The analysis of students' critical problem solving on circle-related questions using pesantren-based scientific approach

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Abstract. The objective of this study was to analyze students' critical thinking skills in solving problems concerning circle material using pesantren-based scientific approach. This research employed qualitative descriptive approach, which involved students at class VIII of Plus Junior High School of Darussalam Blokagung Banyuwangi. The instruments used in this study included lesson plan, worksheet, achievement test, critical thinking ability assessment sheets, and questionnaires. From the instrument validation, the average score of each instrument was 3.87; 3.69; and 3.83 for lesson plan, worksheet, and achievement test. The data on students' learning activities demonstrated the increase in their critical thinking skills. In the first meeting, 77.27% of the students achieved "Good" category. In the second meeting, 89.77% of them gained "Very Good" category, and in the third meeting 92.04% of the students were at "Very Good" category. With respect to the students' learning outcome, which was set at 75 points, most of them were successful in achieving the minimum passing criteria in that 28 students (87.5%) satisfied the criteria, while 4 students (12.5%) failed. In addition, the analysis on observation data germane to students' critical thinking skills also demonstrated an increase. In the first meeting, 65% of the students were at "Good" category. 72.5% of the students achieved "Good" category in the second meeting, and in the third meeting 85% of the students were at "Very Good" category. The results of the data analysis showed that students' critical thinking skills in the solving circle-related questions using pesantren-based scientific approach indicated the achievement at "Very Good" criteria.

1. Introduction

Thinking skills are not always possessed by every student because students rarely transfer their own thinking skills, so there needs to be guided training. Thinking skills can be defined as cognitive processes that are divided into concrete steps which will then be used as the guidance for thinking [7]. The thinking process is closely related to what happens in the human brain. In this regard, thinking is related to the facts that exist in the world, and it may be visualized. What is more, and thinking (when expressed) can be observed and communicated [11]. As such, thinking process can be interpreted as a person's mental activity to help solve problems, make a decision, or to fulfill someone's curiosity.

Critical thinking needs to be honed from an early age because it is expected to guide humans to live their lives, especially when working and moving. According to Elder & Paul [3], "the ability and disposition of one's thinking can be improved by systemically subjecting it to intellectual-self assessment". Critical thinking is the ability and disposition to change a thought according to particular system for more advanced judgment. According to Ennis [8], critical thinking is a process that happens to someone and aims to make a reasonable decision about something believed to be true and projected to be done later. Sabandar gave an example in learning Mathematics or solving Math

problems that it is difficult for people to focus on, such as what the problem is, what is known, what is the point of the problem before opting to specific strategy or procedure ". It is necessary to identify a concept used to solve Math problems.

By contrast, in reality these critical thinking habits are still not well accrued in schools. This has been expressed by critics, among others, Jacqueline and Brooks [12] who mention that only a few schools teach students to think critically. The tendency to give correct answers takes precedence over students rather than encouraging them to come up with new ideas in their minds. As a corollary, many school graduates have superficial thinking skills, instead of achieving critical thinking skills. Therefore, it is necessary to cultivate the habit of critical thinking from an early age.

There are five indicators of critical thinking derived from student activities according to Ennis [3], namely: a) the ability to formulate a problem; b) the ability to reveal the facts needed in solving a problem; c) the ability to choose logical, relevant, and accurate arguments; d) the ability to detect bias based on different perspectives; and e) the ability to determine the consequences of a statement taken as a decision.

Based on the level of critical thinking, the critical thinking skill criteria are adjusted to the indicators of critical thinking according to Ennis [3] as follows: 1) Critical thinking level 0: there are no answers that match the indicators of critical thinking; 2) Critical thinking level 1: student's answer satisfy two or three indicators of critical thinking; 3) Critical thinking level 2: students' answers meet four indicators of critical thinking; 4) Critical thinking level 3: students' answers satisfy five indicators of critical thinking.

One learning that is considered effective to train students' critical thinking skills is pesantren-based scientific approach. The approach is also called the scientific approach. The learning process is a scientific process so that learning in Curriculum 2013 uses a scientific approach or a scientific process-based approach (the regulation of Ministry of Culture and Education number 103 of 2014). According to Daryanto [2], learning with a scientific approach is a learning process designed to encourage students to actively construct concepts, laws or principles through a series of stages, involving observing (to identify or find problems), formulating problems, formulating hypotheses, collecting data using various techniques, analyzing data, drawing conclusions and communicating concepts, laws or principles that are "discovered".

The scientific approach is intended to spark students' understanding in recognizing and understanding various materials using a scientific approach by considering the fact that information can be derived from anywhere and at any time, rather than depending on the teacher in most spoon-feeding teaching. Therefore, the learning conditions expected are to encourage students in finding out various sources through observation, instead of just being told. In carrying out the learning process, teacher roles are needed but only limited to facilitating or directing. Also, as the learning proceeds, the teacher's assistance has to be minimized by taking into account students' maturity and class level. This is essential because the scientific approach is centered on the students' activities to find and develop their own facts, concepts, and values deemed essential. As a corollary, the scientific approach is not only oriented towards the final results, but emphasised on process skills.

In the 2013 curriculum, the learning process is carried out using a scientific approach and concerned with three domains, namely attitudes, knowledge, and skills. The end result of employing the approach is an increase and the balance between the ability to become decent human beings (being able to master soft skills) and humans who have the skills and knowledge to live properly (mastering hard skills). In general, these properties encompass attitudes, skills, and knowledge. The learning phases of the scientific approach include information gathering, observation, asking questions, experimenting, processing data or information, presenting data or information, followed by analyzing, reasoning, then concluding, and creating.

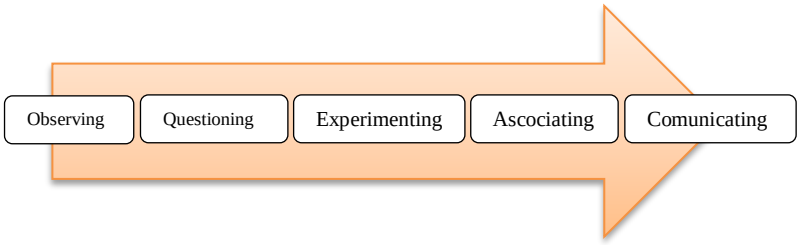

Figure 1. The Learning Steps in Scientific Approach

One previous critical thinking research was conducted by Harlinda Fatmawati in 2014, namely The Analysis of Students' Critical Thinking in Solving Mathematical Problems based on the Polya on The Subject of Quadratic Equations. The research results obtained from 36 students indicated that 19.4% of the students demonstrated critical thinking at level 0; 72.2% of them were at critical thinking level 1; 5.6% of them achieved critical thinking level 2, and only 2.8% of the students achieved critical thinking level 3. From these results, the students' critical thinking level was at most at the level 1, and at least was at level 3. Students with critical thinking level 0 and 1 were not able to change questions into mathematical models.

To propose a solution to the low level of critical thinking skills, the study delved into pesantren-based scientific approach to analyze students' critical thinking skills. The definition of pesantren according to some experts comes from the word "santri", namely "pesantrian" with the prefix -pe and the ending -an which means the place of santri [4]. The existence of pesantren in Indonesia is inseparable from the development of Islam in Indonesia and accompanied by the desire of its followers to study and deepen the teachings of Islam. Pesantren is one of the oldest Islamic educational institutions even though history does not record the first emergence of pesantren in Indonesia [9]. But at least some experts refer to the pesantren which was first founded by Maulana Malik Ibrahim in 1399 AD which focused on the expansion of Islam in Java [10]. Pesantren is educational institution that manifests the development of national education system.

Pesantren is not only synonymous with Islam but also contain the meaning of authenticity in Indonesia. This is because the institutions that are similar to pesantren have existed since the days of Hindu-Buddhist era. As such, Islam only needs to continue to flourish and touch upon the existing educational institutions. However, that does not downplay Islam's role in pioneering education in Indonesia [6]. Pesantren is educational institution which has existed since Islam has not yet emerged, but pesantren remain deeply rooted and even continue to exist in the sophisticated era of science and technology.

Learning Mathematics using pesantren-based scientific is a learning approach that invites participants to solve the problems presented related to Islamic values that often occur in everyday life. Mathematics learning with a pesantren-based scientific approach holds the idea that students can develop critical thinking skills as well as the cultivation of Islamic knowledge. In addition, it focuses on commendable attitude and morality, which is given prominent role in learning Mathematics. Learning process characterized by the context of Pesantren in learning Mathematics in junior high schools is expected to change students' perception on Mathematics as difficult subject in school. It is expected that they will view the subject as a more enjoyable discipline to learn, so that students' mathematics learning outcomes increase [1].

Based on the research problem abovementioned, the researchers collaborate in Mathematics learning with the pesantren-based Scientific Approach. The approach is considered apt to the problem because the problem under investigation is actually present and commonly takes place in boarding schools. The instructional process in boarding school-based mathematics subjects is always praying before and after the learning process, the use of terms, the involvement of visual illustrations, applications or examples that are closely related to pesantren learning or tradition, the insertion of relevant verses or hadiths, searching history, network of topics and symbols of kauniah verses.

2. Methodology

This study employed descriptive qualitative approach because this aimed to study and analyze the students' ability to solve circle-related problems using pesantren-based scientific approach. Research data were obtained from the results of observations, questionnaires, and interviews. In this study, the measured data was the test results of the students' critical thinking skills as measured by achievement tests. The subjects of this study were eighth grade students of Plus Junior High School of Darussalam Blokagung Banyuwangi in the academic year 2018/2019. There were 32 students involved in the study. The class involved in the study was determined by random sampling. The steps in this study were divided into three stages, namely the preparation stage, the implementation phase, and the final stage of the research

3. Results and Discussion

The initial activity of this study was to plan research in learning with a pesantren-based scientific approach. Next, the researcher developed the instructional instruments and the instructional instruments were then validated by validator. The results of the validation of instructional instruments covering lesson plans, student worksheets, and learning achievement tests are outlined in the following table.

Tabel 1. The Results of Validation

No	Instructional Instruments	Validation Scores	Criteria
1.	Lesson plans	3,87	Valid
2.	Student worksheets	3,69	Valid
3.	Learning achievement tests	3,83	Valid

The results of the validation indicate "Very high validity", in that the average validity interval is above 3. These results indicate that the instructional instruments are valid, thus ensuring their applicability in the research. However, few revisions were required, based on the validator's suggestion. The study was conducted in four meetings, where the first to third meetings were concerned with learning activities using the pesantren-based scientific approach. In the initial stages, several alternative learning instruments in the form of student worksheets were used to introduce specific concepts, aid the students in solving questions related to circle material, and illustrate some activities in the realm of pesantren during learning activities. In the fourth meeting, achievement test was carried out to determine the students' critical thinking skill development.

The next stage was the implementation stage. In this stage, the researchers acted as observers, working in tandem with 2 other observers chosen from the teachers at the school. The practitioners who carried out the instruction were Mathematics teachers. During the instruction, teacher's activity was observed, particularly in examining the class management and the students' engagement as assessed by the observer. The average evaluation performed by the observers indicated that the practitioner/teacher was able to manage the class well and the students were active during the learning process.

From the analysis on the observation results, the teachers' ability to manage learning process was scored at 3.76, belonging to "Good" category, and in the second meeting it reached 4.16, satisfying "Very good" category. The score even increased in the third meeting, which was 4.4 at "Very good" category. From the analysis results of student activities, the engagement in the first meeting reached 77.27% and 89.77% in the second meeting. The figure was even higher in the third meeting, which reached 92.04%.

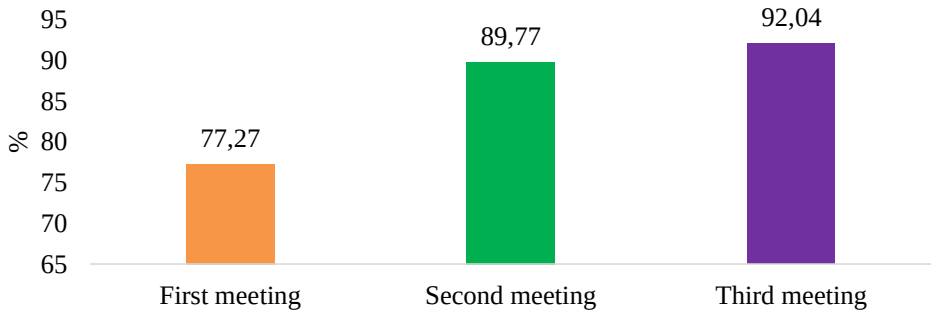

Figure 2. Diagram of the percentage of student activity

At the end of the learning process, a test was conducted to examine the development of students' critical thinking which was then assessed against the critical thinking indicators previously set.

The final stage involved processing, analyzing data and drawing conclusions. The students' critical thinking skills for three meetings were 65%, 72.5%, and 85%, respectively. The achievements in the first and second meeting were classified as “Good”, while that in the last meeting indicated “Very good” achievement. Figure 3 represents the percentage of students' critical thinking skills based on the observation sheet for developing critical thinking skills.

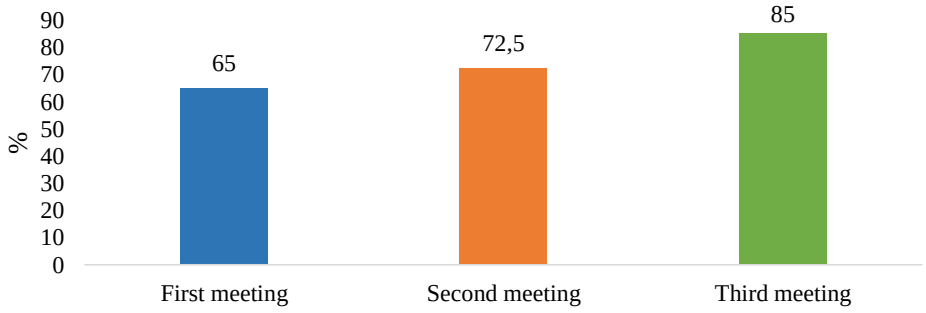

Figure 3. The Percentage of Students' Critical Thinking Abilities

The results of the analysis of students' critical thinking skills were seen from the answers of students who had the ability of critical thinking level 3 on questions related to circle circumference in pesantren-based learning.

1. Mr. Andi and Mr. Hery are Hajj pilgrims who participate the Hajj rituals and tawaf. Mr. Andi is in the tawaf circle which is 10.5 m from the center of the tawaf while Mr. Hery is in the circle of tawaf which is 36.75 m from the center of the tawaf. Mr. Andi and Mr. Hery started the tawaf together and Mr. Andi had finished performing the tawaf. If the speed of Mr. Andi and Mr. Hery is the same, how much is the remaining round that Mr. Hery has to do to complete the tawaf?

Figure 4. Test Questions for Measuring Critical Thinking Skills

One of the students’ works satisfying the criteria for the level 3 is shown in the following Figure 5.

Figure 5 shows the critical thinking ability of students with high abilities which manifest the ability to determine information from the questions given, choose information that is important for problem solving, choose the correct strategy in solving the problem, and perform accurate calculations.

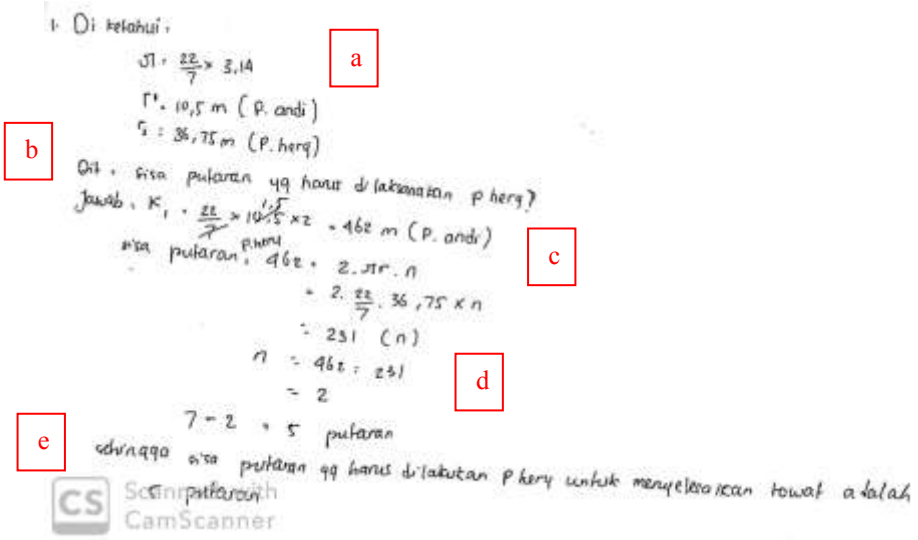

Figure 5. Student's Work at Critical Thinking Level 3

The results of analysis can be grouped into four levels of critical thinking skills where there are 8 students achieving level 3 of critical thinking skills, 20 students achieving level 2 of critical thinking skills, 4 students achieving level 1 of critical thinking skills, and no students achieving level 0. This finding reinforces the opinion that each student actually possesses the ability to think critically. The difference is that their critical thinking skills level varies depending on how students can develop the skills in their own way.

4. Conclusion.

Based on the validation results of lesson plans, student worksheets, and learning achievement tests, these instruments achieved 3.87; 3.69 and 3.83, respectively, which means that they can be put in use subsequent to few revisions. Based on the analysis results on student activities, there is an increase in critical thinking skills as manifested in their learning activities from meeting I to meeting III. The research findings conclude that students' critical thinking skills in solving circle-related questions through scientific learning vary. Thirty two students were classified in various categories, ranging from very critical, critical, and fairly critical. There were 8 students who were able to think very critically. Twenty students were capable of critical thinking, and 4 people were classified into fairly critical. The teacher applies pesantren-based scientific learning properly, so students can develop the critical thinking skills they initially master and immerse Islamic values into their learning.

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