Literature Study: Characteristics of Hands-on Physics Experiment to Improve Science Process Skills

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Abstract. This literature study was focused on Hands-on Physics Experiment (HoPE) characteristics to improve Science Process Skills (SPS) of students. Now, we are in 21st century that identic with the development of technology in many areas. Science (Physics) education is an important subject to overcome the 21st century challenges. With science (Physics), students are able to be expert and mastering the 21st century skills, so they can ensure their competitive in this globalization. SPS try to be a solution for solving the 21st century challenges through teaching the skills structurally in the learning of science. Basic SPS consist of observing, classifying, communicating, measuring and using number, predicting, and inferring. Integrated SPS consist of defining operationally, controlling variables, interpreting data, hypothesizing, and experimenting. HoPE is Physics experiment activities to optimize student psychomotor. The aim of HoPE is to increase student skills. This literature study revealed that HoPE can be used to improve SPS if there're some characteristics, such as enable students to: active in the learning process, interact directly with the scientific tools and materials, use as many as senses particularly hands to get knowledge through the real experiences.

INTRODUCTION

This paper reviewed about Hands-on Physics Experiment (HoPE) to develop and enhance student Science Process Skills (SPS). The aim was to find some HoPE characteristics which can be used not only for developing but also for enhancing the skills. Motivation of this study was to advocate the using of HoPE as an alternative learning media to increase SPS among physics students.

In 21st century, there are many challenges which students should be overcome by mastering the 21st century skills, so they can ensure their competitive in this globalization [1][2][3][4]. The skills such as life and career skills, learning and innovation skills, and for sure information, media, and technology skills [5]. SPS try to be a solution for solving the 21st century challenges through teaching the skills structurally in the learning of science. There are four dimensions of science, such as a way of thinking, a way of investigating, body of knowledge, and interaction with technology and society [6]. Science is learned not only as a product but also as a process. As a process, science means a thinking and working way to sense the world. As a product, science means a body of knowledge produced by the process [7].

Physics is a part of science which learn about natural phenomena, such as energy, force, motion, etc. Physics is learned not only as a product but also as a process. As a process, physics is expected to increase some SPS which usefull for the student life. Furthermore the skills are also needed for solving the 21st century challenges. So Physics can be expected to be a solution for the 21st century life.

HoPE is Physics experiment activities to optimize student psychomotor [8][9][10]. The aim of HoPE is to increase student skills [11][12]. HoPE activities use as many as senses particularly hands to get knowledge through the real experiences. This literature study is needed as pre-research to know the relation between HoPE and SPS. Moreover it's also to analyze the characteristics of HoPE that can be used to develop and enhance SPS.

DISCUSSION

Hands-on Activity

The best way to learn science is by doing the science activity directly. It can make students active physically [9]. Hands-on is a media to learn science using hands activity. The activity designed to give some chances to students for doing, observing, and operating scientific process. So they can interact directly with the scientific tools and materials [13].

If there isn't student interaction in learning process, whatever the methods of learning won't get better result [8][14][15]. Student attitude of science also more positive when teacher regularly giving hands-on activity [16][17]. Students who get chance to produce hypotheses by them self and make their own conclusion will have positive attitude [16]. Hands-on activity is a good way to help student for developing science learning. To get meaningful learning, teacher should use many strategies and tools to increase science concept understanding. Learning activity which optimize student engagement in learning process will help students to increase their performance [18]. Students can work in groups and develop their social interaction. The more senses are used in learning process, the better learning will get and never forget [12].

Science Process Skills

The purpose of learning science is help students to understand science knowledge and developing their skills [19]. Sometimes, students who capable in mastering science knowledge have an upper social system than others. But knowing everything about science isn't useful than getting the skills which needed to solve any problems in life [20]. SPS is a method to engage students actively and help them to more capable in describing the world. The advantages of learning SPS are students can solve their own problems, study with their own method, and more appreciate about science. SPS is the main purpose of science concepts [6]. There're two kind of SPS, basic and integrated SPS. Basic SPS consist of observing, classifying, communicating, measuring and using number, predicting, and inferring. Integrated SPS consist of defining operationally, controlling variables, interpreting data, hypothesizing, and experimenting [1][6][21][22]. Study literature of the explanation and some indicators from each SPS can be seen on Table 1.

TABLE 1. Basic and integrated science process skills

Type	SPS	Definition	Indicator [23]
Basic	Observing	Using some senses for collecting object and situation properties which consisted of similarity and differences, changing, and measurement observing [6][24][25]	• Identifying objects • Using more than one sense • Using all appropriate senses • Identifying the senses used • Using observation equipment • Describing properties accurately • Providing qualitative observations, verbally or pictorially • Providing quantitative observations • Describing object changes
Basic	Classifying	Grouping materials based on specific and similarity characteristic or making correlation between events and objects according to the properties and attribute [6][24][25]	• Identifying major properties by which objects can be sorted • Identifying objects similarities • Sorting accurately into two groups • Sorting accurately in multiple ways • Forming subgroups • Establishing own sorting criteria • Providing rationale classifications • Developing complex classification
Basic	Communicating	Explaining ideas about action and event using words, action, or graph symbol [24][25]	• Identifying objects and event accurately • Describing objects and events accurately • Providing descriptions to identify

Type	SPS	Definition	Indicator [23]
			unknown objects • Formulating reasonable and logical arguments to justify explanations and conclusions • Transmitting information to others accurately in oral or written formats • Verbalizing thinking
Basic	Measuring and Using Number	Using quantitative relation to measure, get answer, use formula, and calculate quantities [6][24][25].	• Selecting appropriate measurement type (length, volume, weight, etc.) • Selecting appropriate units of measurement • Using measurement instrument properly • Applying measurement techniques appropriately • Using standard and nonstandard units • Using measurements as evidence • Using measurement to explain conclusions
Basic	Predicting	Forecasting what will happen in future by using pattern based on past and data extension from evidences [6][24][25]	• Forming patterns • Extending patterns • Performing simple predictions • Applying prediction process in appropriate situations • Exhibiting logical verbalizing reasons for predictions • Suggesting tests to check prediction accuracy • Predicting by data interpolation • Predicting by data extrapolation
Basic	Inferring	Using evidences to explain, interpret, or making pre-conclusion about event that ever happened or something that ever observed [24] [25][26]	• Describing the relations among objects and events observed • Using all appropriate information for making inferences • Making inferences based on evidence • Doesn't use nonexistent information • Separating appropriate from nonessential information • Exhibiting reasoning verbalizing inferences • Applying inference process in appropriate situations • Interpreting graph, tables, and other experimental data
Integrated	Defining Operationally	Developing statements to describe about object or event [6]	• Telling whether a variable can be measured conveniently • Recognizing the need for an operational definition in given situations • Deciding how to measure variable in operational terms • Verbalizing congruence between

Type	SPS	Definition	Indicator [23]
			operational definition and measured variable
Integrated	Controlling Variables	Manipulating and controlling properties to find the caution relation [6]	• Showing ways for keeping the controlled variables constant • Showing ways for changing manipulated variables so the useful data can be obtained
Integrated	Interpreting Data	Stating the relation between variables and making conclusion use information from graph or table data [6][25]	• Identifying data needed and how to measure it • Planning for collecting qualitative and quantitative data • Collecting data that usable for evidence • Constructing data tables • Constructing and interpreting graphs • Making valid data interpretations
Integrated	Hypothesizing	Stating tentative generalization from observation or inferences that may be used for explaining events [6]	• Constructing a hypotheses when given a problem or question • Formulating own hypotheses from own problem • Suggesting several plausible hypotheses to explain observed situations • Developing ways of testing hypotheses • Testing systematically hypotheses concern on observed situation by collecting data and analyzing evidence • Formulating tentative conclusions based on evidence from hypothesis testing
Integrated	Experimenting	Testing a hypotheses through manipulation and controlling variables [6]	• Following directions for an experiment • Developing alternative ways to investigate a question • Manipulating materials • Performing trial and error investigations • Identifying testable questions • Designing own investigative procedure • Formulating valid conclusion based on evidence

Hands-on Physics Experiment and Science Process Skills

HoPE focus in physics major, so the subjects which be learned in HoPE are physics concepts using experiment activities. HoPE can be used to improve SPS if the experiment activities inside HoPE consist of basic and integrated SPS. The SPS contents was chosen based on learning subject characteristics. The indicators from each SPS can be seen on Table 1. SPS example training through the HoPE [27] consist of some activities, such as folio activity, thinking activity, discussion activity, inquiry experiment, investigation activity, guided experiment PEKA, and enhancement corner**.** Science teachers should prepare and arrange learning activity for teaching SPS [28].

Learning and teaching science using some approaches gives inculcation of SPS and gives a chance to students for learning some skills by them self. Some approaches in learning science have equal position and can combine each other because they are a dynamic process, which means that the change of an approach to others can happen during the learning process. From some approaches like discussion, exploration of ideas, open laboratory inquiry, lecture, and student presentation, the most SPS appeared in discussion approach and none in lecture [25]. Based on previous study, SPS which always repeated more frequently in learning process is communications skills [25][29]. Inculcation of SPS based on intensity in previous study, can be seen on Figure 1 [25]:

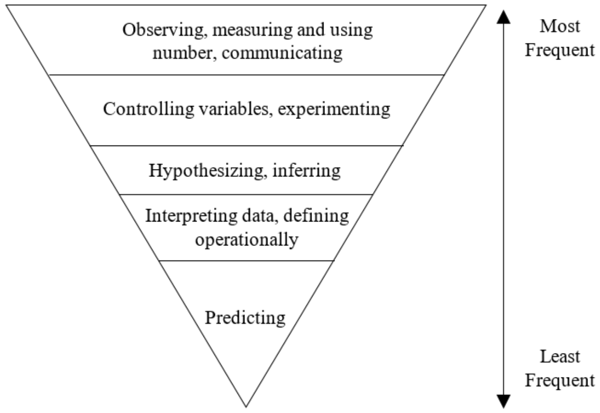

FIGURE 1. Inculcation Intensity of SPS

CONCLUSION

HoPE is Physics experiment activities to optimize student psychomotor. The aim of HoPE is to increase skills that can be also expected to increase SPS of students. Based on the literature study of HoPE, it can be concluded that there are some characteristics which needed in HoPE to increase SPS, such as enable students to: active in the learning process, interact directly with the scientific tools and materials, use as many as senses particularly hands to get knowledge through the real experiences.

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