Analysis of critical thinking skills student on the topic of optic geometry

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Abstract. This study aims to analyze: (1) learning activities with multi representation, (2) critical thinking skills of student with multi representation (3) the effect multi representation compared with assignments to student activities, (4) critical thinking skills and activities multiple representations compared with assignments. This research is quasi experimental research with a pretest and posttest control group design. The population in this study were students of class XI SMA Negeri 5 Binjai. The research sample consisted of two experimental classes with multiple representations and a control. Collecting data using observations and tests that have been tested for validity and reliability. The data analysis technique used the independent t test with a significance level of 5%. The results showed that: (1) student activity multi representation was in the active category (85.7%), while student with assignments was in the fairly active category (65.7%), (2) critical thinking skills of student with multiple representations were in the good category (74.3%), while the students critical thinking skills with assignments were in the fairly good category (68.6%), (4) activities and skills critical thinking is better learned in the experimental class rather than in the control class.

1. Introduction

Education is an important factor for humans. According to Law no. 20 of 2003 concerning the National Education System, education is a conscious and planned effort to create an atmosphere of learning and the learning process so that students actively develop their potential and the skills needed by themselves, society, the nation and the state. Improving the quality of education is by using the active learner paradigm (Student Centered).

Demands of the 21st century that critical thinking skills are the focus of learning today [1]. Critical thinking skills are also one of the goals in higher education (Law of the Republic of Indonesia No. 12 of 2012 on Higher Education). Critical thinking skills are also a factor in competition in the global world. Many graduates from several countries cannot compete globally because of their lack of critical thinking skills [2]. A student is said to be active if he has good critical thinking skills [3]. According to data from the Organization for Economic Cooperation and Development's (OECD) Program for International Student Assessment (PISA) in 2012, Indonesia is ranked 64th out of 65 countries in science education (oecd.org) which is very low compared to neighboring countries such as Thailand which ranks 49, Singapore is ranked 4. Likewise according to the results of one of the international studies on student cognitive abilities, namely Trends in Mathematics and Science Study (TIMSS)
which was held by the International Association for the Evaluation of Educational Achievement (IEA). TIMSS 2011 results in the field of physics show that Indonesia scored 397, where this value is below the international average value of 500 (timssandpirls.bc.edu). These facts indicate that new innovations such as methods or approaches are needed in the physics learning process. The results of observations at SMAN 5 Binjai were collected through a questionnaire, namely that students were still not focused on paying attention to the teacher’s explanation so that the physics learning material had not been conveyed maximally had difficulty understanding physics material. Activeness to discuss and relearn physics learning is still low. Cooperative learning such as group discussions is still not being applied in the classroom as evidenced by rarely discussing with other friends or groups. During learning, teachers rarely provide tests or practice questions that apply critical thinking skills. Students are not used to doing critical thinking questions because the teacher gives questions according to general indicators or has not varied. Learning activities affect student activities, so that there are still students who are not active in discussions, ask questions, do questions and do experiments. Student activity needs to be improved in a good way so that teaching and learning activities can run well.

The cooperative learning model was chosen to improve learning methods, namely the Group Investigation (GI) model. Group Investigation (GI) is cooperative learning that involves small groups, students use planning and group discussions then present their findings in class. The application of the Group Investigation model can increase student activity and learning outcomes. The use of the Group Investigation model is in accordance with the physics learning process which emphasizes active students, both in the process and after the learning ends. The application of the group investigation model to the learning process has advantages for students such as: 1) students have a lot of freedom in exploring their knowledge and experiences in groups, 2) from finding sources students are trained to be selective, so that they are able to hone students’ ability in higher order thinking, 3) train students’ courage in communication (providing arguments and responses), 4) accuracy and calmness in the student’s personality in evaluating their findings. 5) train the research result states that learning with a multi-representation approach can improve verbal representation skills in high criteria, mathematical representations, pictures and graphics are in medium criteria [4].

The use of models with multi-representation based learning is expected to be fulfilled for the multi-representation aspects and student learning activities. Student involvement in learning requires a fun atmosphere and freedom to achieve good results. The results foster excellence in both understanding material and thinking. A learning method and model that emphasizes the development of students’ abilities in the form of learning activities and activities, giving rise to the effectiveness of the learning process about multi-representation, which is expected to be fulfilled for the aspects of multi-representation and student learning activities. Challenges in building multi-representation capabilities can be achieved using models.

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achieve good results. The results foster excellence in both understanding material and thinking. A learning method and model that emphasizes the development of students' abilities in the form of learning activities and activities, giving rise to the effectiveness of the learning process about multi-representation, which is expected to be fulfilled for the aspects of multi-representation and student learning activities. Challenges in building multi-representation capabilities can be achieved using models. The investigation group learning model had several advantages including giving freedom to students to think analytically, critically, creatively, reflectively, and productively [5].

The application of the group investigation model had an influence on conceptual understanding and critical thinking. Slavin supports the statement that cooperative learning is superior in helping students develop the ability to work together, think critically, and communicate [6]. In particular, the group investigation model gave students the freedom to develop ways of thinking and made students know their own abilities so that they could easily identify learning sources inside and outside the classroom in every lesson ploras. Important critical thinking skills cause a lot of research to be conducted to examine that critical thinking skills are important to be developed. Good critical thinking skills of students can cause them to become critical consumers of science, so that they can make a good contribution to the development of science [7]. Critical thinking skills also affect students in following the development of science and technology [8]. A person's learning success is also influenced by his critical thinking skills [9]. Critical thinking skills are the key to learning from students' learning experiences [10]. Critical thinking skills are also needed by students in gathering facts that are used to draw conclusions from themselves [11-13]. Critical thinking skills are one of the important things that must be developed in learning.

The results of observations and problems in the background about critical thinking in physics still need to be researched, so it is important for researchers to examine the problems that occur by conducting a study entitled "The Effect of Group Investigation Type Cooperative Model with Multiple Representations on Activities and Critical Thinking skills of SMAN 5 Binjai".

2. Research Methods

2.1 Types of research
This type of research is a quasiexperiment (pseudo experiment), namely research that aims to determine whether there is a difference due to the influence of something imposed on the subject, namely students. Quasi-experimental research tries to examine the presence or absence of a causal relationship, by comparing one or more groups who are given treatment with those who are not given treatment.

2.2 Research design
This study involved two sample classes that were given different treatments. The experimental class was given treatment, namely the Group Investigation model with multiple representations, while the control class was given treatment with conventional learning. Two sample classes were given treatment, namely by giving a pretest at the beginning of the lesson and postest at the end of the lesson. These two sample classes were tested with the same measuring instrument and became experimental data. The design of this study can be presented with a pretest-posttest control group design. The design of this study is shown in Table 1.

| Class    | Pretest | Treatment | Postest |
|----------|---------|-----------|---------|
| Exp      | X1      | Y1        | X2      |
| Control  | X1      | Y2        | X2      |

Information:
X1 = Pretest given to the experimental class and control class before being given treatment. The test given is a critical thinking skill test.
Y1 = Learning using the Group Investigation learning model
Y2 = Learning using conventional learning models
X2 = Postest is given to the experimental class and control class after being given treatment.

2.3 Location and Time of Research
The research was conducted at SMA Negeri 5 Binjai in class XI IPA 1 and XI IPA 2 in Binjai Academic Year 2019/2020. When this research was conducted in February - March in the even semester of the 2019/2020 academic year.

2.4 Population and Research Sample
The population in the study were all class XI students of SMA Negeri 5 Binjai Semester II of the 2019/2020 academic year. The number of classes XI in the Science Department of SMA Negeri 5 Binjai consisted of six classes. The sample was taken by random class (cluster random sampling). The sample of this study consisted of two classes, namely the experimental class, there were 35 students applied to the Investigation Group learning model with multiple representations and the control class with 35 students using conventional learning.

2.5 Test Validity
The validity of the test is the accuracy of the test to be able to fulfill its function in describing the state of the measured aspects accurately and accurately. The formulation of this test used content validity and item validity.

2.6 Data Analysis Technique
After the data is obtained then processed by data analysis techniques. The first analysis is the analysis prerequisite test which includes: normality test and homogeneity test. Two-party t test was used to determine the similarity of students' initial abilities in the two sample groups.

3. Research Result

3.1 The Effect of Group Investigation Learning Models Compared to Conventional Models on Student Activities
The calculation of determining the tendency of students' activity postest scores on the group investigation learning model with multiple representations is presented as follows.

Table 2. Categories of Student Activity Postest Data Trends in the Experiment Class

| No | Category     | Interval       | F  | Percentage (%) |
|----|--------------|----------------|----|----------------|
| 1  | Active       | X ≥ 66,67      | 30 | 85,7           |
| 2  | Enough Active| 33,33 ≤ X < 66,67 | 5  | 14,3           |
| 3  | Less Active  | X < 33,33      | 0  | 0,0            |
|    | Total        |                | 35 | 100,0          |

Based on the table above, it is known that there are 30 students (85.7%) who are in the active category (85.7%) and 5 students (14.3%) who are in the category of posttest activity score tendencies in the group investigation learning model. So it can be concluded that the category of the tendency of students' activity postest scores on the group investigation learning model with multiple representations was in the active category (85.7%). Postest data on student activities using the direct instruction learning model with the assignment obtained the following results:

Table 3. Categories of Student Activity Postest Data Trends in the Control Class

| No | Category     | Interval       | F  | Percentage (%) |
|----|--------------|----------------|----|----------------|
| 1  | Active       | X ≥ 66,67      | 12 | 34,3           |
| 2  | Enough Active| 33,33 ≤ X < 66,67 | 23 | 65,7           |
| 3  | Less Active  | X < 33,33      | 0  | 0,0            |
|    | Total        |                | 35 | 100,0          |
Based on the table above, it is known that the category of student activity posttest scores on the direct instruction learning model with assignments that are in the active category is 12 students (34.3%) and 23 students (65.7%) are in the good enough category. So it can be concluded that the category of the tendency of student activity posttest scores on the direct instruction learning model with the assignment is in the quite active category (65.7%).

3.2 The Effect of Group Investigation Learning Model Compared to Conventional Models on Students' Critical Thinking Skills

Furthermore, the calculation of the tendency of the post-test score tendency for critical thinking skills on the group investigation learning model with multiple representations is presented as follows.

| Table 4. Posttest Data Categories for Critical Thinking Skills in the Experiment Class |
|---|---|---|---|
| No | Category | Interval | F | Percentage (%) |
| 1 | Well | $X \geq 66.67$ | 30 | 85.7 |
| 2 | Enough | $33.33 \leq X < 66.67$ | 5 | 14.3 |
| 3 | Less | $X < 33.33$ | 0 | 0.0 |
| Total | | | 35 | 100.0 |

Based on the table above, it is known that there are 30 students (85.7%) who are in the good category and 5 students (14.3%) who are in the good category of critical thinking skills in the posttest category. So it can be concluded that the post-test score tendency category of critical thinking skills on the group investigation learning model with multiple representations is in the good category (85.7%). Furthermore, the calculation of the tendency of the post-test score tendency is carried out for critical thinking skills in the direct instruction learning model with the assignments presented as follows.

| Table 5. Posttest Data Categories for Critical Thinking Skills in the Control Class |
|---|---|---|---|
| No | Category | Interval | F | Percentage (%) |
| 1 | Well | $X \geq 66.67$ | 1 | 2.9 |
| 2 | Enough | $33.33 \leq X \leq 66.67$ | 34 | 97.1 |
| 3 | Less | $X < 33.33$ | 0 | 0.0 |
| Total | | | 35 | 100.0 |

Based on the table above, it is known that the category of post-test score tendency for critical thinking skills in the direct instruction learning model with assignments that are in the good category is 1 student (2.9%) and 34 students (97.1%) are in the good enough category. So it can be concluded that the category of the post-test score tendency of critical thinking skills in the direct instruction learning model with the assignment is in the quite good category (97.1%).

4. Data analysis

4.1 Data Analysis Prerequisite Test.

As a condition for being able to perform data analysis, the researcher must perform the prerequisites for data analysis, namely by calculating normality and calculating homogeneity. The results of the normality calculation can be seen in the following table:

| Table 6. Normality Calculation Results |
|---|---|---|---|
| Group | Variable | Kolmogorov | Conclusion |
| Student Activities | Pretest Experiment | Z | Asymp sig | Normal |
| | Posttest Experiment | 1.203 | 0.111 | Normal |
| | | 0.998 | 0.272 | Normal |
From the results of the analysis of homogeneity calculations using SPSS 25.0 for window, the following summary of the levene test statistical values is obtained:

| Category                      | Levene Statistic | Asymp sig | Conclusion |
|-------------------------------|------------------|-----------|------------|
| Student activity pretest      | 0.144            | 0.705     | Homogen    |
| Student activity postest      | 0.072            | 0.789     | Homogen    |
| Pretest critical thinking skills | 0.004         | 0.949     | Homogen    |
| Postest critical thinking skills | 0.677         | 0.414     | Homogen    |

From the table above, it can be seen that the significance value of the levene test results in both the experimental and control groups has a significance value greater than $\alpha = 0.05$. Thus it can be concluded that the variance of the two classes is homogeneous.

4.2 Testing Hypotheses.

Based on the results of data analysis using the independent t test, the following hypothesis testing results were obtained.

| Postest Group | Mean | t-count | p    |
|---------------|------|---------|------|
| Student activity | 76.19 | 4.773   | 0.000 |
| Control       | 67.89 |         |      |

The results of the independent t test posttest student activity in the experimental group after receiving treatment with the group investigation model with multiple representations and the control group after receiving treatment with direct instruction learning with the assignment obtained the tcount value of 4.773 and $p = 0.000 < 0.05$, so it can be concluded that the hypothesis which states "There is an effect of the group investigation learning model with multiple representations compared to the direct instruction learning model with assignments to student activities" was proven.

| Postest Group | Mean | t-count | p    |
|---------------|------|---------|------|
| Critical thinking skills | 71.52 | 7.938   | 0.000 |
| Control       | 60.99 |         |      |

The results of the independent t test posttest critical thinking skills in the experimental group after receiving treatment with the group investigation model with multiple representations and the control group after receiving treatment with direct instruction learning with the assignment obtained the tcount value of 7.938 and $p = 0.000 < 0.05$, so it can be concluded that the hypothesis which states "There is an effect of the group investigation learning model with multiple representations compared to the direct instruction learning model with the assignment of students’ critical thinking skills" is proven.
Table 10. Comparison of Activities and Critical Thinking Skills in the Experiment Class with the Control Class

| Variable               | Investigation group learning model with multiple representations | Direct instruction learning model with assignments |
|------------------------|------------------------------------------------------------------|---------------------------------------------------|
| Student Activities     | 76.19                                                            | 67.89                                             |
| Critical Thinking Skills| 71.52                                                            | 60.99                                             |

Based on the table above, it is known that the mean value of the experimental class student activity is 76.19 higher than the mean value of the control class student activity of 67.89. Likewise, the mean value of critical thinking skills in the experimental class was 71.52 higher than the mean value of critical thinking skills in the control class of 60.99. Based on the comparison of the mean value, it can be concluded that H0 can be rejected and Ha accepted, so that it can be concluded that "Activities and critical thinking skills learned are better in the group investigation learning model with multiple representations than the direct instruction learning model with assignments" is accepted.

5. Discussion of Research Results

5.1 The Effect of Group Investigation Learning Models Compared to Conventional Models on Student Activities in the Experiment and Control Classroom

The results showed that there was an effect of the group investigation learning model compared to the conventional model on student activities in the experimental and control classes. The application of the Group Investigation model can increase student activity and learning outcomes. The use of the Group Investigation model is in accordance with the physics learning process which emphasizes active students, both in the process and after the learning ends. The application of the group investigation model to the learning process has advantages for students such as: 1) students have a lot of freedom in exploring their knowledge and experiences in groups, 2) in terms of finding sources, students are trained to be selective, so that they are able to hone students' abilities in high-order thinking, 3) train students' courage in communication (providing arguments and responses), 4) accuracy and calmness in the student's personality in evaluating their findings. 5) train reasoning through meaningful study and exploration.

Student activities are at the core of the learning process. The learning process activity determines the success or failure of the learning process. Students are expected to actively participate in the classroom during the teaching and learning process. Active participation makes it easier for them to master the material provided by the teacher. Learning objectives are closely related to learning strategies or methods. The application of appropriate learning methods will affect student activity and learning outcomes. Proper learning will create a conducive learning process because students are actively involved in learning. The results of research by Mahardika et al. (2013: 345) states that learning with a multi-representation approach can improve verbal representation skills in high criteria, mathematical representations, pictures and graphics are in medium criteria. The use of models with multi-representation based learning is expected to be fulfilled for the multi-representation aspects and student learning activities.

Group Investigation (GI) type learning, begins with the teacher presenting classical learning for an outline of the subject matter. Students are not only appointed individually to obtain good learning outcomes, but they are required to be responsible for the success of their group. Learning groups of students work collaboratively with group members. Students who are smarter provide assistance to their friends to understand the concepts being learned and each member of the group has responsibility for the success of his group.

Meanwhile, the multi-representation approach focuses on delivering information in various ways or forms, with the assumption that the more learning "modes" are used, the information that students will receive will become clearer, resulting in more conducive learning activities and information transfer.
Different representations provide optimal learning opportunities for each type of intelligence. That is why this learning approach will be easily applied by students based on their intelligence. Through the application of a multi-representation approach, student learning activities are increased due to the flexible learning approach patterns used by teachers and students in the learning process.

5.2 The Effect of Group Investigation Learning Models Compared to Conventional Models on Students' Critical Thinking Skills in the Experiment and Control Class

The results showed that there was an effect of the group investigation learning model compared to the conventional model on students’ critical thinking skills in the experimental and control classes. The application of the group investigation model had an influence on conceptual understanding and critical thinking. Slavin supports the statement that cooperative learning is superior in helping students foster the ability to work together, think critically, and communicate [6]. In particular, the group investigation model gave students the freedom to develop ways of thinking and made students know their own abilities so that they could easily identify learning sources inside and outside the classroom in every lesson. Group investigation is believed to be able to increase the overall student involvement in the activities of providing discourse, assumptions, and providing answers. The group investigation model has an advantage in helping students to take an active role in learning because they are faced with solving various problems faced directly and sensitive to think in answering problems [14]. The group investigation learning model had several advantages including giving freedom to students to think analytically, critically, creatively, reflectively, and productively [14].

5.3 Activities and Critical Thinking Skills Learned Better in Experiment Class than in Control Class

The results showed that the mean value of the experimental class students' activity was 76.19 higher than the mean value of the control class students' activity of 67.89. Likewise, the mean value of critical thinking skills in the experimental class was 71.52 higher than the mean value of critical thinking skills in the control class of 60.99. Based on this comparison of the mean value, it can be concluded that the activities and critical thinking skills learned are better in the experimental class than in the control class.

The results showed that the group investigation learning model with multiple representations had an effect on student activity. According to Simanjuntak and Siregar (2014), the group investigation type cooperative learning model makes students more active in learning, because with this model the knowledge and skills obtained by students are expected not to be the result of remembering a set of facts, but the result of joint investigation. With this model students can also work together in groups. The level of understanding obtained by students is deeper because students are directly involved in the process of seeking or finding lesson information to be discussed and presented by the group, so that the sharing process is more effective and efficient.

The group investigation type cooperative learning model was chosen because it could provide opportunities for students to participate in solving problems that were studied between individuals in the group to obtain agreement in solving the problems given by the teacher. Existing material topics lead to scientific methods starting from problem identification, problem formulation, literature study, formulating hypotheses, conducting research and concluding research results so as to develop student learning experiences. Group investigation is one of the cooperative learning models in which students collaboratively in their groups examine, experience and understand the topic of study to be studied. The application of group investigation with multiple representations was proven to increase critical thinking because learning did not take place informatively. This means that students solve problems on the worksheets to direct and train students in critical thinking. Students’ critical thinking skills will increase along with the learning model used. Therefore, the learning process plays an important role in students’ abilities. Learning with real environmental situations (contextual) is easier for students to understand than learning that is informative (not contextual). Students learning should be directly involved with real objects in life in order to improve their critical thinking skills.
that involve the thinking process and student interaction directly will make it easier for students to construct their knowledge and link the concepts learned.

6. Conclusion
   a. Student activities in the group investigation learning model with multiple representations were in the active category (85.7%), while student activities in the direct instruction learning model with assignments were in the fairly active category (65.7%).
   b. The students' critical thinking skills in the group investigation learning model with multiple representations were in the good category (85.7%), while the students' critical thinking skills in the direct instruction learning model with assignments were in the fairly good category (97.1%).
   c. There was an effect of the group investigation learning model compared to the conventional model on student activity in the experimental and control classes.
   d. There was an effect of the group investigation learning model compared to the conventional model on students' critical thinking skills in the experimental and control classes.
   e. The activities and critical thinking skills learned were better in the experimental class than in the control class.

7. Suggestions
   a. The teacher is expected to be able to apply the group investigation learning model with multiple representations in physics learning because the use of the group investigation learning model with multiple representations has a positive impact in increasing students' activities and critical thinking skills. In teaching and learning activities in class, teachers are advised not to focus only on one learning model because one subject material and another will certainly be different, so there is a need for innovation and variation in teaching so that students are not bored and able to accept the material presented.
   b. There needs to be an increase in skills in the application of the group investigation learning model by means of which it is often used in learning, so that the learning objectives to be achieved can be realized.
   c. Students should always try to improve their understanding of physics subject matter in order to increase students' critical thinking activities and skills.

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