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# THE EFFECT OF SCIENTIFIC ATTITUDES TOWARD SCIENCE PROCESS SKILLS IN BASIC PHYSICS PRACTICUM BY USING PEER MODEL

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**ABSTRACT:** The purpose of the research is to compare the influence of scientific attitudes toward the science process skills in basic physics practicum of PEER model with the conventional model. PEER is an acronym for Planning, Experiment, Evaluate, and Reporting, which is the stage of the model's practicum. Scientific attitudes here are honesty, collaboration, discipline, responsibility, open-mindedness. Scientific process skills here are: classifying, making a question, identifying and controlling variables, measuring, and inferring. The type of research is experimental with the static-group comparison design. Research subjects are 120 students from Physics Department, Chemistry, and Biology of Universitas Negeri Surabaya. Data analysis uses t-test. The results showed that: 1) The score of scientific attitudes and science process skills of the PEER model differed significantly from the conventional model ($t_x$ and $t_y > t_0$, with $t_0 = 2.7764$ and $\alpha = 0.05$); 2) The average score of scientific attitude of PEER model ($x_1 \pm \sigma_{x1}$) is better than conventional model, the average value of science process skill with PEER model is better than conventional model. The results of this study conclude that the PEER model practicum can produce better scientific attitudes and science process skills than conventional models.

*Keywords: scientific attitudes, science process skills, basic physics, practicum.*

## 1. INTRODUCTION

The globalization era is marked by the rapid development of science and technology as well as the acceleration of change in society which pushes the education sector to equip students with 21st-century skills through scientific literacy and science process skills [1]. Education is the enculturation that trains people to live in a particular culture which has some skills such as flexible, adaptive, initiative, self-control, social, productive, leadership, and responsibility [2]. Science process skills are thinking and acting that are used to discover, develop, and apply science, which involve intellectual skills and psychomotor skills related to natural sciences learning in all its aspects that derived from students' basic skills [3]. The elements of science process skills include: observing, classifying, measuring, communicating, inferring, predicting, collecting-recording and interpreting data, identifying and controlling variables, defining operationally, making a hypothesis, experimenting, making and using models [4]. Natural Sciences can integrate some attitudes such as objectivity, accuracy, precision, honesty, collaboration, discipline, responsibility, open-mindedness, courage, humility, decision-making, integrity, diligence, persistence, curiosity, etc. Concurrent development of many attitudes in a learning process is certainly impossible to do but integrating some of the selected attitudes as scientific attitudes in Natural Sciences learning is a real step. Physics is a branch of sciences that studies the nature of the object phenomenon in nature that provides life lessons aligned to the laws of nature and is used as a tool to develop the ability to solve problems in daily life. Basic physics is the basic idea that arises from the application of the scientific method which examines the most fundamental ideas about Physics that include the basic concepts and principles of physics required to study the next level of Physics or other sciences [5]. Physics learning is ideally implemented by using inquiry method to create the ability to think, work, and behave scientifically. Therefore, physics learning traces the scientific skills, which are skills related to scientific products, scientific processes, and scientific attitudes which are used to express the most important procedures, processes, and methods the scientists use when they construct science and solve experimental problems [6]. Practicum is a part of teaching that aims to get students to test and execute in real terms what is

obtained in theory. Practicum has three functions: training, giving feedback, and improving motivation, which in practice, requires adequate information-processing skills (intellectual) and psychomotor skills that are performed through a process that requires scientific attitudes (honesty, collaboration, discipline, responsibility, open-mindedness). This study aims to compare the effect of scientific attitudes on science process skills in basic physics practicum by using PEER model (planning, experiment, evaluate, and reporting) with conventional model practicum.

Basic physics practicum has the same procedures and requirements as experimental investigation, which requires students to carry out a series of steps including planning an investigation, carrying out experiments, evaluating with critical thinking and scientific reasoning, and reporting written and oral investigative activities. Planning is required to prevent students from trial and error which requires initial information to support the investigation. Carrying out Experiments are required to train students to conduct an investigation as planned, systematic, and developing the science process skills. Evaluating is needed to train students to develop critical thinking skills, and scientific reasoning when transferring the results of experiments to new situations. Reporting is required to train students to report scientific and responsible practicum investigative activities both written and orally. Practicum containing these elements is called the PEER model practicum is an acronym of Planning, Experiment, Evaluate, and Reporting.

Practicum is an investigation activity that, in many countries, Natural Sciences teachers apply it through teaching that develops scientific methods, critical thinking, scientific attitudes, problem-solving approaches, discovery methods, and inquiry methods [7]. Hands-on activities and exercises in the laboratory are essential so that students can carry out investigations as the scientists do [8]. The use of inquiry-based laboratory instruction showed a greater improvement in the science literacy and student research skills [9]. Another impact, inquiry-based learning can improve students achievement [10]. The results of research on the assessment of the application process of inquiry-based tasks in science education show that the most widely used method in science and technology is an experiment [11]. While investigation activities have a positive impact on student research skills, teachers should not be exaggerated in providing students with experience [12].

The learning model needed to anticipate the 21st century is what enables the creation of scientific thinking skills, the development of an inquiry sense and the students creative thinking ability [13]. The learning model needed is the one which is capable of producing the ability to learn, not only acquiring a number of knowledge, skills, and attitudes but also, more important is, how the knowledge, skills, and attitudes are obtained by students [14]. The learning model used should integrate science process skills into an integrated material presentation system [15]. The chosen learning model should help students learn to study, and help students acquire knowledge by finding it themselves [16]. Science-based learning process skills emphasize students' ability to discover knowledge based on learning experiences, laws, principles, and generalizations, thus providing an opportunity for the development of high order thinking skills [17]. Scientific experiences that need to be given and developed to students are science process skills, thinking skills, and scientific reasoning skills [4]. Science process skills provide students with the opportunity to get the knowledge by their own ability actively and creatively, enabling students to experience the process of discovery directly. The immediate experience that students experience will make learning more meaningful and make it easier for students to understand knowledge. Science process skills need to be applied in physics learning because students need not only knowledge, but also need to be trained to discover, develop, and apply that knowledge [1]. Mastery of science process skills by students will be the basic skills in further studies such as doing research and solve problems which become life skills. UNESCO in the Handbook for Science Teachers explains that "science is what scientists do" [18], the first point is to collect scientific knowledge to become 'body of scientific knowledge' and the second is a process of obtaining 'scientific knowledge'. Inquiry-based learning results in self-confidence in scientific abilities [9]. It is generally known that laboratory investigation activities can significantly improve student attitudes [19]. Furthermore, laboratory investigation activities have a good impact in getting scientific concepts [20], and the science process skills in physics exams allow students to think reflectively and creatively in problem-solving which leads to discoveries that are an essential thing for the development of science and technology [21]. As there are still few types of research concerning scientific attitude in Basic Physics practicum then this research focuses on finding out the effect of scientific attitude in the above subject during the practicum.

## 2. METHODOLOGY

The research type is static-group comparison design, comparing the two groups that each receive different treatment [22]. The first group receives a

practicum PEER model, the second group is given a conventional model practice. Practicum PEER model is a practicum in which the stages include: planning, experiment, evaluate, and reporting, while the conventional practicum is a common practicum applied so far. The scores of scientific attitudes and science process skills of each group are then compared by using the research design.

The research procedures are: first, dividing the subjects into two groups: the first group is given basic physics practicum using PEER model and the second group is given basic physics practicum with the conventional model. At the time of implementation, each group conducts an assessment to obtain the scores of scientific attitudes and scores of science process skills, then find the relationship between scientific attitudes and the science process skills of both groups. The scientific elements of attitudes are honesty, collaboration, discipline, responsibility, and open-mindedness, while the elements of science process skills are defined as classifying, making a question, identifying and controlling variables, measuring, and inferring. In addition, a comparison of scientific attitudes and science process skills of the first group to the second group is conducted. The procedure applies to students from three different departments: Physics, Chemistry, and Biology.

The subjects of this research are the students of Education Program of Universitas Negeri Surabaya majoring in Physics (40 students), Chemistry (40 students), and Biology (40 students). Students from each department are divided into two groups: the first group (20 students from each department) is given practicum activity using PEER model and the second group (20 students from each department) is given practicum activity with the conventional model.

Data collection techniques use observations and performance tests. The scores of scientific attitudes and the score of science process skills come from the score of performance tests using performance appraisal instruments, which use the Likert scale with the categories: very low = 1, low = 2, medium = 3, good = 4, and excellent = 5.

Data analysis uses correlation and t-test. Correlation is used to know the relationship between scientific attitudes and science process skills. The correlation criterion (r) used is: low = ($0 \leq r < 3$), medium = ($3 \leq r < 7$), and good = ($7 \leq r \leq 1$). The t-test is used to test the differences between the first group and the second group. If the score $t > t_0$, with $\alpha = 0.5$ then the first and second groups differ significantly. One group is declared better than the other if the average score is higher and the standard deviation score is smaller.

## 3. RESULTS

### 3.1 The Effect of Scientific Attitudes

Practicum activities assess the science process skills and the students' scientific attitude. The average score of scientific attitudes from basic physics practicum activities for both PEER models and conventional models from each department of Physics, Chemistry, and Biology major is shown in Table 1, as follows:

Table 1 Average score of Scientific Attitudes

| Unsure | Physics | | Chemistry | | Biology | |
|---|---|---|---|---|---|---|
| | PEER | Conv | PEER | Conv | PEER | Conv |
| 1 | 4.60 | 3.95 | 4.65 | 3.85 | 4.65 | 3.90 |
| 2 | 4.75 | 3.65 | 4.70 | 3.60 | 4.70 | 3.65 |
| 3 | 4.60 | 3.95 | 4.60 | 3.85 | 4.65 | 3.90 |
| 4 | 4.95 | 3.65 | 4.90 | 3.75 | 4.90 | 3.65 |
| 5 | 4.55 | 3.35 | 4.50 | 3.45 | 4.60 | 3.40 |

Note: 1= honesty, 2 = collaboration, 3= discipline, 4= responsibility, 5= open-mindedness.

whereas the average science skills score is as shown in Table 2, as follows:

Table 2 Average score of Science Process Skills

| Unsure | Physics | | Chemistry | | Biology | |
|---|---|---|---|---|---|---|
| | PEER | Conv | PEER | Conv | PEER | Conv |
| 1 | 4.10 | 3.05 | 4.15 | 3.00 | 4.20 | 3.05 |
| 2 | 4.15 | 3.45 | 4.10 | 3.35 | 4.15 | 3.45 |
| 3 | 3.95 | 3.85 | 3.90 | 3.75 | 3.90 | 3.75 |
| 4 | 4.60 | 3.90 | 4.65 | 3.70 | 4.55 | 3.80 |
| 5 | 4.35 | 3.00 | 4.30 | 3.10 | 4.40 | 3.00 |

Note: 1= classifying, 2= making question, 3=identifying and controlling variables, 4= measuring, 5= Inferring.

The relationship between the scientific attitudes and the science process skills can be seen from the correlation score (r) both for the practicum of PEER model and for the conventional model practicum from each Physics department, Chemistry department, and Biology department presented as Table 3 as follows:

Table 3. The Correlation between Scientific Attitudes and Science Process Skills

| Model | Physics | Chemistry | Biology |
|---|---|---|---|
| | Correlation scores (r) | | |
| PEER | 0,67767 | 0,63568 | 0,55768 |
| Conventional | 0,32816 | 0,37122 | 0,30952 |

Based on Table 3, it can be seen that the correlation of scientific attitudes and science process skills shows the correlation score 3> r> 7 which means correlation is in the medium category. This phenomenon happens in Physics,

Chemistry and Biology departments both for PEER model and conventional model practicum. It shows that there is a significant relationship between scientific attitudes and science process skills.

### 3.2 The Effect of Practicum Model

The effect of the model on the scientific attitudes and science process skills can be determined by comparing the practicum score of the PEER model with the conventional model practice score using t-test. The results of calculations with $\alpha = 0.05$ are presented in Table 4 for the scientific attitudes and Table 5 for the science process skills as follows:

Table 4 The effect of Practicum Model on Scientific Attitudes

| | Average ($X$) | | Variants ($\sigma^2$) | | t-test | |
|---|---|---|---|---|---|---|
| | PEER | Conv | PEER | Conv | t | $t_0$ |
| Physics | 4.69 | 3.71 | 0.02 | 0.06 | 7.0817 | 2.7764 |
| Chemistry | 4.67 | 3.70 | 0.02 | 0.03 | 11.8949 | 2.7764 |
| Biology | 4.70 | 3.70 | 0.02 | 0.04 | 9.2350 | 2.7764 |

Table 5 The effect of Practicum Model on Science Process Skills

| | Average ($Y$) | | Variants ($\sigma^2$) | | t-test | |
|---|---|---|---|---|---|---|
| | PEER | Conv | PEER | Conv | t | $t_0$ |
| Physics | 4.23 | 3.45 | 0.06 | 0.18 | 3.7334 | 2.7764 |
| Chemistry | 4.22 | 3.38 | 0.08 | 0.12 | 4.4205 | 2.7764 |
| Biology | 4.24 | 3.41 | 0.06 | 0.14 | 3.8847 | 2.7764 |

Based on Table 4 and Table 5, it can be seen that for each department both scientific attitudes and science process skills $t > t_0 = 2.7764$ for $\alpha = 0.05$. These results indicate that the scientific attitudes and the science process skills practicum of PEER models differ significantly from conventional models.

### 3.3 The Comparison Model

To know which model is better between PEER and Conventional, it can be seen from its average score and the standard deviation. One such model is better than the other if it has a larger mean score but has smaller deviation. The research data are shown in the following Table 6:

Table 6 Score Average and Standard Deviation

| | Scientific Attitudes | | | | Science Process Skills | | | |
|---|---|---|---|---|---|---|---|---|
| | $X_1$ | $\sigma_{x1}$ | $X_2$ | $\sigma_{x2}$ | $Y_1$ | $\sigma_{y1}$ | $Y_2$ | $\sigma_{y2}$ |
| Physics | 4.7 | 0.1 | 3.7 | 0.2 | 4.2 | 0.2 | 3.5 | 0.2 |
| Chemistry | 4.7 | 0.1 | 3.7 | 0.2 | 4.2 | 0.2 | 3.4 | 0.3 |
| Biology | 4.7 | 0.1 | 3.7 | 0.2 | 4.2 | 0.2 | 3.4 | 0.2 |

Based on Table 6, it can be seen that the average score of the scientific attitude of PEER model ($x_1 \pm \sigma_{x1}$) is better than the conventional model ($x_2 \pm \sigma_{x2}$), the average score of PEER model process science skills ($y_1 \pm \sigma_{y1}$) is better than the conventional model ($y_2 \pm \sigma_{y2}$ ). These results show that the PEER model practicum can produce scientific attitudes and science process skills better than conventional models.

## 4. DISCUSSION

Scientific attitudes describe the nature, determination, control, and way of thinking in conveying subjects related to science. Student's honest behavior is carried out when carrying out measuring and inferring activities which become the prerequisite of student's success in the process of solving the problem of his inquiry. Student's honesty in the lab can be seen from the indicators of not manipulating the data, and not dumping the data that is considered bad, but providing information on the data that are considered bad. Cooperation is an active role of students in carrying out the task and success of the group. Cooperation is a condition where students can synergize and support each other to achieve the achievement or goal set in practicum. When students carry out the practicum, they can share the task and role in completing the investigation, and each student can play a role according to his task of synergizing and integrating the results into group success. Student co-ops are seen with indicators of all group members performing the practice in groups, with a clear division of tasks, and each member completing the tasks well. Discipline in practicum activities is seen from the students' ability to manage the time according to allocations provided, and obey the rules. Students'discipline is seen with indicators: starting practicum activities on time, ending early, and each member performs his/her duties in an orderly manner. Responsibility is a consequence of the actions that have been done. When students perform activities of analyzing and synthesizing and take a conclusion from the results of analysis and synthesis, they must be prepared to face the consequences of the decision that has been chosen. At that time students have actually set a decision that has the consequence that the decision may be acceptable or not by others, and when others cannot accept the conclusion, the students are ready to give an explanation. Open-mindedness is the attitude of not imposing own ideas/opinions and can appreciate the ideas/opinions of others, and it is done when the students carry out reporting activities through the expression of ideas with the presentation. Conveying ideas requires good presentation techniques in order to demonstrate the

superiority of the ideas delivered and an open attitude in receiving responses to the ideas. Open attitude impacts effective communication because it produces a win-win solution, which raises the basic concept of effective communication that no one is to blame, so it needs an open attitude from all parties.

Classifying is the ability to classify objects or events by their nature. The students' ability in classifying can be seen from the extent to which students are able to classify information based on its nature such as facts, concepts, and principles. The results of this activity will be the foundation of students when implementing the next activity that is identifying and controlling the variables, and making hypotheses. Making question is an expression of students' curiosity about physical events or phenomena based on the information they have gained from retrieving and classifying activities. Making question can be seen based on the formulation indicator in making the question about the object to be investigated, its relevance, the language structure used is easy to understand, and using the Indonesian standard rules. Identifying and controlling variables are identifying the variables in a situation, selecting the variable to be manipulated and the constant variable. Students' ability to identify and control these variables can be determined based on indicators of the number of variables assigned from existing variables (manipulation, bound, and constant) and can establish relationships between variables appropriately. Measurement is the ability to perform measurements using appropriate measuring instruments to describe quantitatively using standard measurement units. The ability to measure students is viewed from indicators "the students can use measuring instruments according to the characteristics of the tool, use them for appropriate measurement objects, and write down the measurements and their errors with the scientific notation". Inferring is describing events based on observations and data, including causal relationships between events one to another. The event described is an observation when conducting an investigation to obtain data including data measurement results. Students explain the cause and effect relationship between events one with other events that form a collection of facts and building concepts based on the results of the investigation, especially the results of measurements that have been done. Inferring students can be known by the indicator "the students can write down the results from observations that can be understood, systematic, and written in standard Indonesian. This capability, in addition to requiring thinking skills, also requires accuracy, thoroughness, and honesty of the students when observing various inquiry events in order to obtain a sequence of words that describe the facts as they are, easy to understand, and are systematically described.

Based on the above description, it can be understood that the scientific attitudes closely related to the science process skills, which can determine the quality of students' science process skills and can even be a major pre-requisite (e.g. honesty and responsibility). The results obtained (can be seen in Table 3) do not ask what practicum model is used, the correlation obtained are both in the medium category. These results indicate that theoretically, the scientific attitudes support the scientific process skills in research conducted and in conjunction with other studies such as self-confidence in scientific abilities [9] and laboratory investigation activities improve student attitudes [19]. The practical stages of the PEER model are basically based on inquiry and science process skills that emphasize the process of how students' knowledge, skills, and attitudes are obtained [14], help students acquire knowledge by finding themselves [16], and provides an opportunity for the development of high order thinking skills [17]. The science process skills applied in practicum provide an opportunity for students to discover, develop, and apply knowledge [1]. Based on this fact, in practice, the PEER model will provide better scientific attitudes and science process skills than conventional practicum, and it is proven by the results of the research (see Table 4, Table 5, and Table 6). These results are in line with the previous research which concluded that PEER Model practicum gives better result compared to the conventional one both from soft skills and hard skills [23]. Based on the above fact, the conventional practicum which stresses on a scientific product only and less focus on process and scientific attitude needs to be changed into giving the stress on product, process, and attitude proportionally as conducted in PEER Model practicum.

## 5. CONCLUSION

The results showed that: 1) The relationship between scientific attitudes and science process skills is categorized medium; 2) Scores of scientific attitudes and scientific process skills of PEER models are significantly different from conventional models; 3) PEER model average Score of scientific attitude is better than conventional model, the average score of PEER model process science is better than the conventional model. The results of this study conclude that the scientific attitudes have a significant effect on science process skills, and the PEER model practicum can produce better

scientific attitudes and science process skills than conventional models.

There are suggestions as for the follow-up of these research namely: scientific attitudes should be planned and trained as part of the practicum activity goals and not just as a side impact alone. To produce students' maximum ability practicum, scientific attitude should be integrated with science process skills.

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