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Analysis of Critical Thinking Level of Students in Surrounding and Area of Circle Based on Elder and Paul's Critical Thinking Theory in View Of Students' Mathematical Ability

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ABSTRACT

Purpose of the study: The purpose of this research is to find out how the level of critical thinking according to theory can be achieved by students with low, moderete, and high mathematical abilities in solving mathematical problems regarding the circumference and area of a circle and how the characteristics of the level of critical thinking can be achieved by students.

Methodology: The type of research used in this research is qualitative research. The subjects in this study were students in class VIII A and VIII I of SMP Negeri 9 Surakarta, which consisted of six students. The sampling technique in this study used a purposive sampling technique. The instruments used in this research are interview sheets and test instruments. Qualitative data analysis techniques in this study used the Miles and Huberman method which included data collection, data reduction, data presentation, and drawing conclusions.

Main Findings: the level of critical thinking that can be achieved by research subjects with low mathematical abilities is critical thinking level 1 with characteristics of low mathematical ability in solving mathematical problems on the circumference and area of a circle. Furthermore, the level of critical thinking that can be achieved by research subjects with moderate mathematical abilities is critical thinking level 2. The level of critical thinking that can be achieved by research subjects with high mathematical abilities is critical thinking level 3.

Novelty/Originality of this study: The results of this study can provide information and input to teachers so that teachers begin to pay attention to the level of critical thinking and the characteristics of the level of critical thinking of their students in the preparation of mathematics learning models in class, especially on the circumference and area of circles. Students with a low level of critical thinking certainly need more attention in learning activities.

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1. INTRODUCTION

One of the characteristics of mathematics is mathematics as a science with an abstract object of study [1]. Abstract is defined as something that is intangible. Something abstract is intangible in concrete or real form, it can only be imagined in the mind [2], [3]. Abstract objects of study of mathematics are often referred to as mental objects and are not concrete in nature so that mathematics is one of the subjects in formal schools which is difficult to teach and understand.

Geometry is a part of school mathematics [4]–[6]. Some of the geometry topics taught in schools include line equations, plane shapes, and geometric shapes. On the subject of flat shapes there are several sub-topics including triangles, squares, rectangles, parallelograms, trapezoids, rhombuses, and circles [7], [8]. Circles are material that is difficult for students to understand because there are many new definitions that have never been obtained while studying in elementary school. In accordance with the curriculum guidelines in junior high schools, circles are taught to students of class VIII junior high school even semester. The problem that teachers often encounter in teaching circles is students' difficulties in understanding definitions such as wedges, sections, and chords [9]. Students need to develop their thinking skills to understand the definition of each of the existing circle elements.

Reasoning is a thought process to gain knowledge [10]–[12]. To obtain correct knowledge, conclusions must be drawn correctly or follow a certain pattern. This way of drawing conclusions is called logic. In doing reasoning one must use rational to obtain correct and logical knowledge, so that reasoning is often referred to as the ability to think logically. Reasoning in mathematics is divided into inductive reasoning and deductive reasoning. Inductive reasoning requires observation and experimentation to obtain facts that can be used as a basis for argumentation [13]. To avoid the limitations of inductive reasoning, the deductive method is used by drawing conclusions which are logical consequences of previously known facts. Without reasoning it will be difficult to understand abstract mathematical concepts, let alone solve mathematical problems. In solving mathematical problems, students often have difficulty determining initial ideas for work because they cannot understand mathematical concepts properly. Students have not been able to look for relationships and link existing concepts to develop completion steps. Students need skills in working on questions such as critical thinking to determine work ideas [14]–[16]. Reasoning (the ability to think logically) is a means for students to think critically, where students solve problems in a structured manner and make decisions rationally.

Views about critical thinking skills began to emerge [17]–[19]. The ability to think critically implies readiness in making considerate decisions [20], [21]. In the critical thinking level, intellectual standard of reasoning and reasoning elements can be used to measure the level of someone's critical thinking ability. The intellectual standards for reasoning used are clarity, accuracy, thoroughness, relevance, logic, depth, and breadth. The reasoning elements used are information, concepts and ideas, inferences, and points of view. The advantage of Elder and Paul's critical thinking theory compared to other critical thinking theories is that it adds an assessment of the breadth of meaning and depth of critical thinking. Elder and Paul's critical thinking theory is appropriate to use to assess the level of critical thinking of junior high school students because the determination of students' critical thinking level is determined in more detail in terms of clarity, accuracy, logic, depth, and thoroughness in the use of concepts and ideas, the breadth of viewpoints on mathematical problems faced, as well as clarity and logic in the conclusion of the solutions given.

Based on the author's observations of teaching and learning activities in several grades VIII at SMP N 9 Surakarta and also information from teaching teachers, most students only imitate what the teacher does in answering questions. When the teacher gives questions to students in the form of application questions that are different from the practice questions in the book, students often find it difficult. Students find it difficult to determine how to solve the problem. Students who are asked to work on problems tend to only see and follow their friends who are considered smart and wait for the teacher's discussion. Most students can only work on questions that have been discussed by the teacher. Students' ability to solve math problems is called students' mathematical abilities. Mathematical ability can be divided into three categories, namely low, medium, and high. The researcher suspects that low math skills are due to low students' critical thinking skills. This certainly has an impact that is not good for the learning process in the classroom.

The purpose of this research is to find out how the level of critical thinking according to theory can be achieved by students with low mathematical abilities in solving mathematical problems regarding the circumference and area of a circle and how the characteristics of the level of critical thinking can be achieved by students. To find out how the level of critical thinking according to theory can be achieved by students with moderate mathematical abilities in solving mathematical problems regarding the circumference and area of a circle and how the characteristics of the level of critical thinking can be achieved by students. To find out how the level of critical thinking according to theory can be achieved by students with high mathematical abilities in solving mathematical problems regarding the circumference and area of a circle and how the characteristics of the level of critical thinking can be achieved by students.

2. RESEARCH METHOD

This study used descriptive qualitative method. The subjects in this study were students in class A and B of junior high school, which consisted of six students. In qualitative research, the determination of research subjects does not use random samples but uses purposive sampling, namely determining the sample with certain considerations that are deemed to be able to provide maximum data. Researchers and teachers know that students in class A and B have students with heterogeneous mathematical abilities, so they are very suitable as research subjects. The researchers' considerations in selecting subjects included the researcher considering that the subject had sufficient experience in learning mathematics and was proficient in communicating. The instruments used in this research are interview sheets and test instruments. The qualitative data analysis technique in this study adopted from Milles and Huberman which included data collection, data reduction, data presentation, and drawing conclusions [22].

3. RESULTS AND DISCUSSION

Based on the research that has been done, information is obtained about the subject's level of critical thinking on the circumference and area of a circle. The discussion of the results of this study is presented with the following description.

3.1. Characteristics of Critical Thinking Level Data Analysis of Test Results

Table 1. Data Analysis of Subject 2 and Subject 4 Interview Results

Subject 2	Subject 4
Subject 2 can convey what is known and asked in question number one, but the information provided is still inaccurate, inaccurate, and irrelevant. This is indicated by stating the PQRS side as known information, whereas in the problem the PQRS side is not known. Subject 2 stated the sides of the ABCD square as the thing being asked in the problem while what was asked in question number one was only the area of the ABCD square. Subject 2 has not been able to solve question number 1 with the right steps. There was an error in subject 2's solution, where subject 2 considered the side ABCD to be the same as the diameter of the circle (subject 2 did not understand the concept of circle diameter). Subject 2's solution to number one uses imprecise, imprecise, and irrelevant concepts. Subject 2's perspective on question number one is unclear and limited. The conclusion given by subject 2 is unclear and illogical.	Subject 4 can convey what is known and asked from question number one, but the information provided is inaccurate and inaccurate because the sides of the ABCD square are not asked. Subject 4 was confused when asked the researcher's question, it was seen that subject 4 still did not really understand the concept of the radius of a circle, so that in explaining step number one, subject 4 used concepts that were inappropriate, irrelevant, and not deep. Subject 4's point of view on questions is unclear and limited. The conclusions given by the subject are unclear and illogical.
Subject 2 looked confused when explaining what was known and asked during the interview. Subject 2 could not fully explain the garden sketch in problem number 2. Subject 2 could not complete question number two because subject 2 could not answer question number two, namely the amount of costs for planting trees in the park. There was an error in the step of working on subject 2, where subject 2 looked for the distance between trees, even though the distance between trees was already known in the question. Explanation of subject 2 stopped after getting the cost of the banyan tree and waru tree. The point of view of subject 2 on the problem is not clear. Subject 2's solution for number two uses imprecise, imprecise, and irrelevant data and concepts. The conclusion given by subject 2 is unclear and illogical.	Subject 4 can convey what is known and asked, but the information provided is not thorough and not deep, for example by using the term diameter around the park, it should only be the diameter of the park. Subject 4 explained solution number two by using concepts and data that were not thorough, irrelevant, and not deep. This is shown by stating that K (circumference) equals 66m. Even though K (park circumference) should be 660 m and 66 is a lot of each tree. The step for working on subject 4 is not entirely correct and uses an unclear and limited point of view. Subject 4 can provide a conclusion for question number one.
Subject 2 can convey what is known and asked from question number three but the information provided is still not correct, not thorough, and not relevant to question number three. Subject 2 did not realize that what was known from question number 3 was actually the radius of	Subject 4 can convey what is known and asked, but the information provided is inaccurate, inaccurate, and irrelevant because there is no semicircle in question number three. Subject 4 did not really master the concept of the radius of a circle, subject 4 stated that the radius of

circle A and circle B, which is 10 cm. Subject 2 could not complete question number three. Subject 2 felt that he could provide a solution idea, but turned out to be confused when asked for a solution idea. Subject 2, who could not solve problem number three, could not provide any conclusions.	the semicircle referred to by subject 4 was different from the radius of the quarter circle in the problem even though the radius of the semicircle with the radius of the semicircle (in the same circle)) are the same length. Subject 4 has an unclear and limited point of view of the problem, this can be seen from the confused attitude shown when the researcher asked subject 4 to explain the steps for working on subject 4 in question number 3. In addition, subject 4 looked for the area of a complete circle even though what he should have looked for was only the area of a quarter of the circle in the figure. Subject 4 uses concepts that are not thorough, imprecise, and irrelevant in solving question number three. Subject 4 can provide a conclusion for question number three.

Subjects who were in TBK 1 consisted of 2 subjects namely subject 2 and subject 4. In accordance with Elder and Paul's critical thinking theory, the characteristics of subject 2 and subject 4 were that they were not able to solve the given mathematical problem, using clear data or facts, imprecise, imprecise, and irrelevant, using concepts or ideas in the form of clear, imprecise, irrelevant, and not deep definitions, concepts, theorems, principles, and procedures, unclear and illogical conclusions, and in solving problems mathematics uses a point of view that is not clear and limited.

Table 2. Data analysis of subject interview subject 5

Subjek 5
Subject 5 can convey what is known from number one correctly. Subject 5 can convey the things asked from question number one precisely, clearly, and relevant to the problem. Subject 5 was unable to solve problem number one correctly and subject 5 realized his mistake, this indicated that subject 5 actually had the right, clear and relevant concept as well as a clear point of view on the problem but had not been able to apply it correctly in solving math problems. Subject 5 can convey what is known and asked from question number one. The information provided is correct and relevant to question number one. Subject 5 was unable to solve question number two correctly. Subject 5 actually has the right, clear and relevant concept as well as a clear point of view on the problem but has not been able to apply it correctly in solving problem number two. Subject 5 can provide a conclusion for number two but it is less logical. Subject 5 conveys information that is known and asked from number three. And the information conveyed by subject 5 is clear and relevant to the problem. Subject 5 was unable to complete question number three correctly. Subject 5 actually has the right, clear and relevant concept as well as a clear point of view on the problem but has not been able to apply it correctly in solving problem number three. Subject 5 can provide a conclusion for number two but is less logical.

Subjects who were in TBK 2 consisted of 1 subject, namely subject 5. In accordance with Elder and Paul's critical thinking theory, the characteristics of subject 5 were not being able to solve the given mathematical problem, using data or facts that were clear, precise, thorough, and relevant , using concepts or ideas in the form of clear, precise and relevant definitions, concepts, theorems, principles and procedures, unclear and less logical conclusions, and in solving mathematical problems using a clear and limited point of view.

Table 3. Data Analysis of Interview Results of Subject 1, Subject 3, Subject 6

Subject 1	Subject 3	Subject 6
Subject 1 can convey what is known and asked from question number one. The information conveyed is clear, precise, thorough, and relevant to question number one. Subject 1 can convey the solution to problem number one with clear steps. Subject 1 has a clear point of view in solving problem number one. The concept that is known and used by subject 1 to solve problem number one is clear, precise, and relevant. The	Subject 3 can convey what is known and asked from question number one and the information conveyed by subject 3 is clear, precise, thorough, and relevant to the problem. Subject 3 can provide the right solution for question number one with clear steps. Subject 3 uses concepts and data that are precise, clear, thorough, deep and relevant in solving question number one. Subject 3's point of view is clear. The	Subject 6 can convey what is known and asked from question number one. The information conveyed is precise, clear, thorough, and with question number one. Subject 6 can present a solution to problem number one with precise, systematic and clear steps. Subject 6 has a clear point of view in conveying the number one solution, seen from the systematic, complete, and clear steps of subject 6's work. In addition, subject 6 did

solution given by subject 1 for questions number one, two, and three is correct and according to the context of the problem. Subject 1 cannot provide alternative solutions for question number 1, so subject 1's point of view for question number 1 is still limited. The conclusions written are very clear and logical according to what was asked in question number 1.	conclusions written are clear and logical in accordance with those asked in question number 1. Subject 3 cannot provide alternative solutions for question number 1, so subject 3's point of view is still limited.	not feel nervous during the interview and was very focused. The concept that is known and used by subject 6 to solve problem number one is clear, precise, and relevant. The solution given by subject 6 for question number one is correct, and according to the context of the problem. The conclusion given to problem number one is clear and logical. Subject 6 could not find an alternative solution for question number one.
Subject 1 can explain the information that is known and asked from question number two. The information provided is clear, precise, thorough, and relevant to question number two. Subject 1 can convey the solution to problem number two with clear steps. Subject 1 has a clear point of view in solving problem number two. The concept that is known and used by subject 1 to solve problem number one is clear, precise, and relevant. The solution given by subject 1 for question number two is appropriate and according to the context of the problem. Subject 1 can explain the garden sketch that has been described correctly according to the information contained in question number two. Subject 1 can provide clear and logical conclusions according to what was asked in question number 2. Subject 1 cannot provide alternative solutions for question number 2, so subject 1's point of view for question number two is still limited.	Subject 3 can explain the information that is known and asked from number two. The information provided by subject 3 is clear, precise, thorough, and relevant to question number two. Subject 3 can explain the solution to problem number two with the right steps. Subject 3 has a clear point of view in solving problem number two. The concept that is known and used by subject 3 to solve problem number two is clear, precise, and relevant. The solution given by subject 3 for question number two is appropriate and according to the context of the problem. Subject 3 can provide clear and logical conclusions according to what was asked in question number 2. Subject 3 cannot provide alternative solutions for question number 2, so subject 3's point of view is still limited.	Subject 6 can convey what is known and asked from question number two. The information conveyed is clear, precise, thorough, and relevant to question number two. Subject 6 can explain the solution to problem number two with precise, clear, and systematic steps. Subject 6 can answer each of the researcher's questions correctly and clearly, this means that subject 6 has a clear point of view. Subject 6 uses clear, precise, and relevant information and concepts to solve problem number two. Subject 6 was incomplete in explaining the garden sketch. Subject 6 can provide a clear and logical conclusion to question number two. Subject 6 could not provide an alternative solution for question number two, meaning that subject 6's perspective on question number two was still limited.
Subject 1 can explain what is known and asked from question number three. The information provided is clear, precise, thorough, and relevant. Subject 1 can convey the solution to problem number three with clear steps. Subject 1 has a clear point of view in solving problem number three. The concept that is known and used by subject 1 to solve problem number three is clear, precise, and relevant. Conclusion number three submitted by subject 1 is clear and logical according to what was asked. Subject 1 cannot provide alternative solutions for question	Subject 3 can explain what is known and asked from question number three. The information provided is clear, precise, thorough, and relevant to question number three. Subject 3 can explain the solution to problem number three with clear steps. Subject 3 has a clear point of view in solving problem number three. All research questions can be answered correctly by subject 3. The concept that is known and used by subject 3 to solve problem number three is clear, precise, and relevant. The solution given by subject 3 for question number three is	Subject 6 can convey what is known and asked from question number three. The information conveyed is clear, precise, thorough, and relevant to question number three. Subject 6 can explain the solution to problem number three with precise, clear, and systematic steps. Subject 6 can answer each of the researcher's questions precisely and clearly, this means that subject 6 has a clear point of view and can really do problem number three correctly. But subject 6's point of view is still limited because it has not been able to provide an alternative solution

number three, so subject 1's point of view for question number three is still limited.	appropriate and according to the context of the problem. Conclusion number three delivered by subject 3 is clear and logical according to what was asked. Subject 3 cannot provide alternative solutions for question number 3, so subject 3's point of view is still limited.	for problem number two. Subject 6 uses clear, precise, thorough, relevant information and concepts to solve problem number three. Subject 6 can provide clear and logical conclusions according to the problem.

Subjects who were at TBK 3 consisted of 3 subjects namely subject 1, subject 3, and subject 6. In accordance with Elder and Paul's critical thinking theory, the characteristics of subject 1, subject 3, and subject 6 were being able to solve the given mathematical problem, using clear, precise, thorough, and relevant data or facts, using clear, precise, and relevant concepts or ideas in the form of definitions, concepts, theorems, principles, and procedures, clear and logical conclusions, and in solving mathematical problems using the angle clear and limited view.

3.2. Critical Thinking Level Data Analysis of Test Results Based on Mathematical Ability

3.2.1 Low Math Ability

Subjects who have low mathematical abilities are subject 2 and subject 4. In accordance with Elder and Paul's critical thinking theory, the characteristics of TBK owned by subject 2 and subject 4 are not being able to solve the given mathematical problem, using data or facts that are clear, imprecise, not thorough, and irrelevant, using concepts or ideas in the form of clear, imprecise, irrelevant, and not deep definitions, concepts, theorems, principles, and procedures, unclear and illogical conclusions, and in solving mathematical problems using the angle unclear and limited view. Subject 2 and subject 4 occupy TBK 1.

3.2.2 Moderate Mathematical Ability

Subjects who have moderate mathematical abilities are subject 5. In accordance with Elder and Paul's critical thinking theory, the TBK characteristics of subject 5 are that they have not been able to solve a given mathematical problem, using data or facts that are clear, precise, thorough, and relevant, using concepts or ideas in the form of clear, precise and relevant definitions, concepts, theorems, principles and procedures, unclear and less logical conclusions, and in solving mathematical problems using a clear and limited point of view. Subject 5 occupies TBK 2.

3.2.3 High Mathematical Ability

Subjects who have high mathematical abilities are subject 1, subject 3, and subject 6. In accordance with Elder and Paul's critical thinking theory, TBK characteristics of subject 1, subject 3, and subject 6 are able to solve given mathematical problems, using data or facts clear, precise, thorough, and relevant, using clear, precise, and relevant concepts or ideas in the form of definitions, concepts, theorems, principles, and procedures, clear and logical conclusions, and in solving mathematical problems using a clear and limited. Subject 1, subject 3, and subject 6 occupy TBK 3.

The results of research on the level of critical thinking of class A and B students of junior high school provide information that can be followed up. From the research results, it was found that the highest TBK of the study subjects was TBK 3 and there were still subjects who were at TBK 1 or less critical. For future learning, teachers can make improvements to learning methods to improve students' critical thinking levels. Teachers can reproduce more complex mathematical cases or problems so that they can train students, especially those with TBK 1, to get used to thinking critically. Creativity is needed to develop interesting and more educative learning strategies.

The remaining different thinking abilities of students can be used to develop innovative learning activities. It is possible for students with TBK 3 to help students with TBK 2 or TBK 1 in learning. This can be done for example by compiling groups with heterogeneous members' critical thinking skills as applied to problem-based learning. Research by Setyorini (2010) shows that problem-based learning can improve students' critical thinking skills.

4. CONCLUSION

Based on the results of data analysis on research subjects from student class A and B of junior high school, it can be concluded that the level of critical thinking that can be achieved by research subjects with low mathematical abilities is the level of critical thinking. The characteristics of the critical thinking level 1 of research subjects with low mathematical abilities in solving mathematical problems on the circumference and area of a circle are as follows; has not been able to solve the given mathematical problem, uses data or facts that

are clear, imprecise, imprecise, and irrelevant, uses concepts or ideas in the form of clear, imprecise, irrelevant definitions, concepts, theorems, principles, and procedures, and not in unclear and illogical conclusions, using unclear and limited points of view. The level of critical thinking that can be achieved by research subjects with moderate mathematical abilities is critical thinking level 2. The characteristics of the critical thinking level of research subjects with moderate mathematical abilities in solving mathematical problems on the circumference and area of a circle are as follows; have not been able to solve the given mathematical problem, use clear, precise, thorough, and relevant data or facts, use concepts or ideas in the form of clear, precise, and relevant definitions, concepts, theorems, principles and procedures, unclear conclusions and illogical, using a clear and limited point of view. The level of critical thinking that can be achieved by research subjects with high mathematical abilities is critical thinking level 3. The characteristics of critical thinking level 3 of research subjects with high mathematical abilities in solving mathematical problems on the circumference and area of a circle are able to solve given mathematical problems, using clear, precise, thorough and relevant data or facts, using clear, precise and relevant concepts or ideas in the form of definitions, concepts, theorems, principles and procedures, clear and logical conclusions and using a clear and limited point of view .

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