# P06

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# Trained Inquiry Skills on Heat and Temperature Concepts

# Trained Inquiry Skills on Heat and Temperature Concepts

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**Abstract**. Inquiry skills are skills that aperson needs in developing concepts, but the results of the study suggest that these skills haven't yet been trained along with the development of concepts in science feeding, found the difficulties of students in building the concept scientifically. Therefore, this study aims to find ways that are effective in training inquiry skills trough Levels of Inquiry (LoI) learning. Experimental research with one group pretest-postest design, using non-random sampling samples in one of vocational high school in Cimahi obtained purposively 33 students of X class. The research using the inquiry skills test instrument in the form of 15questions multiple choice with reliability in very high category. The result of data processing by using the normalized gain value obtained an illustration that the ways developed in the LoI are considered effective trained inquiry skills in the middle category. Some of the ways LoI learning are considered effective in communicating aspects through discovery learning, predicting trough interactive demonstration, hypotheses through inquiry lesson, and interpreting data through inquiry lab, but the implementation of LoI learning in this study hasn't found a way that is seen as effective for trespassing aspects of designing an experiment.

## 1. Introduction

To build knowledge scientifically and use it in decision making or solving problems then in need of inquiry skills that include asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments [1]. Inquiry skills are the skills needed to conduct a scientific inquiry process. These inquiry skills are developed and experienced through working collaboratively with others and so communication, teamwork, and peer support are vital components of inquiry classrooms [2].

Based on the results of observation analysis of physical learning in vocational high school conducted by researchers to physics learning activities in the classroom obtained that the inquiry aspects of student's skills are not trained on the process of physical learning in class because based on the observation of physics learning process is still centered on the teacher. The role of more students as recipients of what information is conveyed by teachers, student activities in this learning is listening to information, record teacher explanations, reading books and exercise questions. Based on the result o the score of inquiry skills test, it was found that the inquiry skills test results predicting, hypotheses, design an experiment, interpreting data, and communicating the students including very low category. This is because in the learning process students do not trained aspect of inquiry skills, teachers rarely do practical activities that can develop aspects of student inquiry skills, one cause is due to inadequate laboratory facilities. Learning strategies implemented by teachers have not trained aspects of student inquiry skills.

Helping students engage in scientific inquiry and develop science inquiry skills in the context of learning science is one of the most important goals of science education [3]. One characteristic of inquiry learning is that students are fully involved in the active learning process. Students who are making observations, collecting data, analysing data, synthesizing information, and drawing conclusions are developing problem-solving skills. These skills fully incorporate the basic and

integrated science process skills necessary in scientific inquiry [2]. Scientific inquiry is often presented as a set of unorganized but interconnected procedures [4]. Teachers and prospective teachers are regulary encouraged to use inquiry processes in demonstrations, lessons, and laboratories, but few organized patterns are provided to link inquiry into this approach. This often raises questions for teachers and prospective teachers about the differences in demonstrations, lessons, and labs, and what role each inquiry possesses for each of these activities. The science teacher in the world who uses an inquiry-oriented teaching approach should have a comprehensive understanding of relationships among them [5]. Therefore, a construction is needed that can link these procedures in an organized manner so that it is easier for teachers to apply an inquiry activities into science learning. Teachers should have a comperehensive understanding of the hierarchical nature and the relationship between the various pedagogical practices and the inquiry process if they will teach science effectively by using inquiry [4]. Levels of Inquiry learning can train inquiry skills, students have the opportunity to observe, formulate predictions, collect and analyse data develop scientific principles, synthesize laws, and creat and test hypotheses to produce explanations [6,7]. Associated with material contens characteristics temperature and heat inquire needs of skills related to vocational TPTU (Teknik Pendingin Tata Udara), then in this research aspects of inquiry skills revealed are aspects of predicting, hypotheses, designing an experiment, interpreting data, and communicating. The five aspects of inquiry skills in this study trained by applying the Levels of Inquiry (LoI) learning which consists of Discovery Learning, Interactive Demonstration, Inquiry Lesson, and Inquiry Lab.

## 2. Learning Material

The learning material at the first encounter relates to the material of expansion on a substance, as for the material review is as follows: if the object is in heat, then the object will experience temperature rise and expansion, or change its form. The graph $\Delta V = f(\Delta T)$ is a linear function, it can be obtained through the graph curve equation. The expansion coefficient is a characteristic of the physical properties of an object, the object can be seen expanding the length ($\alpha$), expansion area ($\beta$), and expansion of space ($\gamma$), with the ratio $\alpha : \beta : \gamma = 1 : 2 : 3$. Characteristic properties of materials This can be used on the manufacture of bimetal switch, fuse. The material review at the second meeting: If the object is in heat, then the object will experience a temperature rise or a change in form. The graph $Q = f(\Delta T)$ is a linear function, hello expansion can be obtained through the equation of the graph curve line. The effect of heat on an object can be $Q = m\, c\, \Delta T$ (not the important factors of heat). Material review at the third meeting: Heat moves from a high-temperature object to a low-temperature object. Conduction is a heat transfer process without particle transfer. The advanced factors of heat conduction rate: the temperature difference between the two surfaces, the length of the cross section, the cross-sectional area, and the thermal conductivity of the substance, the heat conduction rate formula is $\frac{Q}{t} = \frac{k.A.\Delta T}{l}$. Convection is the process of transfer of heat from one part fluid gets another fluid by the movement of the fluid itself. The advanced factors of heat convection rate: the temperature difference between the two surfaces, the cross-sectional area, and the following convection fluid, the heat convection rate formula is $\frac{Q}{t} = h.A.\Delta T$. Radiation is the process of heat transfer in the form of electromagnetic waves. The advanced factors of the heat conduction rate: surface area, temperature, and emissivity, the radiation heat rate formula is $\frac{Q}{t} = e.\sigma.A.T^4$.

## 3. Experimental Method

Given this research aims to get an overview of ways to improve inquiry skills through the LoI approach on temperature and heat material for TPTU vocational students, then this research was conducted by quasi experimental method with one group pretest-posttest design [8], and the research will produce conclusions on the limited scope.

The population used in this study were the students of class X TPTU of vocational high school in Cimahi city with the number of 70 students, while the sample used was based on the purposive sampling based on the vocational curriculum which has the material of temperature and heat with 33 samples [8].

Based on population percentage and sampling and purposive sampling techniques according to research needs, this sample has drawn population [8].

The inquiry skills instruments developed based on the inquiry aspects of skills [9] totaling 15 multiple choice questions are reasoned. Instrument testing is done through two stages, the first step is to test the validity of the construct and this through expert judgment by using triangulation technique [8]. The second test is carried out by field testing using method of re-test so that obtained value of reliability equal to 0.91 with very high category. Based on this information then the instrument is worthy of use [1]. The sampling technique using non random sampling samples in one of vocational high school in Cimahi obtained purposively by department so that there is one class of 33 students. The study used the inquiry skills test instrument in the form of 15 multiple choice questions reasoned. Question of inquiry skills have been tested the validity of construct by three lecturers who are competent and have been tested by using the re-test method to obtain reliability of 0.91 which is included into the category very high.

In trained inquiry skills students applied Levels of Inquiry (LoI) learning for three meetings. The study of Levels of Inquiry (LoI) in this study is limited from the stages of Discovery Learning, interactive demonstration, Inquiry Lesson, and Inquiry Lab, this is due to the characteristics of the ability of vocational high school student in Indonesia. Physical material taught at the first meeting on expansion, at the second meeting on heat, and the third meeting on heat transfer. In addition to the inquiry skills test, the supporting instruments used are student worksheets which contain aspects of inquiry skills trained on the students and the implementation of Levels of Inquiry (LoI) learning as well as the questionnaire of student responses to learning.

## 4. Result and Discussion

### *4.1 Recapitulation score average normalized gain inquiry skills test*

Associated with the results of the pretest and posttest skeptical inquiry skills of the skills in the samples tested were obtained by the unrealized gain values in the following Table 1.:

**Tabel 1. Recapitulation score average normalized gain inquiry skills test**

| Test | $X_{Ideal}$ | $X_{min}$ | $X_{max}$ | $\overline{X}$ | Normalized average gain score category <g> | Category |
|---|---|---|---|---|---|---|
| *Pretest* | 45 | 2 | 15 | 7,18 | 0,63 | Medium |
| *Posttest* | 45 | 17 | 43 | 31,18 | | |

Based on Table 1., then it can be said that the ways that apply by using the LoI approach is considered effective to increase the inquiry skills students of vocational high school trhough the topic of temperature and heat in the medium category. Some of the ways LoI learning are considered effective in communicating aspects through discovery learning, predicting trough interactive demonstration, hypotheses through inquiry lesson, and interpreting data through inquiry lab, but the implementation og LoI learning in this study hasn't found a way that is seen as effective for trespassing aspects of designing an experiment.

### *4.2 Recapitulation the acquisition of localized gains for every aspect of inquiry skills*

If we distinguish for each aspect of inquiry skills, we get the value of the uniform gain $<\hat{g}>$ as in the following Figure 1:

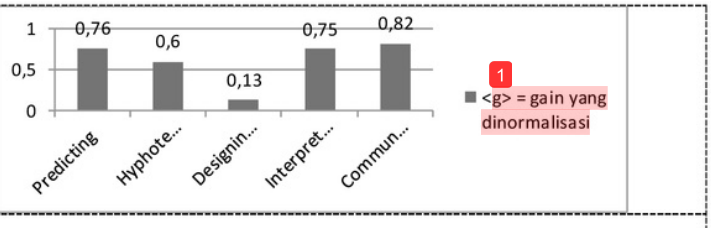



**Figure 1.** Recapitulation of normalized gain scores on each aspect of inquiry skills

Based on the picture above, the discussion that can be expressed in this research are:
Ways that are built with the LoI approach have a low category in improving design an experiment skills. The related instruments designing experiment are as follows:

8. To investigate the heat capacity of a liquid by using the set of tools and materials already provided, then the experiments that Anton does must be repeated using an electric calorimeter, then how to control the variables associated with the investigation…

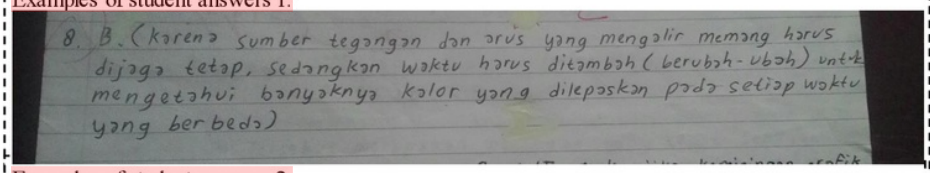
A. The voltage source, the current flowing, and the time must be kept constant
B. The voltage source, the current that flows must be kept fixed while the time must change
C. The voltage source, the current that flows, and the time must change
D. The voltage source must change, while the current that flows and the time is kept constant
E. The voltage source is kept constant while the current that flows and the time must change.

**Give the reason why you choose that answer!**

**Figure 2.** Sample of designing an experiment aspect

And the example of the answer expressed by the party is as follows:

Examples of student answers 1:




Examples of student answers 2:

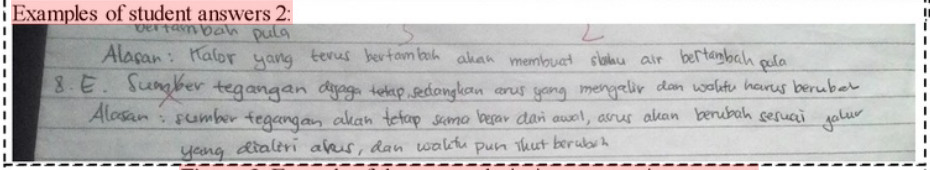



**Figure 3.** Example of the answer designing an experiment aspect

If we observe the result of learning activity, this skill planning training is at inquiry stage, the observation result of the implementation shows students are still mistaken in answering questions on aspects of designing experiments, this gives an indication of the ways in which the LoI approach is perceived to be ineffective. If we observe the results of side performance through worksheet that used, it can be disclosed the students do not know the variables investigation, where variables cause and effect dan mana variables that must controlled. The role o interactive demonstration does not provide for inquiry lesson, for novice students this may have to be trained in a real model that students can

follow, an interactive demonstration must provide a clear example of independent, bonded and controlled variables, and then repeated in the inquiry lesson. Teaching modelling learning by Harlen makes it easy for students to receive ways to designing an experiment [10]. If children are to develop the ability to plan there must be opportunities for them to start from a question and work out how to answer it. To take these steps by themselves is asking a great deal of young children and of older ones unused to devising inquiries. A set of questions related to the decisions they have to take provides a starting point. For instance, planning a fair test can scaffolded using a planning board on which children pin labels showing what they are going to change, what variables must stay the same and what has to be measured or observed to find the result [10].

Figure 1. shows that ways that are effective in Levels of Inquiry (LoI) learning can tap into the aspects of communicating through discovery learning, predicting through interactive demonstrations, hypotheses through inquiry lesson, and interpreting data through inquiry lab. It can be seen from the normalized average gain score on the communicating aspect that is 0.82 and included into normalized gain of predicting aspect is 0.76 included into the high category, the normalized average gain score aspects of the data interpret namely equal to 0.75 incluided into the high category, the average score of normalized gain on hyphothesized aspect that is equal to 0.60 included into the medium category. Aspects of inquiry skills communicating is to place information or data obtained from our observations into several forms that we can understand later. Students learn to communicate in many ways. They learn to draw diagrams, and accurate maps, make the right graph; create an accurate experiment models; and use clear language when describing objects or events. While the predicting aspect is a forecast of future observations based on the conclusions of available data. The more data available, the more confident we are in predicting, but it can also apply otherwise. Without some data we can only guess about the future; To predict is not possible when students put their data in form of graphs, the usually have many opportunities to predict. Students often need help when predicting, a simple diagram can help them reason through data. If they can not calculate the correct predictions, ask them to predict the direction of change that is useful to them [10]. The hypothesized aspect is a prediction of the outcome of an experiment [9]. In the Levels of Inquiry (LoI) study the skills of interpreting data are trained at the inquiry lab stage. In fact, tracing the hypothesized and interpreting aspect of the data requires an example or guidance from the teacher on how to hypothesize an experiment, and how to interpret the data correctly, since the characteristics of high school students in Indonesia still can not hypothesize and interprate the data themselves before given by example teacher. However, after several examples they are accustomed to hypothesize and interprat the data properly and correctly. In this study for three meetings each student is required to complete the student worksheet which contains aspects of inquiry skills trained including aspects of hypotheses and interpreting data, because they are accustomed to complement the student worksheet in making hypotheses and interpret the data although it must be guided by the teacher, so that students obtain average gain scores in the medium categoryon aspects of the hypotheses.

While the implementation of Levels of Inquiry (LoI) in this study has not found a way that is considered effective to trespass aspects of trial experiment. Normalized average gain scores on the design aspect of 0.13 are included in the low category. The inquiry skills aspect of designing experiments belongs to an integrated Levels of Inquiry skills aspect [9]. Aspects of designing experiments to design experiments required several skills including: student's skills in establishing investigative variables, inquiry procedures, preparation of necessary tools and materials. Variables are objects that are observed and investigated. The types of variables in the investigation are independent variables, dependent variables, and control variables. The independent variables is the treatment variable or the manipulation variable, the dependent variable as the result variable, while the control variable is the controlled variable so it does not participate effect on the dependent variable. Students skills of working procedures, can guide students to discover their own concepts of nature and to test hypotheses and predict expected outcomes. The inquiry skills aspect of designing an experiment is a very complex aspect, so it takes a long time to get it done so that the student has the inquiry aspect of designing an experiment well. In fact the students still can not control the variables in the experiment.

Judging from the overall activity of teachers and students when learning can be seen that the learning of physics by using Levels of Inquiry (LoI) can be done well, although there are still shortcomings.

## 5. Conclusion

The result of data processing by using the normalized gain value obtained an illustration that the ways developed in the LoI are considered effective trained inquiry skills in the middle category. Some of the ways LoI learning are considered effective in communicating aspects through discovery learning, predicting trough interactive demonstration, hypotheses through inquiry lesson, and interpreting data through inquiry lab, but the implementation of LoI learning in this study hasn't found a way that is seen as effective for trespassing aspects of designing an experiment.

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