

The analysis of student's critical thinking ability on discovery learning by using hand on activity based on the curiosity

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Abstract. This study aims to determine (1) the effectiveness of Discovery Learning model by using Hand on Activity toward critical thinking abilities, and (2) to describe students' critical thinking abilities in Discovery Learning by Hand on Activity based on curiosity. This study is mixed method research with concurrent embedded design. Sample of this study are students of VII A and VII B of SMP Daarul Qur'an Ungaran. While the subject in this study is based on the curiosity of the students groups are classified Epistemic Curiosity (EC) and Perceptual Curiosity (PC). The results showed that the learning of Discovery Learning by using Hand on Activity is effective toward mathematics critical thinking abilities. Students of the EC type are able to complete six indicators of mathematics critical thinking abilities, although there are still two indicators that the result is less than the maximum. While students of PC type have not fully been able to complete the indicator of mathematics critical thinking abilities. They are only strong on indicators formulating questions, while on the other five indicators they are still weak. The critical thinking abilities of EC's students is better than the critical thinking abilities of the PC's students.

1. Introduction

Mathematics has to be mastered by the students, and to reach high quality mathematics education, the teachers have to encourage to think, ask, do the questions, discuss the ideas and problem solving strategy. High critical thinking and curiosity are one of the important foundations which has to be owned by the students to reach the high quality mathematics education. Aizikovitsh-Udi & Cheng [1] stated that the benefit of critical thinking in the long term can support the students to manage their skill and empower the individual to contribute creatively to the profession they select.

According to [2], critical thinking is reasonable and reflective thinking focused on deciding what to believe or do. The development of critical thinking ability becomes the focus of one of the graduation standards for Junior High School and Senior High School students. Besides that, [3] also stated that critical thinking ability has to be inserted in mathematics curriculum, so the students are able to learn critical thinking ability and apply it in solving the mathematic problems. That's why, the learning process that can train students' critical thinking ability is recommended for teachers in teaching mathematic is the school, with aim to develop the students' ability in mathematic. One way to grow critical thinking to the students is by developing the students' curiosity in criticize a given problem. But in fact, in the real learning process most of teachers have not built students' critical thinking process and curiosity during the learning process.

Maričić & Špijunović [4] stated that many schools in the elementary levels and middle which have not developed students' critical thinking ability. Beside that, based on the study observation result done by the researcher in SMP Daarul Quran Ungaran by doing critical thinking ability test obtained fact that



the students' critical thinking ability is categorized as low. This can be proved by the test result that only 5 students from 26 students could answer correctly critical thinking questions. It means only 19,23% students could answer correctly and 80,77% students could not answer the questions well.

Based on the analysis and interview with students shows that most students get difficulty to identify and analyze the given problems. Students also have not fully been able to do the questions based on the critical thinking standard. This problem could happen because of many factors. Some of them are the teacher way of teaching only one way and the teachers mostly only give the routine questions and it makes the students do not optimize their critical thinking. The usage of routine questions causes the low students curiosity.

Curiosity is will or desire to know what we have not known or to know deeper from what we have known before. According to Berlyne as quoted by Chukwuyenum [5], divided curiosity into two dimensions, they are Epistemic Curiosity (EC) and Perceptual Curiosity (PC). Epistemic Curiosity is a stimulation to learn or to obtain further information related to the knowledge. While Perceptual Curiosity (PC) is curiosity appears because of being motivated by sensorics stimulation or necessity [6]. Curiosity is an important supporting factor in learning process especially mathematics. That's why, curiosity needs to be developed because it can be a motivation in learning mathematics.

Because of the low critical thinking level and the necessity to develop students' critical thinking, we need a learning model which can encourage students to interact and create their idea using observation, experimenting and questioning. Discovery Learning (DL) model is one of learning model which can facilitate the students' critical thinking in learning [7]. Discovery learning has some strengs one of them is it can make the students more active in learning because students have to relate the new knowledge with their obtained knowledge to find a new concept. This makes the learning process more meaningful and motivate the students' curiosity in mathematic.

Applying DL model in learning will be maximum if the application is collaborated with Hand on Activity. The performance of various Hands-on Activies (HoA) can influence students' interest differently [8]. HoA can give freedom to the students in constructing their thinking and discovery during doing learning so it is able to make happy feeling and high motivation to the students. Mathematic learning using HoA invites the students to work together in doing experiment to find, built self knowledge and make them have critical thinking and also curiosity through activities, task and project. The obtaining knowledge using DL and HoA will enlarge and enrich the students' knowledge and ability in the school. This learning model can motivate the students to make innovation and learn better.

Based on the explanation above, the purpose of this research are: (1) to know the effectiveness of learning using DL by HoA toward the students' critical thinking ability, and (2) to describe the students' critical thinking in the DL learning by HoA based on curiosity.

2. Methods

This research is a kind of research with mixed method type concurrent embedded which emphazies in the qualitative research method. The qualitative method is used as the primary method, while the quantitative method is used as the secondary method. Quantitative research is used as supportive data to analyze critical thinking ability based on curiosity according to Berlyn are curiosity Epistemic Curiosity, and Perceptual Curiosity type.

In the quantitative research phase, the researcher chooses pre-experimental in the form of static group comparison. This design uses comparation group and the treatment is only given to the experiment group. The population in this group is all students of 7 grade in SMP Daarul Qur'an Ungaran academic year 2016/2017. While the sample in this research is taken from two classes. They are VII A as the experiment class and VIIB as the control class. Then in the subject qualitative phase research is chosen by using nonprobability sampling technique with purposive sampling type. The subject selection is based on the students' curiosity character. They are the students EC and PC group type. The selection of research subject EC category is obtained from three students with the EC questionnaire score in the first quarter, the second and the third quarter. Also in the PC subject research selection category is obtained from three students with the PC questionnaire score in the first, second and the third quarter.

The data collection technique in this research consists of observation, test and interview. The test type in this research is critical thinking ability test (CTAT) which is done in the beginning and in the end of the learning process. The data analysis is done in the phase before in the field until analysis phase in the field. The analysis before in the field is done by validation equipment and research instrument. The quantitative data analysis is obtained from CTAT data final consists of completeness experiment, average different experiment and critical thinking ability proportion different experiment. While qualitative data analysis is done by reducing data, presenting data and concluding from the collected data and verifying the conclusion.

3. Result and Discussion

The result of this research is explained into two phases. They are quantitative research and qualitative research. In the phase of quantitative research, the researcher tests the effectiveness of DL by HoA toward students' critical thinking ability using completeness test, average different test and different proportion test.

The result of learning completeness test using t test right side obtained $t_{\text{count}} = 3,622$ and the score of $t_{\text{table}} = 1,703$, because $t_{\text{count}} \geq t_{\text{table}}$ so H_0 is rejected. So the students' critical thinking ability using DL model by HoA more than 70. While for classical completeness test with the proportion test right side obtained score $z_{\text{count}} = 1,67$ and the score $z_{\text{table}} = 1,64$. So $z_{\text{count}} \geq z_{\text{table}}$, so H_0 is rejected, it means the students' critical thinking ability experiment class which obtained from learning material using DL model by HoA has reached the criteria of minimum completeness more than 75%.

The analysis of critical thinking ability average different result is obtained $t_{\text{count}} = 5,8164$ and $t_{\text{table}} = 1,67$. The $t_{\text{count}} \geq t_{\text{table}}$, so H_0 is rejected. It means the students' critical thinking ability using DL by HoA is higher than the students' critical thinking ability which is taught using expository learning model. While the result of critical thinking ability different proportion test shows $z_{\text{count}} = 4,187$ and $z_{\text{table}} = 1,64$. Because $z_{\text{count}} \geq z_{\text{table}}$, so H_0 is rejected, it means the students critical thinking ability proportion in DL using HoA is higher than students critical thinking ability using expository learning.

Based on statistical test, it is concluded that DL by HoA is effective toward the student's critical thinking ability. This is because (1) the students' critical thinking ability using DL by HoA can reach the standard; (2) the students' critical thinking ability in average by using DL by HoA is higher than the students' critical thinking ability in the expository learning; and (3) students' critical thinking ability proportion in DL by HoA is higher than the students' critical thinking ability in expository learning. These three results provide illustrations that DL by HoA can provide better results in improving students' critical thinking skills. This is because DL by HoA gives freedom to the students in constructing their thoughts and knowledge during learning activities take place, so it can produce more meaningful learning.

The effectiveness of DL by HoA in this research is supported by previous research finding. Some experts also stated that Discovery Learning is effective in the mathematic learning. Sulistiani [9] stated that Discovery Learning model is effective toward the students' critical thinking ability in VII grade. Balim [3] also stated that experimental group (uses Discovery Learning method) is better than the control group in the academic achievement.

The critical thinking ability and curiosity are really related. Curiosity influences the students' ability in doing the critical thinking questions. The students with the different curiosity also have different critical thinking ability. This research explains that the students' critical thinking ability becomes two types. They are EC dan PC.

The decision of curiosity type of the students of VII A SMP Daarul Qur'an Ungaran is done by filling the curiosity inventory sheet by the students and obtained data in Table 1.

Table 1. the students grouping categorized from students' curiosity dimention

Curiosity Dimension	Students	Percentage
Epistemic Curiosity (EC)	14	51,85%
Perceptual Curiosity (PC)	13	48,15%
Total	27	100%

Based on Table 1, the selection of every subject dimension is selected by three students to be analyzed the critical thinking ability deeply. The subject in the first quarter is called low EC/PC category, the subject in the second quarter is called medium EC/PC category, and the subject in the third quarter is called strong EC/PC category. So the researcher chooses 6 subjects some of the are three students EC type. They are E21, E22, and E24, and three students with PC type. They are E12, E13, and E20.

After determine the research subjects, next it is done by DL model by HoA. The implementation of DL by HoA in the experiment class is divided into six phases. The first phase is stimulation, in this phase the teacher gives question to the students about the problem the students are going to learn. The students is given a problem so they have curiosity to investigate by themselves and to know how far the readiness of the students to receive the lesson. The second phase is problem statement, in this phase the teacher gives opportunity to the students to identify as many as possible that relevant problem with the lesson material to be formulated as hypoteses. The the teacher gives scaffolding to the students by giving problem examples in the daily life which is related to the learned material. This phase is suitable with the implementation from the first phase in the critical thinking. It is basic clarification. In this phase the students are hoped to be able to identify the issue, problem or the event they are facing.

The third phased is data collecting. In this phase, the teacher divided 27 students from experiment class into six heterogeneous group, then she gives student work sheet to every group. This student work sheet is a series of Hand on Activity has to be done by the students to be able to find the concepts related to the learned material. Every group member does the task, so the students are able to observe the task given. The teacher gives the chance to the students to collect data/information as many as possible by reading the literature, books, etc. In this phase, this is hoped to train the students' critical thinking ability in the second step. It is the bases for a decision, which is in this phase the students are trained to consider and measure the source credibility.

The fourth phase is data processing. In this phase, the students start to observe and answer the questions given in the student work sheet. This phase is the implementation from the forth phase in the critical thinking. It is advanced clarification. In this phase, the students are trained to interpreted information result obtained by reading, interview result, observation, etc. Then the information is classified more, then it is defined as assumption.

The next phase is verification, and generalization. In this phase, the students investigate accurately to prove the correctness from the answer given. The teacher gives some examples in the daily life related to taught material to encourage the students to find concept, theory or more meaningful understanding. This phase is related to the third phase (inference) and the fifth (supposition and integration) in critical thinking where the students are demanded to make and decide the result based on the fact, then the students combined the preference and the ability to make a decision. On the other words, students can give reason from the given answer based on the sure proves, then they compose a report by using good and clear sentences.

After the designed learning is done, then tested critical thinking ability that have been validated by experts and have been tested try. Further interviews were conducted with selected subjects. Then do data analysis result of critical thinking ability and interview from selected subject.

3.1. The critical thinking ability of Epistemic Curiosity (EC) subject

Epistemic Curiosity subjects have been able to finish the six indicators of critical thinking which four from six indicators done correctly and completely and for the two indicators from EC subjects have been able to finish with some mistakes. The mistakes done by EC subjects are in the third indicator. It is doing observation and assessing observation result. Here is the example of the students' work done by EC subjects in the question number 2 in finishing indicator of doing observation and assessing observation result.

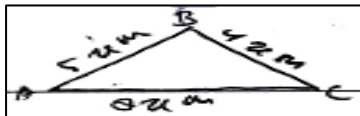


Figure 1. EC Subjects' Work in Indicator of Observation and Assessing Observation Result

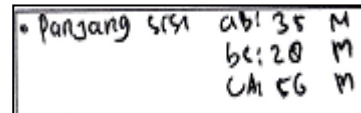


Figure 2. EC Subjects' Work in Indicator of Making Induction and Assessing

Figure 1 shows that EC subjects have been able to make sketch of a park in the form of triangle, give the name of triangle and write the size correctly as a form of observation result report. But there are still some mistakes done by EC subjects because the sketch and the length size have not been contextual. The sketch should be in the form of scalene triangle because the length side of the park size is different, but the work result of EC subjects shows that the sketch is isosceles triangle. The mistake can still be tolerated because EC subjects have attached the length size side of the park and the sketch result is not influenced the other critical thinking indicators.

Besides that, the mistakes done by EC subjects are on the sixth indicator. That is making induction and assessing induction. Figure 2 shows that EC subjects have been able to make induction (conclusion) correctly, but incomplete. EC subjects have been able to conclude the size of park length size in the form of triangle, but they have not written the conclusion related to the cost total of installing the fence. Based on the EC subjects' work result and interview, EC subjects show that they have been able to decide the cost total needed in the fence installation. Because they are careless, EC subjects forget to write the conclusion incompletely.

The EC subjects' ability in finishing critical thinking questions based on their curiosity to learn abstract things. EC students tend to have high curiosity to get new knowledge in the form of concept, idea or fact they have not learned before. In the result of this, they are encouraged to develop their critical thinking ability by observing then they make a definition and combine the information they get then it will be used to make and assess induction or conclusion. This is suitable with the research done by Litman [10], which states that epistemic curiosity tends to motivate someone to get knowledge related to the new idea, omit the information discrepancy, and find the intellectual solution. Richards, Litman & Roberts [11] also stated that epistemic curiosity is a theory that underlie the development of critical thinking ability. The same thing is also stated by Berlyne & Loewenstein, as quoted in Litman [10] adds that epistemic curiosity especially epistemic-specific is a will to search the knowledge or information directed to answer specific questions. This is what encourages the EC students to have high critical thinking level. The stronger someone's epistemic curiosity level, the better the critical thinking they have.

3.2. The Subjects' Critical Thinking Ability of Perceptual Curiosity (PC)

The students with the curiosity of PC, they have lower ability in doing the questions to assess critical thinking ability. The students' answer sheet of PC especially question number 2, shows that PC subjects are only able to answer in the column of indicator (1) asking and answering the questions; (2) formulating questions; (3) observing and assessing the observation result report; and (4) defining and assessing definition. While PC subjects' work result in indicator of combining and making induction has not been answered. Based on the answer from four answered indicator column, PC students are only able to master indicator of formulating question. While for the three other column have been answered,

it shows that the PC subjects are still incorrect. The PC subjects' incorrect answers in doing critical thinking questions, especially question number 2 can be seen in the following figure.

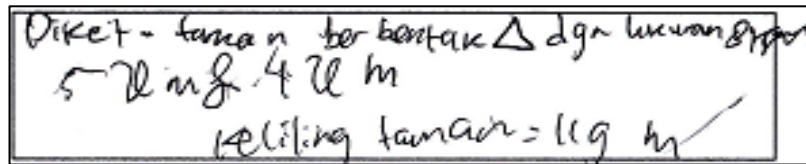


Figure 3. EC Subjects' Work in Indicator of Ask and Answer Question

Figure 3 shows that the subject of the PC is less able to complete an indicator asking and answering questions. PC students have not been able to write down the issues stated in the problem correctly. It appears that the PC subject is still wrong in writing down the length of the sides of the park.

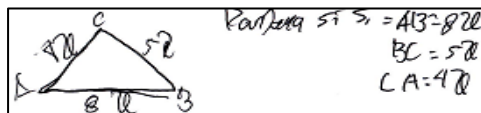


Figure 4. PC Subjects' Work in Indicator of Observing and Assessing the Observation Result

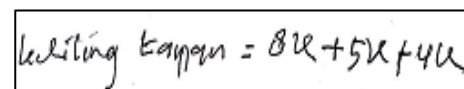


Figure 5. PC Subjects' Work in Indicator of Defining and Assessing the Definition

Figure 4 shows that PC subjects are able to make park sketch in the form of triangle and name the triangle. But in writing the park length size, EC subjects have not attached the unit and the picture which is made also is not contextual.

Figure 5 shows that PC subjects have not been able to master the indicator of defining and assessing the definition. PC subjects have not been able to make mathematics model and deciding the real length park side.

Based on the explanation above, it seems that the students with the curiosity PC type are not really able to finish the questions about assessing critical thinking ability. PC students are only able to master the indicator of finishing the problem, while for other indicators, the answer of PC subjects are still incorrect. The PC students' low critical thinking ability is caused by their natural character from every individual of perceptual curiosity shows that the curiosity they have is not from themselves but as the result of the sensoric stimulation or needs. The PC subjects tend to be lazy to search information related to the knowledge. This is what makes their motivation low in doing CTAT. The impact is, they tend to be weak in finishing critical thinking ability questions. This is related to the opinion from Berlyne as quoted by Levitt, Williams, Uruk, Kannan, Obana, Smith, Wang, Plexico, Camp, Hardison & Watts [12] that perceptual curiosity is more related with the feeling which impacts the environment, which their curiosity appears after they get challenge from others. Perceptual curiosity tends to be weak in solving the abstract questions and they are more challenged to find information related to the environment. This basic character causes the students of PC type tend to have low critical thinking ability. In General, strong PC and weak PC have same mathematics critical thinking ability, none of the are dominant from one another are indented.

4. Conclusion

The curiosity influenced students' critical thinking ability. The analysis of students' critical thinking ability in DL model by HoA based on curiosity was obtained that Epistemic Curiosity student group type have been able to master six indicators of mathematic critical thinking ability. The subjects' critical thinking ability from strong Epistemic Curiosity group was better than the ability of the weak Epistemic Curiosity critical thinking ability group. While the group of the students of Perceptual Curiosity type have not been able to master the indicator of mathematics critical thinking maximally. Both strong Perceptual Curiosity students and weak Perceptual Curiosity students had same critical thinking ability. In other words, there was no one dominant than other. That's why, the teacher has to give extra guide

to the students Perceptual Curiosity type to make them able to solve the problem related to critical thinking.

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