Mental Model Students on Thermodynamics in the Application of Guided Inquiry

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ABSTRACT
Inquiry learning is a model that facilitates the construction of students' scientific knowledge, which can also improve students' mental models. By considering the student learning process, the guided inquiry learning was chosen. The purpose of this study was to determine whether the use of the guided inquiry learning could teach thermodynamics and affect the student learning process. The data obtained were then analyzed through quantitative and qualitative methods. The results confirm the importance of using appropriate learning models in delivering learning materials.

Keywords: *Mental model, Guided inquiry learning, Thermodynamics.*

1. INTRODUCTION

Learning physics and scientific literacy in higher education can help students become productive and responsible [1]. Universities are responsible for achieving this goal and the role of lecturers is very important in learning. Many lecturers still think of students as rather simple thinkers. This is wrong thinking. If students are guided properly, then students can think accurately and abstractly [2]. Therefore, lecturers are required to apply learning models that are considered suiTable to help students to build scientific knowledge with accompanying abilities such as predicting and analyzing. Educating practitioners are now experiencing a shift in the former learning model to a learning model that actively involves students using problems in everyday life [3]. The use of learning models helps lecturers in conveying material to students so that students are able to explain phenomena and encourage the development of their own mental models. This is because there is a relationship between the acquisition of knowledge during the learning process [4]. So we need a learning model that can provide opportunities for students to research, explore, collaborate, make choices and imagine.

From the explanation above, the inquiry learning model can be chosen in delivering material that provides opportunities for students to explore, because the inquiry learning model is a category of investigative approach in the learning process [5]. And as a pedagogy that allows students to experience the process of creating new knowledge [6]. The inquiry learning model uses complex problems in everyday life [7]. Although the inquiry learning model may have been considered to have been carried out in the twentieth century and the inquiry learning model is not a new phenomenon in education, but teachers / educators believe that everyone should strive to develop themselves continuously until excellence is achieved. So that the inquiry learning model is still believed to be able to activate students in the classroom [8]. The purpose of the inquiry learning model is to position students as producers of new knowledge and meaning through exploration in the learning process [5].

Spronken-Smith and Walker [9] identified that the inquiry learning model is (1) question driven, (2) based on knowledge building processes, (3) student-centered, (4) student take responsibility to their own learning, and (5) focusses on the learning. The inquiry learning model varies in conveying material to students (structured, guided and open inquiry) [10]. The guided inquiry learning model that is in accordance with the characteristics of students aged over 12 years according to Piaget's theory that children can already use their concrete thinking of formal operations to form detailed operations, the developmental characteristics are hypotheses, abstracts, deductive and inductive such as logical and probability [11].

Guided inquiry, lecturers provide questions related to daily life problems related to learning materials then students investigate problems independently presented by lecturers through specified procedures, work collaboratively, decide which processes to follow and targeted solutions. The result is not known by the lecturer. In guided inquiry, the lecturer provides questions and investigation procedures to students to reduce errors in the investigation process. Students take the lead in the investigation process, and have main role to collect data and create conclusion.

In the investigation process, mental models help students predict phenomena. Mental models are representations and concepts that come from someone or someone's mind which is presented in the form of a picture or explanation of the phenomena that occur when learning and is the result of understanding the surrounding reality [13][14][15]. Mental models can be generated from new understanding, old knowledge, existing ideas and experiences that are used to figured out events in the real world [16]. The role of lecturers in forming students' mental models is very important. Changes in information obtained by students about a problem can result in changes in their mental models. The learning process to train students to make mental models can be started gradually by asking students to match information based on students' imaginations in different explanations. Darabi, et.al [17] suggested that the availability of information is one of the factors in building students' mental models.

The purpose of this study was to determine the use of the guided inquiry learning model that was integrated into the intervention could teach thermodynamics material and affect the student's learning process.

2. METHODS

The research method used combining quantitative and qualitative methods simultaneously without any greater value to either of them. Participants were students with a total of 40 people who were given treatment using a guided inquiry learning model. The learning process with thermodynamics material is carried out for 3 hours of lessons with three face-to-face meetings. The instrument and data collection used were pre-test and post-test on thermodynamics with the number of questions consisting of 4 open-ended questions with the purpose to analyzing the development of students' mental models. Finally, interviews were conducted to clarify participants' answers to the pre-test and post-test to analyze mental models and the use of guided inquiry learning models. Thermodynamics questions and interview questions have been validated by two experts.

3. RESULTS AND DISCUSSION

Collecting data with various types of quantitative data (through pre-test and post-test), and qualitative data (through interviews). In accordance with the research objectives, which were analyzed more deeply. Thus, the analysis and discussion of the data which organized into three distinct subsections. There are development of mental models student; assessment of the typology of guided inquiry learning models; and the importance of the learning model in delivering the material. For each of these subsections, have big role to the achievement of the objectives, data were collected by different instruments, described earlier in the research methods section: pre-test, post-test and interviews for analysis of student mental model development, for assessment of typology of guided inquiry learning models and for analyzing the importance of learning model in delivering the material.

3.1. Development of Mental Models Student

The results of developing a mental model using the rubric adaptation of Abraham, et al [18] on each question indicator as follows: The pre test and post test scores are based on the number of students and the level of 5-sound understanding, 4-partial understanding, 3-inccorrect understanding, 2-no understanding, 1-no Response. The treatment of the lecturer delivering thermodynamic material using the guided inquiry learning model is as follows

Table 1. Students' Answers for Pre test and Post test

No. Test	*Pre-test*					*Post-test*				
	1	2	3	4	5	1	2	3	4	5
1	10	20	10	0	0	0	0	4	6	30
2	4	26	10	0	0	0	0	4	18	18
3	10	20	10	0	0	0	0	4	12	24
4	8	22	10	0	0	0	0	4	6	30

Then the interviews were recorded and transcribed to make sure the objectivity and facilitate data for analysis. One of the objectives of this interview was to understand whether the change in answers was caused by the content discussed during the lesson. Questions for the following students: Does the material discussed in class affect the change in your answer? Which material? Does the lecturer in delivering learning materials in class allow you to understand thermodynamics material so that it changes the answer? To clarify the answer to the question, 1) ten kilograms of carbon dioxide (CO_2) is stored in a piston-and-cylinder device. CO_2 undergoes a cycle with the data: T1 = 145ºC, T2 = 440ºC, P1 = 150 kPa thermodynamics consisting of three processes. The process is process 1-2: constant pressure expansion Process 2-3: constant volume Process 3-1: constant temperature compression and sketch the PV cycle diagram and calculate the total work done in kJ, 2) Gas in isolated container A, at the initial conditions P1, V1, m, and T1. (pressure, volume, mass, and temperature). A valve is then opened which causes the gas to expand freely into the insulated container B, (the initially empty container B). After the gas is stationary, the final state of the gas is P2, V2, m, and T2. In thermodynamics, a process is said to be reversible if it does not produce entropy. Why is the described process irreversible and describe the state of the particles in the container, 3) A house using an isolated system requires 138 MJ / h to maintain a comfortable room temperature in the rainy season so use a heat pump compressor with an electric power of 7.7 kW and determine the COP heat pump (Picture), if the heat pump operates 125 hours in a month during the rainy season, how much will the owner of the house pay for the heat pump that month? for electricity costs Rp. 1,600, -/ kW-h, 4) If the heat absorbed by the high temperature reservoir is 1200 joules, determine and explain it in this PV image then determine the efficiency of the Carnot engine, the work of the Carnot engine, the ratio of the heat discharged at low temperatures with the work done by the Carnot engine, and explain in the picture the types of processes ab, bc, cd and da.

Students' opinions vary, examples of answers in class material affect the answer, because the lecturer guides but in learning activities the lecturer does not help in the investigation process, so there are some questions that are not sure of the truth, namely question no.2. Clarification of questions, each student answered the same according to the test results.

The above data needs to be analyzed more deeply to find out whether there are differences between the pre-test and post-test results of students in this research. To this end, we begin with a simple statistical analysis of the mean and standard deviation across both tests, as follows.

Table 2. Student results (pre test and post test)

Treatment	Pre-test	Standard Deviation	Post-test	Standard Deviation
Guided Inquiry Learning	26.25	15.77	88.44	15.67

Based on the data in Table 2, the average post-test result is higher than the pre-test. This data is to confirm an increase in students' knowledge of thermodynamics. In order for this information to be relevant, an n-gain test is carried out, obtained as follows.

Table 3. Results of N-gain score

Treatment	Pre-test	Post-test	N-gain	criteria
Guided Inquiry Learning	26.25	88.44	0.84	High

The results of the n-gain score test showed that there is a significant increase in student outcomes. This shows that students develop knowledge and develop their mental models on thermodynamic.

3.2. Assessment of the typology of guided inquiry learning

Based on the collected results (students' opinions about the treatment using the guided inquiry learning model) showed that this model encourages meaningful learning. There are differences in the results of pre-test and post-test and the results of the n-gain test in high criteria, namely there is an increase in post-test results, then students experience mental model development. Guided inquiry learning encourages students to carry out practical activities, methods to collect and analyze data, build hypotheses, and draw conclusions. Students also become able to do scientific research.

3.3. The importance of the learning model in delivering the material

In today's era, there is no doubt that learning through inquiry is an important step to develop a scientific literation, critical, logical, and creative society [19]. The advantage of the inquiry process in an every element such as a school, is to prepare for a modern way of life with many aspects of dynamism, entrepreneurship, teamwork, and metacognitive thinking [12]. Critical and logical thinking plays an important role in the process of investigating and developing mental models. The inquiry learning model is carried out to emphasize the gradual experience through the inquiry process. Improvements in the use of appropriate inquiry learning models in delivering material will be beneficial for students. In particular, the guided inquiry learning model is an active learning model that focuses on understanding concepts and prioritizing student discovery as the core of learning [20]. Learning activity will be more meaningful if students are given the opportunity to know and be actively involved in finding concepts from facts seen from the environment with teacher guidance [21].

4. CONCLUSION

Prior to the application of the guided inquiry learning model, a pre-test was used to ascertain the mental models possessed by students. The data shows that their mental model is thermodynamically inconsistent, and this is because it is related to the previous concept. After the treatment by applying the guided inquiry learning model, the post-test was used to show the development of students' mental models. This study is to develop a mental model by being treated with a guided inquiry learning model and this analysis has limitations. This guided inquiry learning model was used to the research sample for this research. All students actively participate in these activities, they ask questions and have opinions about the material being taught. Interview analysis led to the conclusion that the guided inquiry learning model succeeded in developing students' mental models.

AUTHORS' CONTRIBUTION

Tutut Nurita: Wrote the manuscript. An Nuril Maulida Fauzia: Data analysis. Enny Susiyawati: analysis the references. Dyah Astriani: analysis the references. Erman: Review manuscript

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