to do or solve a particular problem. The ability to think critically can be determined through aspects that exist in critical thinking, namely; identifying problems, finding solutions, giving reasons, checking again, and making conclusions (Fisher, 2009). Some researchers who are interested in critical thinking skills include Landsman & Gorski (2007) showing that critical thinking skills receive less attention from teachers and students, according to Lundquist (1999); Rippen, et al, (2002),

states that students who are not mastered in compiling or giving reasons and problem-solving steps will have an impact having difficulty in developing critical thinking skills.

Research conducted by Perkin & Murphy (2006) and Jacob & Sam (2008) have not explained the occurrence of students' thinking processes in solving problems and also have not linked the criteria of critical thinking. This research is a quantitative study and emphasizes the percentage of research subjects that fall into aspects of clarification, assessment, inference, and strategy. In this study aspects of critical thinking skills using Fisher (2009), namely aspects of identifying problems, finding solutions, giving reasons, checking back, and making conclusions. First, the aspect of identifying problems is an attempt to gain insight into information related to what is known and asked for the problem at hand. Second, the aspect of finding a solution is an effort to dig up information that is relevant to the problem and can also determine ideas/ways to resolve the problem at hand. Third, the aspect of giving reasons is an effort to give logical reasons and then solve the problem at hand. Fourth, the aspect of re-checking is an effort to evaluate the steps in the settlement that has been done. Fifth, the aspect of concluding is an attempt to get a conclusion after going through a previous evaluation.

Some examples of problems of quadratic equations fall within the criteria of the problem of "critical" thinking and "uncritical". Examples of quadratic equations problem that include non-critical problems are: (1) it is known that $x \in R$ and $x \in R$, determine x!, and (2) Suppose that $x^2 - 2x + a = 0$ the quadratic equation has roots x_1 and x_2, determine a. Meanwhile, the problem of quadratic equations that leads to "critical" thinking is: (1) it is known that p is a prime number and the two roots of the equation $x^2 + px - 6p = 0$ are integers. Determine p, and (2) find all integers x such that $x^4 + 6x^3 + 11x^2 + 3x + 31$ are perfect squares.

Based on the explanation above related to the importance of critical thinking, research needs to be done to determine the category of critical thinking skills of high school students in solving quadratic equation problems. This research was conducted to describe the problems of:

- How high school students solve the quadratic equation problems?
- What categorizes of critical thinking skills of high school students in solving quadratic equation problems?

METHODOLOGY

Based on the research objectives, this study uses a qualitative approach to the type of exploratory research. Creswell (2004) suggests that qualitative research is research that aims to explore problems and develop a detailed and in-depth understanding of the source of the problem.

The respondents in this study were 84 students of Class X Science 1 of SMA Negeri 9 Malang. While the process of selecting research subjects begins with the provision of 3 problem-solving problems with quadratic equation material that aims to group students/research respondents based on low, medium, and high mathematical abilities. Interviews were then conducted to find out whether prospective subjects could communicate well or not. Furthermore, 2 students were selected as research subjects for each group based on low, medium, and high mathematical abilities. Student work outcomes are corrected based on questions that can be solved.

Furthermore, research subjects that have been categorized according to their mathematical abilities and communication abilities are asked to solve two quadratic equation questions and take part in an interview session to reveal more about critical thinking skills.

There are two types of research instruments used in this study, namely the researcher as the main instrument, the questions of critical thinking ability tests as an assistive instrument consisting of the Initial Ability Test (TKA), and the Critical Thinking Ability Test and Interview guidelines as supporting instruments. Data obtained from the Preliminary Ability Test and Critical Thinking Ability Test are collected and thereafter analyzed. Data analysis techniques examine the work results of the low, medium, and high ability students and interview transcripts were examined to obtain important data that lead to indicators of critical thinking skills in table 1, through the stages of data reduction, data exposure, and verification, and conclusions.

The critical thinking ability test questions consist of three questions of quadratic equations, and are shown in the following figure 1:

Resolve the following problems:
1. Suppose k is a real number so $\sqrt{x-3} + \sqrt{6-x} \geq k$ it has a solution. Determine the maximum value of k!
2. It is known that p is a prime number and the roots of $x^2 + px - 6p = 0$ is an integer. Determine p!
3. Let p of odd prime numbers and k positive integers so $\sqrt{k^2 - pk}$ be positive integers. Determine the value of k!

Figure 1. The Problems Used in Students' Critical Thinking Skills Test

Table 1.   Categories ofStudents' Critical Thinking Abilities

Category of Critical Thinking Ability	Characteristics of Critical Thinking
Critical	1. Identify problems by writing down things that are known and asked in full. 2. Find a solution by writing down the steps to solve the problem proposed in full. 3. Give a reason to be able to write down the completion steps with an explanation to support the settlement process and the right conclusion. 4. Re-check by showing that the solution obtained meets the problem raised. 5. Make conclusions by determining the solution based on the correct completion steps.
Critical enough	1. Identify problems by writing down things that are known and asked in full. 2. Few find solutions, so describe the problem solving with less precise. 3. Give the right reasons by writing down the completion steps accompanied by an explanation. 4. Check back a little, so that it gives a less thorough settlement. 5. Has not been able to make conclusions based on the correct completion steps.
Less critical	1. Identify problems by writing down things that are known and asked in full. 2. Unable to find a solution, so unable to solve the proposed problem. 3. Not giving the right reasons to support the process of settlement and the right conclusion. 4. Not able to double check whether the solution obtained meets the problem raised. 5. Has not been able to make conclusions based on the correct completion steps.
Uncritical	1. Not able to identify the problem 2. Did not find a solution so unable to solve the problem at hand. 3. Not giving the right reasons to support the settlement process and the right conclusion. 4. Not re-checking appropriately for information obtained in support of making complete and accurate conclusions. 5. Not able to make precise conclusions based on correct steps of completion s.

After working on a critical thinking ability test and following an interview session, the data obtained is collected, reduced, verified and concluded. Furthermore, to verify the data and test the credibility of the study

triangulation techniques were used by comparing the results of written tests and interview results. Based on the stages of reduction, and verification conclusions will be submitted based on the tendency of low critical thinking skills (SKR), sufficient critical thinking (SKC) and high critical thinking (SKT).

RESULTS

Through the results of tests of critical thinking skills and the way they are conducted, it is expected to be able to describe students' critical thinking skills in completing mathematics related to the material of quadratic equations. To better understand the process of analysis, the researcher will present the results of the subject's work, interview the researcher with the subject and continue the analysis of critical thinking skills in solving mathematical problems.

1. **Low Critical Thinking (SKR) Subjects**

   The results of the work of low-ability students (SKR) when solve the problems no 1 are as following figure 2:

Problem 1 Suppose k is a real number so $\sqrt{x-3}+\sqrt{6-x} \geq k$ it has a solution. Determine the maximum value of k!

Answer:

$$\left(\sqrt{x-3}+\sqrt{6-x}\right)^2 \geq K^2$$
$$(\sqrt{x-3})^2 + 2(\sqrt{x-3})\cdot(\sqrt{6-x}) + (\sqrt{6-x})^2 \geq K^2$$
$$x-3 + 2\cdot\sqrt{x-3}\cdot\sqrt{6-x} + 6-x \geq K^2$$
$$(x-3 + 6-x) \geq K^2$$

Jadi, nilai maksimum dari K ialah $\sqrt{6}$

Figure 2. Figure of SKR's Written Answer in Problem 1.

Based on the results of the analysis of student work on problem 1 (figure 2) and the results of interviews that have been conducted it can be concluded that SKR: (1) able to identify problems, (2) not able to find solutions, (3) have not been able to give reasons, (4) have not been able to check back, and (5) made a wrong conclusion.

Based SKR answer of question number 2 written on the settlement sheet as we can see in figure 3, and it shows that SKR has not been able to find solutions that link the quadratic equation $x^2 + px - 6p = 0$ that has two roots integers and use of p primes. Based on the results of student work analysis on problem 2 it can be concluded that SKR: (1) has not been able to identify the problem, (2) has not been able to find a solution, (3) unable to give a reason, (4) unable to check again, and (5) make wrong conclusions.

Problem 2 It is known that p is a prime number and the roots of $x^2 + px - 6p = 0$ is an integer. Determine p!

.Answer:

$$x^2 + px - 6p = 0$$
$$3^2 + p(3) - 6p = 0$$
$$9 + 3p - 6p = 0$$

Jadi nilai $p = 3$.

Figure 3. Figure of SKR's Written Answer in Problem 2.

SKR answer of question number 3 written on the settlement sheet as we can see in figure 4. Based on the results of the analysis of student work on problem it can be concluded that SKR: (1) has not been able to identify the problem, (2) has been able to find a solution, (3) has not been able to give a reason, (4) unable to check again, and (5) has not made conclusion.

Problem 3 Let p of odd prime numbers and k positive integers so $\sqrt{k^2 - pk}$ be positive integers. Determine the value of k!

Answer:

Figure 4. Figure of SKR's Written Answer in Problem 3.

2. Medium Critical Thinking (SKC) Subject

The results of the work of moderately capable students (SKC) are as following figure 5:

Problem 1 Suppose k is a real number so $\sqrt{x-3} + \sqrt{6-x} \geq k$ it has a solution. Determine the maximum value of k!

Answer:

Figure 5. Figure of SKC's Written Answer in Problem 1.

Based on the results of the analysis of student work on problem 1 it can be concluded that SBS: (1) able to identify problems, (2) able to find solutions, (3) unable to provide reasons, (4) not able to check again, and (5) not able to make conclusion.
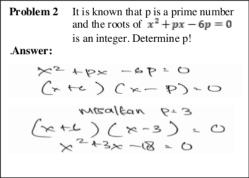
Problem 2 It is known that p is a prime number and the roots of $x^2 + px - 6p = 0$ is an integer. Determine p!

.Answer:

Figure 6. Figure of SKC's Written Answer in Problem 2.

Based on the results of the analysis of student work on problem 2 (figure 6) it can be concluded that SKC : (1) able to identify problems, (2) have not been able to find a solution, (3) have not been able to give a reason, (4) unable to check again, and (5) not able to make conclusions.

Problem 3 Let p of odd prime numbers and k positive integers so $\sqrt{k^2 - pk}$ be positive integers. Determine the value of k!

Answer:

Figure 7. Figure of SKC's Written Answer in Problem 3

Based on the results of the analysis of student work on problem 3 (see figure 7). it can be concluded that SBK : (1) able to identify problems, (2) able to find solutions, (3) able to give reasons, (4) able to re-examine, and (5) unable to make conclusions .

3. High Critical Thinking (SKT) Subjects

The results of the work of moderately capable students (SKT) can be illustrated in the following figure 8:

Problem 1 Suppose k is a real number so $\sqrt{x-3} + \sqrt{6-x} \geq k$ it has a solution. Determine the maximum value of k!

Answer:

Figure 8.   Figure of SKT's Written Answer in Problem 1

Based on the results of the analysis of student work on problem 1 (see figure 8) it can be concluded that SBT: (1) able to identify problems, (2) able to find solutions, (3) able to provide reasons, (4) have not been able to check again, and (5) able to make conclusions

Based on the results of the analysis of student work on problem 2 (see figure 9) it can be concluded that SBT: (1) able to identify problems, (2) able to find solutions, (3) able to provide reasons, (4) able to re-examine, and (5) able to make conclusions, but not careful
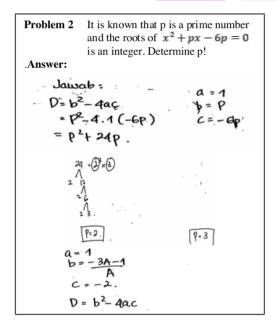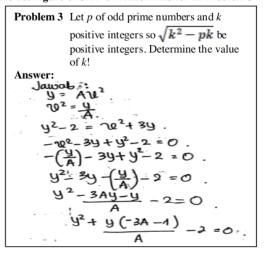
Problem 2 It is known that p is a prime number and the roots of $x^2 + px - 6p = 0$ is an integer. Determine p!

.Answer:

Figure 9. gambar hasil kerja SKT pada soal 1

Figure 10. Figure of SKT's Written Answer in Problem 3

Problem 3 Let p of odd prime numbers and k positive integers so $\sqrt{k^2 - pk}$ be positive integers. Determine the value of k!

Answer:

Based on the results of the analysis of student work on problem 3 (see figure 10), it can be concluded that SBT: (1) able to identify problems, (2) able to find solutions, (3) able to give reasons, (4) have not been able to check again, and (5) able to make conclusions.

DISSCUSSION
Students' Low Ctitical thinking Ability
    Based on the results of the analysis of student work, it can be concluded that low-ability students have not been able to identify problems, because it is incomplete in writing things that are known. The inability of low-ability students to find the right solution results in not being able to give the right reasons and check back to support making conclusions from the problems they face. So, since the fifth aspect of critical thinking is to identify problems, find solutions, giving reasons, recheck and make a conclusion is not met, then the low-ability students are categorized on the level of thinking that is not critical.

Students' Medium Ctitical thinking Ability
This student has been able to identify problems including things that are known and asked, find solutions and give reasons, but have not been able to check back and make conclusions based on the exact steps of solving the problem of quadratic equations faced for problems 1, 2 and 3.

Students' High Ctitical thinking Ability

This student has been able to identify problems including things that are known and asked, determine solutions and provide reasons, be able to check back and make conclusions based on appropriate steps of solving the problem of quadratic equations faced for problems 1, 2 and 3.

CONCLUSION

Based on data analysis and discussion of high school students' critical thinking skills in solving the quadratic equation problem, the following conclusions are obtained; First, the ability to think critically low ability students in solving problems of quadratic equations is categorized as not critical, because the five aspects of critical thinking are not met. It is shown that students in this category: (1) have not been able to identify problems because they are incomplete in writing things that are known, (2) have not been able to find a solution, because they make mistakes in squaring or factoring quadratic equations, (3) not giving reasons , because only writing down the completion steps without any explanation (4) is not able to re-check whether the solution obtained meets the proposed problem, and (5) makes a wrong conclusion, because it makes a conclusion based on the wrong completion steps. Secondly, the ability to think critically capable students in solving problems of quadratic equations is categorized quite critical, because it fulfills three aspects of a total of five aspects of critical thinking. It is shown that students of this category: (1) able to identify problems, by writing things that are known and those that are asked in full, (2) able to find a solution, by writing down the steps to solve the problem proposed in full, (3) being able to give reasons, being able to write the steps of completion accompanied by an explanation, (4) not being able to check again, because it is incomplete in writing whether the solution obtained meets the proposed problem, and (5) makes a wrong conclusion, because it makes a conclusion based on wrong settlement steps. Third, the critical thinking ability of students with high ability in solving quadratic equation problems is categorized as critical, because all five aspects of critical thinking are fulfilled. It is shown that students in this category: (1) are able to identify problems, by writing things that are known and asked in full, (2) able to find solutions, by writing down the steps to solve problems proposed in full, (3) able to give reason, can write down steps to resolve with the explanation, (4) able to check indicates that the solution obtained meet the problems posed, and (5) be able to make a conclusion, by determining solutions based measurement correct.

ACKNOWLEDGMENTS

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