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Original Research Article

Interaction of Scientific Inquiry Learning and Formal Reasoning Models toward Students' Physics Scientific Knowledge

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Abstract

Scientific knowledge is one of the expected direct impacts in the Scientific Inquiry learning model (Joyce, 2009), which means that Scientific Knowledge is the learning outcome that is to be achieved in learning. Scientific knowledge is the result of student physics learning that is concerned with strengthening cognitive structures in understanding, mastering and applying physics concepts so students can solve physics problems from simple to complex. As for the purpose of this study are: 1. To know whether or not there are differences Scientific Knowledge of Physics between students taught using the Scientific Inquiry learning model and conventional learning 2. To find out whether or not there are differences in Scientific Knowledge of Physics caused by students 'Formal Reasoning 3. To find out the interaction between the learning model and Formal Reasoning in increasing students' Scientific Knowledge? As for research design in this study using different analysis for the two dependent variables. Variables are bound to Scientific Knowledge using analysis of variance or 2x2 ANOVA. The research instrument used was in the form of a description for the scientific knowledge test, and multiple choice forms on the students' formal reasoning test. The conclusion of this study was 1. The ability of scientific knowledge of students to use scientific inquiring learning was better than the scientific knowledge ability of students using expository learning models, The ability of scientific knowledge of students in the formal reasoning group is above average better than the scientific knowledge ability of students in the formal reasoning group below the average, 3. There is an interaction between the learning model and formal reasoning in improving students' scientific knowledge. The scientific knowledge learning outcomes of students taught through the scientific learning model in the formal reasoning group above average and formal reasoning are below the higher average compared to the results of scientific knowledge learning students taught through conventional learning in the formal reasoning group above average and in the formal reasoning group below average.

Keywords: Scientific Knowledge, Scientific Inquiry, Formal Reasoning.

INTRODUCTION

Background

Based on the results of observations conducted by researchers at the Senior High School Al-Fityan in Medan, it was found that the implementation of learning physics was still not able to show the nature of physics. The results of interviews with several students also stated that students very rarely do Physics learning with laboratory activities. The teacher usually directly teaches the concept of physics without experiment first. The use of student sheets has also not yet practiced science process skills in students so that students are not optimally motivated in the learning process. So the learning objectives so that students have scientific knowledge from the research process they do are not achieved.

In a previous study, Nasution [1] found that the problems that exist in students are having a low ability to solve problems in real conditions, because students are more concentrated on equations and mathematical calculations not on conceptual knowledge, so students find it difficult to apply their knowledge get in everyday life.

The *Scientific Inquiry* learning model can be used to create an environmental system that teaches students and part of the teaching model of processing information. According to Metz [2], *"Scientific Inquiry models have been developed for use with students of all ages, from preshschool through college."* Furthermore, according to Joyce [2], *"The essence of the model is to engage students in a genuine problem of Inquiry by confronting them with an area of investigation, helping them identify a conceptual problem within the area of investigation, and inviting them to ways of overcoming*

that problem." This learning model is used because in practice the teacher provides guidance or guidance that quite broad to students, or in other words most of the plans are made by teachers including problem formulation activities.

The application of the *Scientific Inquiry* learning model is to expose students to a scientific activity (experiment). Students are trained to be skilled in obtaining and processing information through thinking activities by following scientific procedures (methods), such as: skilled in observing, measuring, classifying, drawing conclusions and communicating findings. Students are directed to develop their science process skills in processing and discovering the knowledge themselves.

The expected goals of learning activities are certainly not easy to get good learning outcomes for students. Likewise with the use of the *Scientific Inquiry* learning model, it is certainly not easy to obtain good learning outcomes by simply applying the learning model without including students' abilities in learning. This study chose one of the students 'abilities, namely the existence of students' formal reasoning abilities. From the description above can be identified several problems, among others, they are: 1. In the process of learning physics, students are only emphasized in aspects of memorizing concepts and principles or formulas, 2. Scientific knowledge of students is still low, 3. Utilization of laboratories that have not been optimal, 4. The existence of differences in *Formal Reasoning* of students, in the previous study mentioned that there is a *Formal Reasoning* effect on student learning outcomes.

Research Purposes

To find out the interaction between the *Scientific Inquire* Learning and *Formal Reasoning* models in enhancing students' Scientific Knowledge.

Problem Solving Approach

Are there interactions with the *Scientific Inquire* Learning and *Formal Reasoning* models in enhancing students' Scientific Knowledge?

SCIENTIFIC INQUIRY LEARNING MODEL

Theory of Learning Cognitive Development Piaget argues that knowledge is formed by individuals. Because individuals carry out continuous interactions with the environment. The environment changes. With the interaction with the environment, intellectual functions are increasingly developing [3].

Dahar [4] said that the important idea of Vygotsky is scaffolding, which is giving assistance to children during the early stages of development and reducing the assistance and providing opportunities for children to take on greater responsibilities as soon as the child can do it.

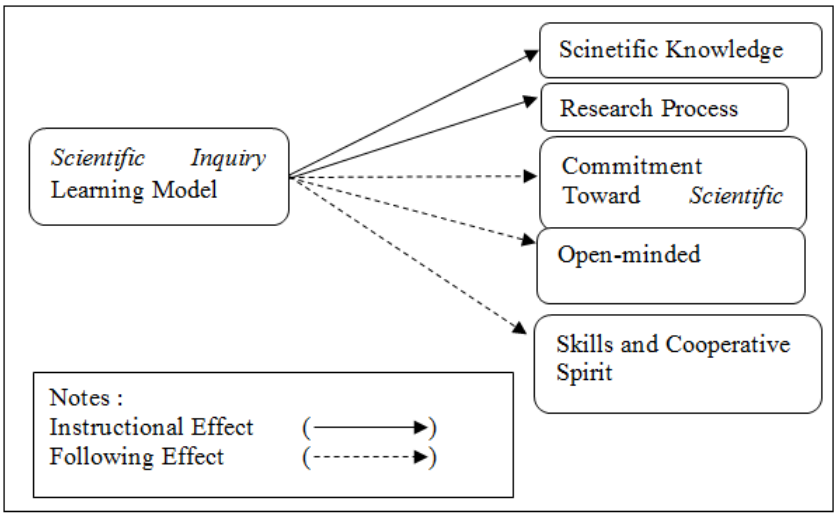
Joyce *et al.*, [5] stated that the essence of the *Scientific Inquiry* learning model is to involve students in investigating actual problems by confronting them in investigations, helping them identify methodological or conceptual problems in investigations and inviting them to design ways to overcome these problems. Thus, students can find out how a knowledge is built in the community of scientists. At the same time, students will also appreciate knowledge as a result of exhausting research processes and may also learn the limitations and advantages of present-day knowledge.

Table-1:Syntax of *Scientific Inquiry* Learning Model

First Phase Presenting problem to students
Second Phase Students formulate the problem
Third Phase Students identify the problem in inquiry
Fourth Phase Students find the ways to solve the problem

Source, Joyce *et al.*, [5]

The *Scientific Inquiry* model is designed to teach the process of scientific research, to teach students how to process information, and to foster commitment to scientific research. This model can also foster openness and the ability to defer alternative assessment and balance. Besides that, it can also maintain the spirit of cooperation and the ability to work with others in scientific research.



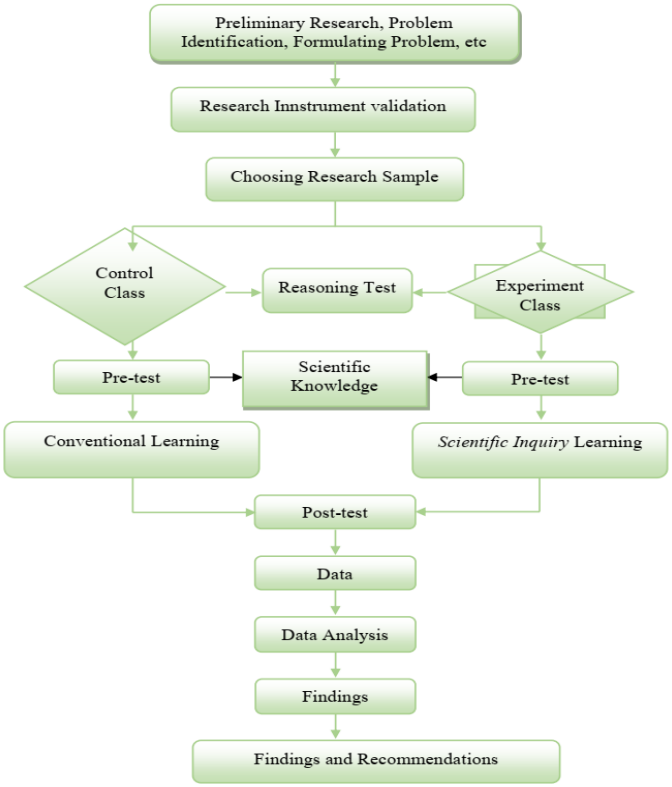
Picture I: Instructional Effect

The *Scientific Inquiry* learning model that is different from other Inquiry in the proposed explanation can be revised or discarded considering new information. Students can consider alternative explanations because they compare their results with others. Students realize their results are related to the flow of scientific knowledge [6].

Based on the explanation above, the *Scientific Inquiry* learning model is a learning innovation that can be applied to physics learning. Physics is one of the sciences that is acquired and developed based on experiments that seek solutions to various kinds of questions about natural phenomena and phenomena, and this is in line with the essence of *Scientific Inquiry* learning model which is to involve students in real problems by involving students directly under investigation.

RESEARCH METHODS

In order to make it easier in conducting research, steps are presented in the research flowchart.



Picture II: Research Scheme

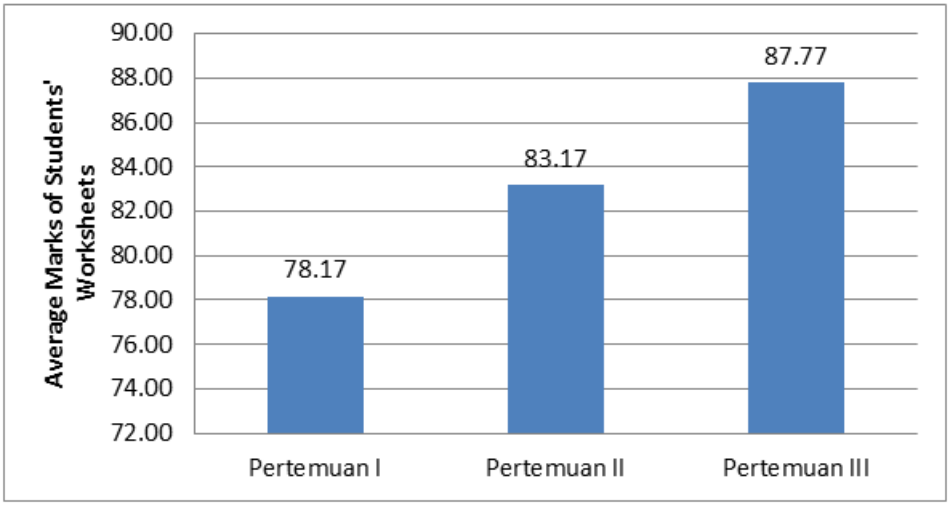
Research Location

This research is conducted in Al-Washliyah High School 3 Medan class X semester II with the subject matter of Temperature and Heat.

DISCUSSION

This research was conducted in class XI 1st Semester Senior High School Al-Washliyah 3 Medan, in the 2018/2019 academic year. This research is a quasi-experimental study involving two homogeneous classes of samples where each class is given a different treatment (learning model). Class XI IPA 2 is a control class given treatment using conventional learning, while class XI IPA 1 which is an experimental class is given explore using the scientific inquiry learning model. At the time of pretesting students are given two types of instruments, namely instruments for learning outcomes in the form of scientific knowledge and formal reasoning instruments. Formal reasoning instruments are instruments that must be filled by students to classify students based on their formal reasoning. In this study students will only be grouped into two, namely students who have formal reasoning above average and formal reasoning below the average.

The results of students' scientific knowledge observation, the researchers also analyzed the results of the worksheets of students' work that had been done by students during conducting experiments at each meeting. Students' worksheets done by students are assessed by referring to the results of the student worksheet tests conducted by the researcher. The results of the assessment of student worksheets can be seen in Figure.



Picture III: Average Marks of Students' Worksheets

Based on the data for testing the student activity sheet from the three meetings conducted by the researchers it was found that there was an increase. This can be seen as Picture III. above shows that for the first meeting the average test sheet for student activities has an average of 78.17, for the second meeting has an average value of 83.17 and for the third meeting student activity sheet 87.77 . From the data above it can be concluded that the value of the activities of the student worksheets carried out through practicum through improvement.

Learning in the control class is carried out with ordinary learning. The teacher provides oral and written explanations based on the handbook owned by students. Students are given practice questions to master the concepts given by students. Students are given practice questions to master the concepts that have been given. Students are required to answer questions and write them in their exercise book. This is the treatment given by the teacher in the control class. After both classes get treatment, then both classes are tested posttest scientific knowledge of students. The average obtained in the experimental class was 70.83 while in the control class 70.80, after that an interaction test was conducted on exploring the Formal Reasoning and reasoning models

Table: SPss

Class	High_Low	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	Below Average	70,222[a]	1,817	66,582	73,863
	Above Average	70,667[a]	2,226	66,208	75,125
Experiment	Below Average	73,538[a]	2,138	69,255	77,822
	Above Average	82,588[a]	1,870	78,842	86,334

Whereas in the experimental class formal reasoning is above the average of 82.58 and formal reasoning is below the average of 75.53. It can be concluded that the level of formal reasoning above the average in the experimental class is better than the class. Likewise for formal reasoning below the average for the experimental class (inquiry training) is better than the control class.

Tests of Between-Subjects Effects					
Dependent Variable:Nilai					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1629,807[a]	3	543,269	9,138	,000
Intercept	321219,433	1	321219,433	5403,306	,000
Class	845,451	1	845,451	14,222	,000
High_Low	328,218	1	328,218	5,521	,022
Class * High_Low	269,636	1	269,636	4,536	,038
Error	3329,126	56	59,449		
Total	338272,000	60			
Corrected Total	4958,933	59			
a. R Squared = ,329 (Adjusted R Squared = ,293)					

Based on the results of hypothesis testing for interactions between the scientific inquired learning model with formal student reasoning (formal * reasoning models) can be seen a significant value (sig) is 0.038. Because of the sig value. 0.038 <0.05 then Ha is accepted, which means that there is a significant interaction between the model of *Scientific Inquiry* learning and expository learning with a level of *Formal Reasoning* towards student scientific knowledge

Learning physics not only helps students acquire knowledge, skills, and attitudes, but more important is helping students learn about how to learn knowledge, skills and attitudes obtained. The physics learning process is not enough just to transfer teacher knowledge to students, but it must go through a dialogical experience that is characterized by a learning atmosphere characterized by real experiences.

Learning models explored to interact with *Formal Reasoning* applied to both groups of samples have the same effect on the level of formal reasoning of students. But in its implementation there are differences in the level of *Formal Reasoning* of each individual in learning, both from observational data made during the learning process. The level of formal reasoning is distinguished in the category of formal reasoning above the average and below the average.

Based on research conducted by I Nengah Surata, Budi Kustoro, Abdurahman [7], which states that students' critical thinking skills given the deductive-hypothesis learning cycle model are higher than the empirical-inductive learning cycle model in the high *Formal Reasoning* group compared to the reasoning group formal low. In line with that, based on the research of M. Nawi [8] states that students' formal reasoning abilities influence student learning outcomes. besides that based on M. Tawil's research [9], *Formal Reasoning* ability has a positive effect on mathematics learning outcomes.

Formal Reasoning of student influences students' achievements. *Formal Reasoning* is important for students to solve problems in a study. Based on research conducted by Baird *et al.*, [10] formal reasoning is important for increasing scientific knowledge, especially in data manipulation, controlling variables for research and for determining causal relationships in solving problems.

The existence of interaction between the *Scientific Inquiry* learning model and the above *Formal Reasoning* for scientific knowledge is because in the scientific inquiry learning model students encourage students at a higher level of thinking ability and more meaningful learning. Students who are more interacting and active in the class are more dominant in increasing their scientific scientific knowledge. This is what makes students more easily understand the subject matter given and will be stored longer in the memory of students, so the results of students' scientific knowledge are better than before, which can be seen from achieving higher average student scores compared to the average value students are taught using conventional learning models. This is in line with the

research conducted by Bao *et al.*, [11] saying that formal reasoning is needed in the inquiry stage in the form of experiments, evaluations, inferences, arguments that support and modify the theoretical concepts of science and social knowledge. To achieve better learning achievement, each student must have formal reasoning above the average so that students who are diligent in learning, responsive to difficulties, attention focus more on the material being taught.

CONCLUSION

There is an interaction between learning models and *Formal Reasoning* in improving students' scientific knowledge. The scientific knowledge learning outcomes of students taught through the *Scientific Inquiry* learning model in the *Formal Reasoning* group above average and formal reasoning are below the higher average compared to the results of scientific knowledge learning students taught through conventional learning in the formal reasoning group above average and in the formal reasoning group below average.

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