Need assessment for development of inquiry based learning materials using PhET media to enhance students’ science process skills

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Abstract. This study is a preliminary stage on development learning materials using inquiry model and PhET media to enhance junior high school students’ science process skills. The need assessment is aimed to give preliminary understanding in term of curriculum, learning theory, challenge and needs in the future. The data is gathered by observation, interview and documentation methods. Descriptive analysis had been chosen as the data analysis method. The result showed the following facts. First, the implementation of Curriculum 2013 with inquiry learning model and supported by PhET Media is necessary to improve the students’ science process skills. Second, the students need to have competencies in affective learning outcome, psychomotor skills, cognitive product and process skills. Third, the set of learning materials needed are including syllabus, lesson plan, students’ book, students’ worksheet and assessment sheet in density and buoyancy topic for the eight-grade junior high school students of SMP Lab Undiksha Singaraja.

1. Introduction
Science has an important role to develop students’ logical, analytical, systematically and critical thinking. It is also valuable to enhance creativity and cooperative work among the students. In national curriculum of Indonesia, called Curriculum 2013, science is defined as a branch of subject in school that has three aspects, including scientific product, scientific process and scientific attitude. Science as scientific product consists of the body of facts, concepts and principles, and also the symptoms in nature. The implementation of scientific approach in Curriculum 2013 is expected to improve the quality of science teaching and learning [1]. During learning, the students will do a scientific activity, called science process skills, to re-invent the scientific concepts.

Science education is established based on the balance principal among cognitive, process and affective skills to help the students understand themselves, the nature and further to implement science in daily live. Hence, the learning process is emphasized on students’ direct experiences in exploring nature or real event, instead of merely remembering the scientific products. The scientific process is used as a bridge to develop conceptual understanding and affective skills. As in the requirement in Curriculum 2013, the science teaching and learning should promote students’ process skills followed by affective skills to independently construct their conceptual understanding [2]. Science process skills is an empirical and analytical skills that used by the scientist in understanding the nature of the universe. The skill consists of the affective, product cognitive, product process and psychomotor
aspects [3]. Using the process skills, the students will be able to learn science as the scientist do, which is by observing, formulating hypothesis, predicting, investigating, interpreting, concluding and communicating the results [4]. In science process skills, the students are guided to understand the steps used by the scientist to independently discover and develop the facts and concepts. Hence the students’ understanding will stand longer in their memory. Besides that, the process skills will encourage the students’ affective skills in order to use the scientific values in solving daily life problems. Therefore, it can be said that improve the students’ process skills is one method to enhance the students’ achievement in science [5].

However in fact, the implementation of science teaching and learning in formal school is still far from the expectation. It can be seen from the result of Program for International Student Assessment (PISA) 2015 that put Indonesia in the last 10 countries among 69 participants. Specifically, in term of reading literacy, Indonesian students got 61st place, in scientific literacy got 62nd place and in mathematical literacy got 63rd place [6]. It means, the students’ achievement in science is still low. There are some reasons that predicted as a caused for the low result in science, for instance the teacher-centred and the not-innovative method in learning process. The teacher-centred learning process is usually done by using lecturing method that put teacher as the one and only source in learning [7]. It contributes to the low result in learning since the students get the knowledge in passive way and set the central point in theoretical aspects, rather than to learn how to learn [8].

The research by Sadia [9] found that the teaching and learning science in all schools in Singaraja-Bali was focused on the mastery of scientific products (95%), while only 5% of the schools that focus on science process skills. In term of method, it is found that most of teacher were using lecturing (70%), followed by cooperative group, demonstration and experiment (each 10%). The result is supported by Suastra, et al. [10] who found that the current assessment in science, by using quiz, test and homework without authentic assessment, is merely able to measure the students’ cognitive aspects.

The gap between the expectation and the reality of the implementation of Curriculum 2013 contributed to the low quality in education. The teachers are still lacking in guiding the students to use scientific approach, including observing, questioning, collecting data, negotiating and communicating, during their study. One of the possible solutions to solve this problem is by conducting an innovative learning model combine with interesting learning media to encourage students’ motivation and willingness to learn. The appropriate learning model on this case is inquiry supported by the PhET learning media.

Inquiry is a recommended model for a lesson with scientific approach since it can support the students to be an intelligent, critical and open minded [11]. It has a purpose to train the students to conduct a research, find a reason behind a phenomenon and find the core and meaning from an event and solve a problem using an independent scientific procedure. According to Sadia [11], inquiry learning model also support the students to develop their higher order thinking by using questions that can enhance the students’ curiosity in solving and concluding their findings. Based on the characteristics of inquiry learning model, it can be stated that this model is effective to foster the students’ science process, cognitive and affective skills. Hence, it is important to develop the set of learning materials that can support the implementation of inquiry learning model.

The preliminary observation at junior high school SMP Lab. Undiksha Singaraja found that the learning model employed by the teacher was not completely accommodate the students’ need in learning. The time allocation for laboratory practices is limited. In this case, the students tend to wait their teacher’s instruction. Hence, the lesson is using a teacher-centered orientation. It is happened due to the lack of the room and the instruments for scientific experiment. Furthermore, the current learning materials, including lesson plan, book, students’ worksheet and assessment instrument are not holistic nor supporting each other. It is found that the type of assessment given in the worksheet and the book are not directly measure the indicators of the topic.

The lack of the room and laboratory instruments in the school needs a special attention, because it is limiting teacher and students to employ scientific approach in the classroom. Lunetta (in Hofstein)
[12] stated that the laboratory experiences are having a central and specific role in Science Curriculum since it has many benefits for the students. Hence, it is compulsory for a school to have an appropriate lab. However, due to school situation and condition science laboratory cannot be maximally used. Some possible reasons of the condition are including: (1) in specific topics, the availability of the tools and sources for science practices are less than the number of the students, (2) damage tools and resources due to the lack of its endurance, (3) some practices are high risk (for instance in chemistry), hence the teacher cancel it, and (4) school has a limited classroom such that the laboratory has been used as it and therefore the laboratory activities cannot be conduct by the other classes.

To solve the lack of room, tools and resources of laboratory practices, school can employ the computer technology by creating a virtual laboratory and experiments application using Physic Education Technology (PhET) program. The solution was chosen due to some considerations, including the availability of the facility such as computer, notebook, LCD projector and the internet connection. Through PhET program, the user can experience a virtual experiment that resemble to the actual laboratory activities [13]. It can also be used for basic to higher topic as well. To use the PhET online, user can go to https://phet.colorado.edu/.

Based on the aforementioned explanation, to solve the problem on inadequate room, tools and resource in laboratory and also to provide a valid and reliable set of learning materials in order to enhance the students’ science process skills, it is an urge to develop a set of inquiry-based learning materials with PhET media for classroom laboratory practices. Hence, a study entitled “Developing a Set of Inquiry Based Learning Materials Using PhET Media to Enhance Junir High School Students’ Science Process Skills” is conducted.

We realized that a developmental research needs a longer time. Therefore, in the present study we limited our study to the need analysis stage. It was aimed to do preliminary observation of the students’ condition, curriculum needs, relevant learning theory and the needs and challenges in the future to enhance students’ science process skills. The result of this study will be beneficial to design a prototype of a set of learning inquiry-based learning materials with PhET media.

2. Methods
This is a design research study. The steps used are following Plomp and Nieveen [14] consists of Preliminary Research, Prototype and Assessment phases, integrated with Thiagarajan [15] using the 4-D (Four D-Models) that consists of Define, Design, Develop, and Disseminate procedures. Due to some limitations, Assessment and Dissemination phases were not be included in this study. The subject of the study is two science teachers of junior high school SMP Lab Undiksha Singaraja, Bali. The data were collected through observation, interview and documentation methods. Observation was done to the preparation, teaching implementation, and assessment employed by the teachers and also to the laboratory facilities. On the content side, we observed the scope and the purpose of the topics for the students. The interview was done to investigate the difficulties in conducting science teaching and learning. Documentation was done to examine the curriculum, syllabus and the laboratory inventory. The data were analyzed descriptively.

3. Result and Discussion
In the need analysis, the direct observation was done to the science learning process and laboratory facilities in the second semester of VIII grade, in March - April 2017. The interview for the teachers was emphasized on the teaching method, practices, assessment, and innovation in learning that had been implemented. The following explanation described the results.

3.1 Curriculum
The school is using Curriculum 2013 with scientific approach. In the curriculum, science is seen as a subject which focus on scientific products, processes and attitudes. The recommended model in teaching and learning using Curriculum 2013 is Inquiry. Hence, the set of learning materials produced from this study focused on the effort to improve the students’ science process skills. To support the inquiry model, we also employed the PhET media.
3.2 The Set of Learning Materials
In this study, we designed syllabus, learning scenario, lesson plan, students’ worksheet, key-answer sheet, assessment sheet and students’ book.

3.3 Underpinned Learning Theory
From the theory analysis we found that there are two learning theories that will relevant to the need of developing inquiry-based learning materials, which are cognitive and constructivism theories. Based on the cognitive theory, learning is more than remember something, but an effort to understand it. To help students gain the knowledge, they have to work independently to solve a problem, connect their previous experiences and the new findings. The students also have to construct their holistic understanding by making sense the ideas and conjectures [16]. Based on the constructivism, the students should construct their understanding in mind. Therefore, teacher is expected to give the chance for the students proceed a meaningful learning, for instance by explore, invent, and implement a strategy to learn. The teacher could provide a scaffolding to support the students’ development but let the students take the next step to make themselves go higher [16].

3.4 Learner Condition
In this stage, we observed the characteristics of the students based on the interview result with the science teachers. From that, we found that the students’ science process skills are relatively low. Therefore, it is necessary to the researcher to develop a set of inquiry-based learning materials with PhET media to help the students understand the content better.

3.5 Task Analysis
We analyzed the core content that enable students to achieve, at least, the minimum competency. We used the data to formulate a comprehensive learning goals for the topic of Density and Buoyancy [15]. The result can be seen in the following Table 1.

| Competency            | Task Analysis                                                                 |
|-----------------------|-------------------------------------------------------------------------------|
| Core Competency       | Cognitive Learning Outcomes                                                   |
| K-I 3                 | 3.8 Understanding the density of liquid and its application in daily life to   |
|                       | explain about blood pressure, diffusion, respiration and osmosis.              |
| K-I 4                 | 4.8 Conducting an experiment to investigate the density of certain liquid in   |
|                       | certain level, buoyancy, capillarity (liquid transportation in plant) and     |
|                       | density of liquid in a closed container.                                      |
| Affective             | 2.1 Showing a scientific attitude (curiosity, objective, trustworthy,        |
|                       | intellectual honest, diligent, open mindedness, creativity, innovative and     |
|                       | awareness) in daily activities as a result of being accustomed to do         |
|                       | scientific experiences, report and discuss the results and findings.          |
| Basic Competency      | Cognitive Learning Outcome                                                    |
| 3.2                   | Analyzing the implementation of density and buoyancy concept in daily life.   |
| 4.2                   | Planning and conducting an experiment about density and buoyancy              |
| Psychomotor           | Conducting an experiment about density and buoyancy using PhET learning      |
|                       | media.                                                                        |
| Topic                 | Density and Buoyancy                                                          |
| Sub Topics            | 1. Density                                                                    |
|                       | 2. Pressure and Buoyancy                                                     |
|                       | 3. Sinking and Floating                                                       |
3.6 Concept Analysis
The concept analysis was done by considering the content in the curriculum. Besides that, the chosen topics also following the recommendation from Lippmann in Pujani [17] which are: (1) the topic is used by the scientist, (2) has benefits for the students in the further career or study and (3) can be learned in the laboratory. Based on the concept analysis, the appropriate topic is Density and Buoyancy because it supports the development of students’ science process skills. The reference for the topic is the Science Book for eight grader students combined with Focus on Physical Science Grade 8 [18].

![Conceptual Map of Density and Buoyancy]

Figure 1. Conceptual Map of Density and Buoyancy

Figure 1 shows there are 3 sub topic which used to develop a set of learning materials using inquiry model with PhET Media to enhance junior high school students’ science process skills, such as density, pressure and buoyancy and sinking and floating. The learning materials are including syllabus, lesson plan, student book, student worksheet and keys, assessment instrument for affective, product cognitive, process cognitive, and psychomotor.

3.7 Challenge and Possible Solution
There are several challenges encountered by the teacher in conduction science lesson can be identified into several aspects as follows. We tried to give some possible solution as recommendation to solve the problem, as follow: (a) Teachers’ skill to design and create a science laboratory activity need to be improved. Hence, the teacher needs to follow the personal development class to design inquiry-based students’ worksheet and laboratory experiment’s guideline, and (b) The lack of scientific tools that can be used to conduct experiment in school. The problem can be solved by using the PhET media. Hence, it is necessary to conduct a teacher’s training program to use PhET media.

Based on the identified challenges, the researcher believed that improvement is completely needed to increase the quality of science lesson in the junior high school, especially to enhance the students’ science process skills. We expect that the development of inquiry-based learning materials with PhET media enable the students to actively engage to the learning process. These findings are coherent with the findings of other researchers about effectiveness of inquiry based learning with PhET media on improving process science skills, like as Pujani [19] and Savitri [20].

3.8 Specifying Instructional Objectives
Based on the analysis of the curriculum, students, task and concept, challenge and possible solution, we formulated the instructional objectives as a foundation to construct the complete set of learning materials. The availability of the instructional objectives is useful to guide the teacher to create the lesson trajectory.

4. Conclusion
Based on the afore mentioned discussion, we can conclude the following points. First, the implementation of Curriculum 2013 should be supported by the inquiry learning model and will be better if it is collaborated with PhET media to maximally enhance the students’ science process skills.
Second, the students need to master affective, product cognitive, process cognitive, and psychomotor to gain the minimum competency standard. Last, the recommendation for the set of learning materials are including syllabus, lesson plan, students’ book, students’ worksheet and assessment instrument for the Density and Buoyancy topic. The prototype of the learning materials will be experimented for the 8th grader students in junior high school Laboratorium Undiksha, Singaraja Bali.

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