The use of physics practicum to train science process skills and its effect on scientific attitude of vocational high school students

E Wiwin¹ and R Kustijono²

¹SMK Negeri 12 Surabaya, Surabaya, Indonesia
²Department of Physics, Universitas Negeri Surabaya, Indonesia

E-mail: buelok@gmail.com

Abstract. The purpose of the study is to describe the use of Physics practicum to train the science process skills and its effect on the scientific attitudes of the vocational high school students. The components of science process skills are: observing, classifying, inferring, predicting, and communicating. The established scientific attitudes are: curiosity, honesty, collaboration, responsibility, and open-mindedness. This is an experimental research with the one-shot case study design. The subjects are 30 Multimedia Program students of SMK Negeri 12 Surabaya. The data collection techniques used are observation and performance tests. The score of science process skills and scientific attitudes are taken from observational and performance instruments. Data analysis used are descriptive statistics and correlation. The results show that: 1) the physics practicum can train the science process skills and scientific attitudes in good category, 2) the relationship between the science process skills and the students' scientific attitude is good category 3) Student responses to the learning process using the practicum in the good category. The results of the research conclude that the physics practicum can train the science process skill and have a significant effect on the scientific attitude of the vocational high school students.

1. Introduction

Nowadays, the world of education is required to be able to equip students with 21st-century skills such as: flexible, adaptive, initiative, self-control, social, productive, leadership, and responsibility [1]. These abilities must in line with the view of life, life attitudes, and life skills from students, and they can thrive in school, out of school, and family. In schools, these abilities can be trained through scientific literacy and science process skills [2]. One subject that supports the field of expertise in vocational high schools is Physics, which is the science related to facts, processes, theories, concepts and generalizations, which are not merely about memorization, but also processes that enable students to link one concept with another to express a meaningful relationship. Therefore, the study of physics must be able to present the phenomenon in everyday life that can encourage and train students to think analytically, critically and creatively. The best way to develop that ability is to give students the opportunity to investigate a physical phenomenon in everyday life. So physics learning requires investigative activities as part of scientific work involving process skills and also involving scientific attitudes. One effective method that can be used in physics learning is practicum, because it can be used to trill the three domains of intelligence (cognitive, psychomotor, and affective) simultaneously.
Science process skills are empowering the basic skills of students by thinking and acting to discover, develop, and apply natural science, involving both intellectual and psychomotor skills [3]. Therefore, Physics practicum basically also applies science process skills. 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]. In addition, Physics practicum can also integrate many 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 selected attitudes as scientific attitudes in Physics learning is a real step. Practicum is a part of teaching that aims to get students to test and execute in real terms what is obtained in theory. Three functions of practicum are training, feedback, and improving motivation, practicum requires adequate information-processing skills (intellectual) and psychomotor skills that are conducted through a process that demands scientific attitude (curiosity, honesty, collaboration, responsibility, and open-mindedness). The purpose of this study is to describe the use of physics practicum to train the science process skills and its influence on the scientific attitudes of vocational students.

Physics is a branch of science that studies the nature of the phenomenon of things in nature that provides life lessons aligned according to the laws of nature, and used as a vehicle to develop the ability to think to solve problems in everyday life. Physics taught in secondary schools includes basic physics that is the basic idea that arises from the application of scientific methods that examine the most fundamental ideas about the physical properties that include the basic concepts and principles of physics necessary to study further physics or other sciences [5]. Physical learning is ideally implemented in an inquiry to foster the ability to think, work, and be scientific. 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 scientists use when they construct science and solve experimental problems [6]. Vocational secondary school (SMK) is one form of formal education units that provides vocational education at secondary education as the next step from a secondary junior high school or other equivalent or advanced form of recognized learning outcomes. In vocational schools, there are many skill programs, but not all of them require physics. In the meantime, education in SMK demands the development of human resources quality who are also creative, and have competitiveness in facing global competition. An attempt to meet the needs of human resources at the secondary level is the fostering of vocational secondary schools quality. The role of Physics is to help improve the quality of program learning skills that require physics with practicum activities to trace the science process skills that are expected to increase scientific attitudes.

There are many science teachers use practicum in learning activities that develop scientific methods, critical thinking, scientific attitudes, problem-solving approaches, discovery methods, and inquiry methods [7]. Hands-on activities and workouts in the laboratory are essential so that students can conduct an investigation as scientists [8]. The use of inquiry-based laboratory instruction enhances the science literacy and research skills of students [9], in addition, those activities also improve student’s achievement [10]. The most widely used method in science and technology is experimentation [11]. Although investigation activities have a positive impact on student research skills, however, teachers should not be excessive in providing students with experience [12]. The learning model needed to anticipate the 21st century is what makes possible the scientific thinking skill, the development of a sense of inquiry and the creative thinking ability of students [13]. The required learning model is capable of generating the ability of how the knowledge, skills, and attitudes are derived by students [14]. The learning used should integrate the science process skills into the material presentation system [15]. In addition, learning should help students learn to learn, and help students acquire knowledge by finding it themselves [16]. The science-based learning process skills emphasize 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 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 [2].

Physical learning cannot be separated by the development of character, the nature of a person in responding to the situation in a moral manner is shown by the action through a good behavior. The counterproductive natures that attack today's students such as low ethics and morality, requires teachers and schools to take them seriously. The teacher is a vital and fundamental component in the education process, which emphasizes the process of mental maturation, mindset and the formation and development of student character to realize the whole person. The character of the student will be seen from his or her behavior and can be observed when the learning process takes place. Therefore, Physics learning cannot be separated from the scientific attitudes in addition to science process skills. Learning-based learning produces self-confidence in scientific abilities [9]. It is generally found that laboratory investigation activities can significantly improve student attitudes [19]. Scientific skills in physics practicum are the ability to perform a scientific process that requires adequate intellectual skills and psychomotor skills and is conducted through a process that demands the scientific attitudes of the students. Scientific skills can be maximized if the science process skills and the scientific attitudes in a Physical practicum can be trained in an integrated manner [20].

Science process skills and scientific attitudes in the practicum will be interrelated, for example, a student will be able to assemble the experimental tools correctly (science process skills) if the student is doing it thoroughly and scientifically (scientific attitudes). Another example, scientifically written experimental data (scientific attitudes), although not in accordance with the theory will encourage students to develop the ability to analyze the results lead to problem-solving (science process skills). From various observations so far there are some students who have a bad attitude, although not yet known exactly how many, but should be attempted to be minimized. Teachers as the key actors in learning need to play a maximum role in the formation of student characters through the formation of a good attitude in learning. The formation of student attitudes in Physics learning can be fully obtained when students perform the process of practicum activities that focus on the integrity of training in science process skills and scientific attitudes.

2. Research Methodology
The type of research is an experimental research with the one-shot case study design, ie. giving treatment to one group then the dependent variable is measured with the aim to know the effect of the treatment [21]. Variable manipulation in this research is learning using practicum, while the dependent variables are science process skills and scientific attitudes. The science process skills defined in the study are: observing, classifying, inferring, predicting, and communicating. Scientific attitudes established in this study are: curiosity, honesty, collaboration, responsibility, and open-mindedness.

The procedure implemented in this research is applying Physics learning using practicum, then, at the execution of the learning science process skills and scientific attitudes are measured through observation using attitude scale. Science process skills and scientific attitudes scores obtained are then described to know the performance of students when the learning is in progress. To find out how far the relationship of science process skills with scientific skills, the correlation coefficient is calculated based on the average score of students. To complete the results, students are then given a questionnaire to get their response to Physics learning using the practicum. The Practicum topic applied in this research is Simple Pendulum. The subjects are 30 students from the Vocational High School (SMK) 12 Surabaya.

Data collection techniques use observations and performance tests. Science process skills and scientific attitudes score are derived from the score of performance tests using performance appraisal instruments with Likert scale (very less = 1, less = 2, enough = 3, good = 4, and very good = 5). The questionnaire used to know the student's response to Physics learning using the practicum also use the Likert scale.
The data analysis uses the average score description of each element of science process skills and scientific attitudes, while the relationship between the two uses correlation. The criteria used for the average score are: very less (1 ≤ x < 1.5), less (1.5 ≤ x < 2.5), enough (2.5 ≤ x < 3.5), good (3, 5 ≤ x < 4.5), very good (4.5 ≤ x ≤ 5). The correlation criterion (r) used is: less (0 ≤ r < 3), enough (3 ≤ r < 7), and good (7 ≤ r ≤ 1). Criteria of student response is obtained by summing all the average score given by students divided maximum score multiplied by 100%, good criterion if score obtained ≥ 61%. Physics learning using practicum is declared to be successful in scaling up the science process skills and having good effect on the scientific attitudes if the average score of student performance is in either good or very good category, the correlation coefficient obtained is enough or good, and the student's response to Physics learning using the practicum is also in good category.

3. Results of The Research

3.1. The Effect of Practicum on Science Process Skills and Scientific Attitudes

The average score of students science process skills in the process of learning physics using practicum work is shown in Table 1, while the average score of students scientific attitudes are shown in Table 2 as follows:

| Aspects     | Score | Category |
|-------------|-------|----------|
| Observing   | 4.4   | Good     |
| Classifying | 3.7   | Good     |
| Predicting  | 3.7   | Good     |
| Inferring   | 3.5   | Good     |
| Communication | 3.6 | Good     |

| Aspects      | Score | Category |
|--------------|-------|----------|
| Curiosity    | 4.4   | Good     |
| Honesty      | 3.9   | Good     |
| Collaboration| 3.8   | Good     |
| Responsibility| 3.9  | Good     |
| Open-mindedness | 4.1 | Good     |

Based on Table 1 and Table 2, it can be seen that the scores of all elements of science process skills and scientific attitudes are in good categories in which the range of values is 3.5 ≤ x < 4.5. These results indicate that the Physics learning process by using practicum has a good impact on science process skills and scientific attitudes.

3.2. The relationship between Science Process Skills and Scientific Attitudes in Practicum

The relationship between science process skills and scientific attitudes can be seen from the correlation score (r) as presented in Table 3 as follows:

| r | Category |
|---|----------|
| 0.82861 | Good |

Based on Table 3, it can be seen that the relationship between science process skills and scientific attitudes shows the correlation coefficient of 7 ≤ r ≤ which means the correlation is in good category.
It shows that in the process of Physics learning using practicum, there is a significant relationship between science process skills and scientific attitudes.

3.3. **Student's Response to Physics Learning Using Practicum**

To complete the results of the science process skills and scientific attitudes in the Physics learning process by using the practicum, students are given questionnaires to assess the effectiveness of the practicum. The results obtained are shown in Table 4 as follows:

| Aspects                                      | Score | Category |
|----------------------------------------------|-------|----------|
| Provide an opportunity to observe            | 4.1   | Good     |
| Provide an opportunity to classify           | 4.0   | Good     |
| Provide an opportunity to predict            | 4.1   | Good     |
| Chance to infer                              | 3.8   | Good     |
| The opportunity to communicate               | 3.9   | Good     |
| Encourage curiosity                          | 4.1   | Good     |
| Encourage honesty                            | 4.1   | Good     |
| Encourage work together                      | 4.3   | Good     |
| Encourage responsibility                     | 4.0   | Good     |
| Encourage openness                           | 4.1   | Good     |
| Total average score                          | 40.5  |          |
| Maximum average score                        | 50    |          |

Based on Table 4, it can be seen that all the elements asked about the practicum is considered good by students. The elements related to the science process skills (observing, classifying, inferring, predicting, and communicating) and scientific attitudes (curiosity, honesty, collaboration, responsibility, and open-mindedness) all received good judgment from students, and overall practicum effectiveness based on students’ responses have a good category (81%).

4. **Discussion**

Science process skills such as observing, classifying, measuring, communicating, inferring, predicting, etc [4] are the abilities of a scientist which can be trained to students. In this study, the ability trained is limited to: observing, classifying, inferring, predicting, and communicating. Observing is determining the nature of an object or event by using the senses. Each practicum will always start from sensory observation, and the results of these observations will be the basis of the next step, because if there is a mistake on the observation it will affect the final result. Therefore, observation becomes important to the students so that they are familiar with Physical Phenomena carefully. The student's ability to observe can be seen from how far the observation of the object is done in accordance with the actual situation. Classifying is the ability to group objects or events by their nature. In practicum activities, each group formed is given the opportunity to observe the object under investigation, then they are given the opportunity to group objects or events according to their nature which is aimed to: 1) the ability to group the various information obtained, 2) the ability to classify objects (tools and materials) used in the practicum. The ability to classify students that can be seen from the extent to which students are able to group information based on its nature (facts, concepts, and principles), and able to sort and choose the right object.

Inferring is an explanation of a particular event based on observations and data. The ability of the inference needs to be trained to the students so that they are used to express a Physics event clearly without incurring other perceptions that deviate from the actual intent. The students inferring can be seen from the following indicators: the students can write the results of observations well, describe systematically, and write with the standardized Indonesian. Those abilities require the skill to think
with good accuracy, and honesty when observing the events of an investigation conducted in order to get a series of words that describe the facts which are easy to understand and systematic. Predicting is to anticipate the consequences of a new situation or change past experience and previous observations. The ability to predict needs to be trained to students so that they are used to anticipate the consequences that will occur due to deeds or behavior performed. The example in Physical practicum is: the heat travels on the metal (metal is the heat conductor). If using a metal as a hot liquid stirrer for example (boiling water), then the tip of the metal must be coated with a heat resistant insulator (e.g. wood). Communication is the use of written and oral words, graphics, tables, diagrams, and other information presentations, including technology-based ones. Ability is considered necessary to be trained to students, because it is necessary for everyday life. In Physics practicum, students are required to write a report of results in writing and present it to other friends. With this experience, students familiarize themselves with an idea systematically and easily understood by utilizing graphs, tables, and diagrams, and trying to utilize the features of information technology, especially the use of multimedia. The use of multimedia is expected to motivate students to carry out a better Physics practicum.

Scientific attitudes are humanist performances which are personal and interpersonal behaviors in the scientific context, which describe the person's nature, determination, control and way of thinking in conveying subjects related to science [20]. A scientist always has the scientific attitudes that can be trained to students. The study is limited to: curiosity, honesty, collaboration, responsibility, open-mindedness. Curiosity is a person's curiosity on a symptom or event. This nature is always present in a person and needs to be developed by the student, for his curiosity is accustomed to events or symptoms related to the development of science. The emphasis of curiosity is directed to the benefit of deepening the previously taught knowledge. Student's honesty in the practicum can be seen from the following indicators: they do not manipulate data, and dispose of data that is considered bad. In fact, they give information about the data that is considered bad. Cooperation is an active role of students in carrying out the task and success of the group. Feeling the same fate among peers in a group is a positive factor. 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 practicum, they can share the task and role in completing the investigation and each student can play a role according to his or her task, synergize and integrate the results into group successes. So cooperation does not mean every member of the group should do the same job, but rather on how each group member can support the joint success. Student co-ops are seen with indicators of all group members performing the practicum in groups, with a clear division of tasks, and each member completing the task. Responsibility is a consequence that must be borne as a result of the actions that have been done. When students take a conclusion, 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 accepted or not by others, and when others can not accept the conclusion, the students are ready to give an explanation. Open-mindedness is the attitude of not imposing ideas/opinions themselves and can appreciate the ideas/opinions of others, and it is done when 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 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.

These results indicate that the science process skills are related to scientific attitudes and co-exist with other studies such as self-confidence in scientific abilities [9] and laboratory investigation activities improve student attitudes [9]. Practicum is an inquiry-based and science process skill that emphasizes the process of how knowledge, skills, and attitudes are acquired by students [14], helps students acquire knowledge by finding it 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 [2]. The result of this research
shows that physics practicum can be able to train science process skills well and have a significant influence on students' scientific attitudes.

5. Conclusions
The results of the research show that: 1) learning process by using practicum can train science process skills and scientific attitudes in good category 2) the relationship between science process skills and scientific attitudes of students is in good category 3) Students’ response to Physics learning process by using practicum is in good category. The conclusion is that the process of learning physics by using practicum can train science process skills and have a significant effect on the scientific attitudes of Vocational High School students.

Suggestions that can be submitted is that scientific attitudes should be planned and trained as part of the Physics learning process objectives by using the practicum and not just as a side impact alone. To produce the maximum ability of students to the learning process, scientific attitude should be integrated into the science process skills.

6. Acknowledgments
Our gratitude goes to the Headmaster of SMK Negeri 12 Surabaya who has supported this research. Thank you also to colleagues, and students who have helped finish this research, because without it this project would not be completed.

References
[1] Trilling B and Fadel C 2009 21st Century Skills: Learning for Life in Our Times (California: Jossey-Bass)
[2] Turiman P, Omar J, Daud A D and Osman K 2012 Procedia Soc. Behav. Sci. 59 110
[3] Sheeba M N 2013 Educ. Confab 2 108
[4] Valentino and Catherine 2000 Developing Science Skills (Houghton Mifflin Company)
[5] Feynman R 2010 Basic Physics The Feynman Lectures on Physics Volume 1 Chapter 02
[6] Etkina E, Heuvelen A V, White-Brahmia S, Brookes D T, Gentile M, Murthy S, Rosengrant D and Warren A 2006 Scientific abilities and their assessment Physical Review Special Topics-Physics Education Research 2, 020103 (2006)
[7] Abd-El-Khalick F, Boujaoude S, Duschi R, Lederman N G, Hofstein A, Mamlok-Naama R, Niaz M, Treagust D and Tuan H 2004 Inquiry in Science: International Perspectives (New York: Wiley Periodicals, Inc)
[8] Bell R L 2008 Teaching the nature of Science through Process Skills-Activities for Grades 3-8 (Boston: Pearson, Education, Inc)
[9] Brickman P, Gormally C and Armstrong N 2009 Int. J. Scholarsh. Teach. Learn. 3 2
[10] Learning A 2004 Learning and Teaching Resources Branch (Focus on inquiry: a teacher’s guide to implementing inquiry-based learning Alberta Canada)
[11] Akinoglu O 2008 Int. J. Instr. 1 1
[12] Lane J L 2007 Inquiry-Based Learning. Schreyer Institute for Teaching Excellence (Penn State University Park)
[13] De Vito A 1989 Creative Wellsprings for Science Teaching West Lafayette (Indiana: Creative Venture)
[14] Joice B and Weil M 1996 Model of Teaching (Boston: Allyn and Bacon).
[15] Beyer B K 1991 Teaching Thinking Skill: A Handbook for Elementary School Teachers (New York, USA: Allyn and Bacon)
[16] Carin A A and Robert B S 1989 Teaching Science Through Discovery (Columbus, Ohio: Merrill Publishing Company)
[17] Houston W R 1988 Touch the Future Teach (St. Paul, MN: West Publishing Company)
[18] UNESCO 2013 Handbook for Science Teachers
[19] Ural E 2016 J. Educ. Train. Stud. 4 217
[20] Kustijono R, Jatmiko B and Ibrahim M 2017 *The use of physics practicum to train science Process Skills and Its Effect on Scientific Attitude of Vocational Highschool Students* The 2nd Int. Joint Conf. on Science and Technology September 27-28 2017 Bali-Indonesia

[21] Fraenkel J R and Wallen N E  2003 *How to design and evaluate research in education (Fifth Edition)* (New York: McGraw-Hill Higher Education)