Development of Physics Module based on Process Oriented Guided Inquiry Learning as a Tool to Increase Student Science Process Skills

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Abstract: Based on preliminary research conducted at the beginning of the odd semester of academic year 2017, information about the problems and needs in the Basic Physics lectures in the Industrial Engineering Study Program at STT Dumai is obtained. The problem found is the unavailability of teaching materials that facilitate the development of process skills in students, which supports students to learn independently in constructing their own knowledge in accordance with the nature of science. Hence, this study develops physics modules based on process oriented guided inquiry learning (POGIL) models. This module is developed with the ADDIE development model consisting of analysis, design, development, implementation, and evaluation stages. But this paper only present physics module based on POGIL models that has been developed by analysis, design, development. The results of the development from the three stages of ADDIE are modules which each part is related to the syntax POGIL model, such as 1) formulating the hypothesis, 2) designing the experiment, 3) writing data and analyzing the results of the experiment, 4) applying the concept (related to the problem presented at the beginning of the worksheet) and 5) communicate.

Keywords: Physics module; Science process skills; Process oriented.

1. Introduction

Physics as one of the compulsory subjects in higher education, especially for industrial engineering, is expected to be a vehicle for students to learn about nature by themselves, to develop positive spiritual attitudes, foster social attitudes, have cognitive abilities that provide them to survive and be able. Learning activities to achieve all these goals have to emphasize the scientific process to build cognitive abilities carried out directly by students. Thus, learning is not only a transfer of knowledge from educators to students textually but also have to involve student activities during the process to get knowledge itself.

On the other hand, recent studies have indicated that students have difficulties in learning Physics [1],[2], [3]. In addition according to several studies on learning physics in Indonesia, it is known that physics learning process generally focuses on the many cognitive aspects mastered by students without regard to the process of how cognitive aspects are built by students. So that the common physics learning does not provide opportunities for students to train various skills, such as high-level
thinking skills, science process skills, problem solving skills, and even aspects of student concern. It is also stated that there were complaints about the low ability of critical-creative thinking. Keterampilan Proses Sains (KPS) that mastered by graduates of basic education to higher education in Indonesia.

In accordance with the results of the literature study, the preliminary study of Physics learning in the Sekolah Tinggi Teknologi (STT) Dumai shows that the learning process undertaken has not facilitated students to have balanced knowledge, skills and positive attitudes. Students still assume that the results that must be achieved through the learning process is in the form of memorizing learning materials, students do not even know about aspects of skills and positive attitudes required to be possessed after attending a learning process. This does not correspond to the demands of the Indonesian National Qualifications Framework (Kurikulum Kerangka Kualifikasi Nasional Indonesia - KKNI) which is currently applied in Indonesia, that learning must be able to train the competencies of knowledge, skills and attitudes.

The results of this observation indicate that there is a problem in Physics learning process in STT Dumai which has an impact on the low cognitive abilities and students KPS. Furthermore, it is necessary to think of an effective learning model and innovative learning tools to improve cognitive abilities and student KPS. One of learning model that can be used to solve this problems is inquiry learning models. Rick Moog developed a learning model based on inquiry activity, namely process oriented guided inquiry learning (POGIL). The POGIL is presented as a learning model that can facilitate the implementation of inquiry learning both in the classroom and in the laboratory. POGIL emphasizes cooperative learning, students work in teams, design activities to build cognitive abilities (conceptual understanding), and develop skills during the learning process such as science processes, thinking skills, problem solving, communication skills, management, attitude building positive social and self-assessment skills that can develop metacognitive knowledge [4].

Besides learning models the use of learning tools is also important. One of the teaching tools that can be used to help the learning process is Module. Russell in Wena said that learning system that used module will make learning more efficient, effective, and relevant compared to conventional learning which tends to be classical and carried out face-to-face [5]. Advantages of modules is that the module has a self-instruction that allows students to learn independently.

In this study the POGIL learning model is used as the basis for the implementation of learning activities so that learning tools such as teaching materials are also based on the POGIL model. hence in this study developed a physics learning module based on the POGIL model. The module is expected to facilitate students to learn physics independently while being able to facilitate students to gain cognitive knowledge, train many skills especially science process skills, and foster positive attitudes. This study using research and development Method (R & D) which consists of four stages of development. Still however, this paper only presents the portfolio form as assessment tools that has been developed by steps one and two i.e. (1) Collecting information through literary study as a preliminary study to comprehend portfolio as assessment tools; and (2) Determine the objective of development, arrange the preliminary draft model, and validate the content of preliminary draft model by involving evaluation by an expert to face global development, as well as many skills that can be applied to everyday life.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method

The procedure for developing this module uses the ADDIE model which stands for analysis, design, development, implementation, and evaluation steps. The ADDIE model was developed by Dick and Carr to used for developed something that associated with learning system [6]. This paper only describes the process of developing physics modules based on POGIL model in three steps of ADDIE.
a. Analysis
Analysis phase analyze the need of development physics module based on POGIL models for industrial engineering students in STT Dumai. The steps in this phase are: 1) analyze syllabus, 2) analyze text book, 3) literature review, and 4) interview with colleagues.

b. Design
The results from the analysis phase are used at the design stage. At this stage, the action that will be taken is to design a physics module based on POGIL model for basic physics courses.

c. Development
Development steps include activities to create and modify modules to achieve predetermined learning goals. At this stage the action taken is validating the content and the construct of the module.

Validation sheet Used to find out whether the modules and instruments that have been designed are valid or not. Validation results from the validator on all aspects assessed are presented in table form. Next, the average score is searched by using the formula:

$$ R = \frac{\sum_{i=1}^{n} V_i}{n} $$(1)

Where
- $R$ = average result of the evaluation of the validators
- $V_i$ = score from i-validator
- $n$ = number of validation

Then the average obtained was confirmed with the specified criteria as seen in Table 1.

| Mean       | Category       |
|------------|----------------|
| > 3.20     | Very valid     |
| 2.40 > R > 3.20 | Valid         |
| 1.60 > R > 2.40 | Quite valid   |
| 0.80 > R > 1.60 | Less valid    |
| < 0.80     | Invalid        |

3. Results and Discussion

Process Oriented Guided Inquiry Learning (POGIL) as learning model is the basis for the development of this module. POGIL facilitates students to carry out concept by discovery processes so that science process skills can be trained, and is expected to increase student science process skills. Hence, the module developed was adjusted to the POGIL model syntax.

Of the five stages of the development procedure with the ADDIE (analysis, design, development, implementation, and evaluation) development model up to the time this progress report was made, it was only implemented in the analysis, design and development stage.

3.1. Analysis
Based on the review of the KKNI, the nature of science and the results of the syllabus analysis note that physics learning is not only in the form of knowledge transfer but a process of constructivism where through the process students can build their own knowledge, train skills and foster a positive attitude. And the learning process that has been done so far does not seem to emphasize the process, but is more dominant in the transfer of knowledge.
The problems in learning process also linked with the text books. Existing textbooks are generally in the form of material descriptions without any directives of activities that students can do to construct their own knowledge. Figure 1 shows a snippet of commonly used textbooks.

3.2. Design

The results from the analysis phase are used at the design stage. At this stage, the action that will be taken is to design a physics module based on POGIL model for basic physics courses. A good physics module that presents material in a contextual ways. Material presented based on real environment and real live situation, so students feel learning physics is very useful [7]. This is in line with the POGIL model that places the process as the main experience to shape knowledge.

The modules that will be designed contain competency standards, learning objectives (cognitive and student science process skills aspects), physics material based on POGIL models, simple experiments, examples of problems in each sub-section, worksheets for independent experiments, independent exercises for cognitive abilities, self-training for KPS, peer assessment sheets, self-assessment sheets, feedback and follow-up, bibliography.

3.3. Development

Module making is carried out based on the draft that has been compiled. In the first stage the design is done by designing the contents section for each chapter. At the beginning of each chapter will be filled with learning objectives that must be achieved by students. Figure 2 shows the presentation of indicators and learning objectives for static fluid material.
Figure 2. Learning Goals

The contents of the module developed are adapted to the POGIL model syntax. So that, at the beginning of the subject will be presented a phenomenon or application of physical material that will be studied in everyday life, shown by Figure 3. This subject will be an introduction for students to develop physics concepts. It is linked with first steps in POGIL that called orientation steps. In this part of module provide opportunities for students to be ready to take part in learning physically and psychologically.

Figure 3. Orientation Steps in POGIL as a Beginning Part in Module

Figure 4 shows in the module also presented a simple experiment that can be done by students to prove the theory, concepts and laws of physics that have been presented in the material section. This part linked with steps exploration in POGIL model.
This module also provide worksheet that have to be done by students, this part of module also linked with exploration steps in POGIL model. Worksheets begin with issues related to physics theory in daily life. For example, the application of the theory of static pressure and fluid on dams, then students will analyze the relationship of physics theory with their application in daily life. The steps that students must take are within the framework of the POGIL learning model that is linked to the indicators of science process skills (SPS) that will be trained. The steps that students must take to complete the worksheet are: (1) formulating the hypothesis, (2) designing the experiment, (3) writing data and analyzing the results of the experiment, (4) applying the concept (related to the problem presented at the beginning of the worksheet) and (5) communicate (write report and presentation of experimental results report). While finished the worksheet student already done steps 3 and 4 in POGIL models (concept formation and application step). Figure 5 shows the worksheet that presented in module.

As mentioned at the design stage that each chapter will be completed with a sample problem. Figure 6 is an example of the problem presented in the sub-section of pressure.
After sample problem in module will present many question that have to solved by students. This part related with closure step in POGIL model. POGIL end with students validating the results they have achieved, reflecting on what they have learned and assessing their performance in learning and task isone of a kind to validating the result that student get from learning actifities.

According to tittle stating that this module develop to train student to have science process skill, module that built based on POGIL model is the right way. It is in line with Dahar opinion that science process skills is a science behavior that can be learned and developed by students through classroom learning giving students more opportunities to play an active role [5].

4. Conclusion

The development of the basic physics module based on the POGIL learning model has been carried out to facilitate students in training process skills and supporting students to discover their own knowledge include physics laws and concepts of physics. Every part on this module is linked with POGIL model sintaks. Especially in sintaks concept formation student will be facilitated by this module to train their science process skill. those indicators are science process skills indicator that will trained by physics module based on POGIL model, namely: 1) formulating the hypothesis, 2) designing the experiment, 3) writing data and analyzing the results of the experiment, 4) applying the concept (related to the problem presented at the beginning of the worksheet) and 5) communicate

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