The Experiment of Heat Matter Based on Scientific Inquiry in Senior High School

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Abstract. This study aims to determine (1) whether the science process skills of students who are taught with the scientific inquiry model are better than students who are taught using conventional learning, (2) whether the critical thinking skills of students who are taught with the scientific inquiry model are better than in students who are taught with conventional learning. This type of research is a quasi-experiment with two groups pretest-posttest design. Sampling was carried out by means of cluster random sampling by taking two classes from three classes, namely class XI IPA-3 as the experimental class, amounting to 30 people and class XI IPA-1 as the control class, amounting to 31 people. The instruments used were tests and non-tests in which science process skills were in the form of student worksheets and critical thinking skills were in the form of essay questions consisting of 5 validated questions. Hypothesis testing using different test (t-test). Based on the results of the study, it was concluded that: (1) the science process skills of students who were taught with the scientific inquiry model were better than those who were taught using conventional learning, (2) the critical thinking skills of students who were taught with the scientific inquiry model were better than in students who are taught with conventional learning.

1. Introduction

Critical thinking skills and science skills are very important skills that students have. Critical thinking skills because, students can more easily understand concepts, are sensitive to problems that occur so they can understand and solve problems and be able to apply concepts in different situations [1]. Critical thinking helps students to express their opinions about scientific or social problems, make decisions, build their problem solving. Critical thinking is a skillful and active interpretation and evaluation of observation and communication, information and argumentation [2]. Critical thinking is the ability to organize, analyze and evaluate arguments, mental processes, strategies and representations of a person used to solve problems, make decisions and learn new concepts and reflective thinking that makes sense or is based on reasoning that is focused on determining what to do. Critical thinking skills are important because they provide space for students to ask questions, make assumptions, analyze, and evaluate [3].

The next practical skill in physics that is important for students to have is science process skills. Science process skills are psychomotor skills used in problem solving. Science process skills include problem identification, objective investigation, data collection, transformation, interpretation and communication [4]. Science process skills are skills that facilitate learning science so that it allows students to be active in solving problems and developing a sense of responsibility using the scientific method [5].
The reality in the field is based on research conducted by some researchers show in their respective studies that the critical thinking skills of students are at a low level was supported by the results of a preliminary study at SMA Primbana Medan where students are unable to answer critical thinking test questions correctly [6-9]. The facts are supported by the results of student interviews which state that students rarely find critical thinking skills tests such as tests in preliminary studies at school. Based on the results of interviews with teachers, tests of critical thinking skills were never given to students because they were considered complicated and difficult to solve. Tests given to students in the form of questions with the category of remembering (C1), understanding (C2) and counting (C3).

Another fact shows that physics learning is conventional with monotonous learning with lectures that still emphasize material explanation, problem solving, assignment without interacting with students. Learning like this results in a lack of opportunities for students to participate in experimental activities in the laboratory. Students rarely do practicum so that during the practicum many students are confused in following the experiment on the student activity sheet, are less able to discuss, are less able to submit hypotheses and draw conclusions. Learning conditions like this lead to a lack of science process skills of students.

One alternative to improving students' critical thinking skills and science process skills is to use the scientific inquiry learning model, because it helps students develop science process skills and develop students' knowledge. The scientific inquiry learning model can improve students' science process skills [10]. Scientific inquiry learning can build students' science process skills because inquiry learning can involve students actively (student centers) to investigate problems presented on student worksheets, provide experience and familiarize students to process and find their own knowledge [11].

Scientific inquiry learning is closely related to process skills such as observing, concluding, classifying, estimating, measuring, questioning, interpreting, and analyzing data. Not only covering science process skills, scientific learning also refers to the incorporation of this process of scientific knowledge, scientific reasoning and critical thinking to develop scientific knowledge [12]. Scientific inquiry-based learning helps students develop critical thinking skills and allows students to build knowledge like a scientist [13].

2. Method

This research was conducted at the Primbana Private High School, Medan. The time of the research was carried out on February 19 to March 6 in T.P. 2019/2020. ). The population in this study were all students of class XI IPA at SMA Primbana Medan in the even semester of T.P 2019/2020 and the sample was class XI IPA-3 as the experiment class and XI IPA-1 as the control class which was taken using cluster random sampling.

This research is a quasi-experimental research type and the variables in this study are two independent variables, namely the independent variable of this study is the scientific inquiry learning model for the experimental class and conventional learning for the control class, while the dependent variable in this study is science process skills and thinking skills critical of students on the subject matter of temperature and heat. The research design was in the form of two groups pretest-posttest as shown in table 1.

| Table 1. Research Design |
|--------------------------|
| Sample       | Pre-test | Treatment | Post-test |
| Experimental | Y₁       | X         | Y₂        |
| Control Class | Y₁       | Y         | Y₂        |

Information :
Y₁: Pre-test in the experimental class and control class before being given treatment
Y₂: Post-test in the experimental class and control class after being given treatment
X: Treatment for the scientific inquiry learning model
Y: Treatment for conventional learning models
This study uses two types of instruments, namely a critical thinking skill test in the form of an essay which consists of 5 questions and a science process skill in the form of a Student Worksheet.

3. Result and Discussion

The research results obtained are presented in Table 2.

| Table 2. Statistical Description of Pre-test and Post-test Science Process Skills and Critical Thinking Skills |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                              | N   | Min  | Max  | Mean  | Std. Dev |
| Science Process Skills                       |     |      |      |       |          |
| Pretest control                              | 31  | 36,67| 53,33| 47,11 | 4,33     |
| Pretest experimental                         | 30  | 36,67| 60,00| 46,02 | 6,29     |
| Posttest control                             | 31  | 56,67| 76,67| 66,23 | 4,92     |
| Posttest experimental                        | 30  | 60,00| 86,67| 73,00 | 6,91     |
| Critical Thinking Skills                     |     |      |      |       |          |
| Pretest control                              | 31  | 16   | 56   | 35,20 | 10,20    |
| Pretest experimental                         | 30  | 12   | 77   | 37,70 | 12,45    |
| Posttest control                             | 31  | 32   | 84   | 62,71 | 13,20    |
| Posttest experimental                        | 30  | 48   | 84   | 71,22 | 9,88     |

The pretest data normality test for both classes used the Shapiro-Wilk test using the SPSS 16.0 application which can be shown in Table 3.

| Table 3. Normality Test of Science Process Skills and Critical Thinking Skills |
|--------------------------------------------------------------------------|-----------------|-----------------|-----------------|
| Science Process Skills                     | Class          | Statistic | Df  | Sig.   |
| Pretest control                           | 0,942          | 31          | 0,101 |
| Pretest experimental                       | 0,935          | 31          | 0,600 |
| Posttest control                           | 0,954          | 30          | 0,222 |
| Posttest experimental                      | 0,941          | 31          | 0,089 |
| Critical Thinking Skills                   | Class          | Statistic | Df  | Sig.   |
| Pretest control                            | 0,939          | 31          | 0,079 |
| Pretest experimental                       | 0,935          | 30          | 0,066 |

The pretest homogeneity test for both classes used the Levene test.

| Table 4. Homogeneity Test of Science Process Skills and Critical Thinking Skills |
|--------------------------------------------------------------------------|-----------------|-----------------|-----------------|
| Levene                      | Pre-test | Post-test |
| Science Process Skills      | 4,069    | 5,483    |
| Critical Thinking Skills    | 0,195    | 1,431    |

The hypothesis test used is the one-way t test with the Independent Sample T-Test on SPSS 16.0, the results are shown in Table 5.
Table 5. Hypothesis Test of Post-Test Data Skills

|                          |     T  | Df | Sig. (2-tailed) |
|--------------------------|-------|----|----------------|
| Post-test experimental (Science Process Skills) | 4,413 | 59 | 0.000          |
| Post-test experimental (Critical Thinking Skills)  | 2,843 | 59 | 0.003          |

3.1. The Science Process Skills of Students who are taught with the Scientific Inquiry Learning Model are better than Students who are taught with Conventional Learning

The results showed that the physics science process skills of students who were taught with the scientific inquiry model were better than conventional learning. The pretest average value of control class students' science process skills was 47.11 and the post-test average score was 66.02. Students who were taught by scientific inquiry learning had an average pretest score for science process skills was 46.02 and the mean value posttest is 73.00.

The results of this study are in line with Meliala's study which concluded that the science process skills of students who were taught with the scientific inquiry learning model showed better results compared to students taught with conventional learning. Students who were taught with the scientific inquiry learning model obtained an average science process skill score of 78.14 and students who were taught with the conventional learning model obtained an average science process skill score of 74.14 [14]. The same thing was also obtained by Anggreini who concluded that the science process skills of students with scientific inquiry learning using mind mapping were better than the science process skills of students using conventional models [15].

Research conducted by Nababan, et al also showed that the science process skills of students using the scientific inquiry learning model were better than conventional learning [16]. Putri in her research concluded that the science process skills of students taught with the scientific inquiry learning model were better than the science process skills of students taught by conventional learning. These results indicate that there is an effect of the scientific inquiry learning model on the science process skills of students [17].

The scientific inquiry model is very suitable to be used to improve science process skills because in scientific inquiry activities students are faced with scientific activities or investigative activities through experiments. Students are trained to become skilled in obtaining and processing information through thinking activities by following scientific procedures (methods) such as designing experiments, carrying out experiments, observing, asking questions, formulating hypotheses, finding patterns and variable relationships, communicating effectively and concluding. Students are directed to develop their own process science process skills and find out for themselves. Along with the increasing ability of students to carry out investigations, not only do science process skills develop, but student learning outcomes will increase because students have learned physics more meaningfully, understand the process, not just the results [18].

The scientific inquiry model involves students in real real research problems, by exposing students to the field of investigation, helping them identify methodological or conceptual problems in their investigation and inviting them to design ways to solve these problems [19]. The stages of the scientific inquiry model support the improvement of students' science process skills. The stages that begin with (1) Presentation of the problem to students, which include the methodologies used in the investigation. (2) Formulate the problem so that students can identify difficulties in the investigation. These difficulties include interpreting data, generalizing data, controlling experiments or making conclusions. (3) Learners identify problems so that they can identify difficulties in the investigation. (4) Students find ways to overcome these difficulties, by redesigning the experiment, processing data in different ways, generalizing data, developing ideas, and so on.

Scientific inquiry learning familiarizes students by exposing them to events related to the material, which allows students to make observations. In addition, students also make observations when they carry out investigations. This stage trains students in observing, which is a basic skill when students
conduct experiments [20]. One of the stages of scientific inquiry learning is conducting investigations where students are taught to get used to doing experiments or practicum. Through this activity students use different senses by touching, feeling, moving, observing, listening, and smelling [21]. After conducting an investigation, students are trained to analyze data, by providing an explanation of the object or event from the information collected [22]. At this stage students are trained to use interpreting skills.

According to Sanjaya the use of the inquiry learning model has the following advantages: (a) A learning model that emphasizes the development of cognitive, affective and psychomotor aspects in a balanced manner, so that learning using the inquiry model is considered more meaningful. (b) Provide space for students to learn according to their learning style. (c) The inquiry learning model is considered in accordance with the development of modern psychologists who think learning is a process of changing behavior due to experience. (d) Serving the needs of students who have abilities above average [23].

Lu et al also stated that inquiry learning is learning through scientific investigation where students learn how to solve problems and investigate scientifically which allows students to learn about real life in science and scientific knowledge in life [24]. This learning model includes identifying problems, proposing hypotheses, identifying relevant variables, designing experiments to test hypotheses, carrying out investigative procedures, collecting data based on experiments, changing data in tables and graphs, and drawing conclusions [25], [26].

This learning model is very suitable for use because, in practice, the teacher provides sufficiently broad guidance or guidance to students. The teacher's job is to guide, train and educate research by emphasizing the research process and persuading students to reflect on that process. Furthermore, the most important thing in this case is how teachers can encourage students to face complex research problems properly and carefully. Teachers must direct students to create hypotheses, interpret data and develop constructs, which are also part of the ways they interpret reality which is constantly evolving. This is in line with research by Ulfa which states that in scientific inquiry learning, the role of the teacher is very important in stimulating and challenging to think, providing flexibility in opinion, taking initiative and acting, providing support in learning, and diagnosing difficulties and helping overcome them [27].

Activities carried out during learning with the scientific inquiry model encourage students to develop science process skills as reported by Yager & Akcay [28], Lati et al., [29], Green et al., [30], Şimşek & Kabapinar [31] and Hofstein & Lunetta, [32], so as to improve the science process skills of students [33], [34]. So it can be concluded that the Scientific Inquiry learning model is better at improving the science process skills of students compared to conventional learning. Unlike the case with conventional learning which prioritizes the training process for students. Knowledge is taught by training students, the tendency of students is required to memorize the knowledge given by the teacher. A series of activities carried out instructional without giving the opportunity for students to find their own knowledge. This series of instructional activities conditions a silent classroom situation, without student activity, without question and answer activities, students only pay attention to the teacher's explanation. The passive student activities have an impact on the weak absorption of knowledge by students. The knowledge obtained does not last long in the memory of students, so that the science process skills of students are low.

3.2. Students' Critical Thinking Skills who are taught with the Scientific Inquiry Learning Model are better than Students who are taught with Conventional Learning.

The results obtained in this study indicate that the critical thinking skills of students who are taught using the scientific inquiry model are better than conventional learning. The pretest average value of the control class students' critical thinking skills is 35.20 and the mean post-test score was 62.71. Students who were taught by using scientific inquiry learning had an average pretest score of critical thinking skills was 37.70 and the post-test average score was 71.22. This finding is in line with the NRC statement which states that one of the goals of the scientific inquiry learning model is to provide
opportunities for students to practice and improve their critical thinking skills. This ability is important, not only for scientific activities, but for making decisions in everyday [35].

The results of this study are also in line with the results of research conducted by Safarati which states that students' critical thinking skills are above average by applying the scientific inquiry model and will be better than students who are taught using direct teaching models (direct instruction) [10]. The average critical thinking skills of students in the experimental class was 50.58 and the control class was 49.17. In addition, Suryani also argues that the critical thinking skills of students who are taught with the scientific inquiry learning model are better than students who are taught using conventional learning. Students who were taught with the scientific inquiry learning model obtained an average value of students' critical thinking abilities was 50.58 and students who were taught with conventional learning models an average value of 49.17 [36].

Scientific inquiry is learning that trains students to develop their thinking power in developing the application of concepts that have been learned in real life. Students try to learn how to ask questions by using facts to answer them [37]. In the scientific inquiry process, it is based on three important bases, namely the nature of scientific investigation, scientifically tested questions and scientific evidence and explanations. This is in line with what Pluck and Johnson stated where inquiry learning provides an advantage in fostering curiosity of students which is one part of students' motivation in learning [38].

Scientific inquiry can develop students' skills in critically questioning researchable events that occur in everyday life. When students learn scientific concepts and processes, students develop skills to approach phenomena like a scientist [39]. Scientific inquiry helps students explore knowledge by improving students' critical thinking skills. The increase in critical thinking skills of students is influenced by the learning stages of the scientific inquiry model. The stages in the scientific inquiry model require students to conduct research that helps accelerate the development of students' curiosity. This is in line with that stated by Pluck and Johnson where inquiry learning provides an advantage in fostering curiosity of students which is one part of student motivation in learning.

The stages of scientific inquiry learning are orientation, namely a step to foster a responsive learning atmosphere between teachers and students. Formulate a problem which is a step to bring students into a problem that attracts the attention of students. The problems presented are in the form of problems that can challenge students to think about how to solve these problems. To test the truth, a hypothesis is formulated as a temporary answer to the problem being studied. Collecting data is an activity to capture the information needed to test the hypothesis that has been proposed. Testing hypotheses to determine the answers that are considered in accordance with the data that has been obtained based on data collection. The level of confidence of students on the answers they give is the most important thing in testing a hypothesis. Draw conclusions based on the results of hypothesis testing.

Critical thinking skills are important skills because they prevent someone from making bad decisions but help them in solving problems. Critical thinking skills are not easy skills to develop or use. The scientific inquiry learning model provides students with specific directions so that students can explore new fields effectively. Thus, it can be concluded that the scientific inquiry learning model is better at increasing students’ critical thinking skills compared to students who are taught with conventional learning.

In the control class, it can be seen that the critical thinking skills of students increase but not higher than the experimental class. This is because conventional learning is learning that tends to be teacher-centered, where learning activities are fully held by the teacher in order to achieve all learning material so that students are basically active in class experiencing an increase in learning outcomes, while students who are not active just sit on the knowledge that is delivered the teacher. Therefore, the increase in critical thinking skills obtained by students is not significant when viewed from the average value.

The constraints experienced by researchers when conducting research include guiding students in forming groups and organizing activities to be carried out. In addition, students do not fully understand
the physics practicum tools used. The result is the use of considerable time to coordinate these conditions. The activities that appear in accordance with the Scientific Inquiry learning model are not used and even have never been carried out by students. So that there is still a sense of shame and doubt when doing practicum, proposing hypotheses and drawing conclusions that are still embedded in students, so that students have difficulty making conclusions on the results of their group practicum. Students are also still confused with the form of problems given by researchers because students never receive questions in the form of problems related to everyday life because students are only accustomed to working on questions in the form of formula applications. The obstacles faced by researchers are finding and determining the practicum to be carried out in learning and providing the necessary practicum tools.

4. Conclusion
Based on the results of research at SMA Primbana Class XI Semester II Academic Year 2019/2020, it can be concluded that; (1) The science process skills of students who are taught with the scientific inquiry learning model are better than students who are taught with conventional learning models. So it can be concluded that the scientific inquiry learning model has an influence on the science process skills of students, especially on temperature and heat material; (2) The critical thinking skills of students who are taught with the scientific inquiry learning model are better than students who are taught with conventional learning models. So it can be concluded that the scientific inquiry learning model has an influence on critical thinking skills of students, especially on temperature and heat material.

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