The development of the physics practicum worksheet in electricity based on modified inquiry approach

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Abstract. The aim of this research is to develop physics practicum worksheet electricity by modified inquiry learning approach. The method used in this research is research and development (R & D) with the ADDIE models (Analysis, Design, Development, Implement, Evaluation). Data collection techniques used through interviews, observations and questionnaires. The respondents of this study are expert respondents consisting of physics experts, media experts and learning experts. And field test respondents are first-year students of the Department of Physics Education Universitas Negeri Jakarta (UNJ). Based on the results of validation by material experts was 83.13 %, media experts was 93.61%, and learning expert was 94.06 % which is considered very good. The result of field testing to student of Departement of Physics Education, Universitas Negeri Jakarta was 83.89% which is considered very good. The conclusion of this research is physics Practicum worksheet electricity by modified inquiry learning approach developed feasible use as a teaching material.

1. Introduction

Scientists obtain a great deal of the evidence they use by observing natural and experimentally generated objects and effects [1]. Therefore, for students to truly learn science concepts, they both need practical opportunities to apply knowledge and also need help in integrating or exchanging the knowledge they gain [2]. Through practicum activities, a person can actively learn, find his own concept, investigate and be able to solve the problems he faces [3]. Learning with practicum is a means of achieving science learning orientation, besides being product-oriented and process oriented [4]. In the Physics and Physics Education program, the University has several courses that focuses practicum activities for one semester. One of them is Physics practicum course as a support for Physics courses. In the Physics practicum course, the study program provides Physics guide book for students.

However, based on the results of requirement analysis conducted by 10 UNJ Physics laboratory assistants, the score obtained was 44.64 %. According to the Likert scale score range, if the score is <56, it means that they do not agree of the existing guidebook has not made the students understand practicum activities without asking laboratory assistants. While based on the results of requirement analysis on 48 Physics students of Universitas Negeri Jakarta, the students disagree if the existing guidebook helps in making hypothesis for the upcoming experiment with a score of only 49.47%.
48.95% also disagrees if the existing practicum guidebook can direct students to conduct independent experiment activities. 46.35% is also disagree if the existing practicum guidebook can direct and assist students in analyzing the graphs or diagrams of experimental results into related concepts.

Based on the facts found from the results of the requirement analysis conducted by researcher to three Physics lecturers at UNJ through interviews, it can be said that the existing practicum guidebooks have not optimally directed students to make hypothesis, process test data, describe, analyze and interpret graphs and draw a better conclusion. In addition, based on the results of the lecturer interview, the practicum guide book has not provided many opportunities for students to try to arrange experiments independently. So, based in the result of the requirement analysis, a better teaching material is needed to overcome the shortcomings in practicum guide book.

One of the teaching materials that can be used in the Physics practicum is practicum worksheet. Worksheet is a printed teaching material in the form of paper sheets containing materials, summaries and instructions for implementing learning tasks that must be done by students, which refers to the basic competencies that must be achieved [5]. One of the roles of worksheet in learning is as a teaching material which can minimize the role of educators but encourage students to be more active [6]. The use of worksheets also encourages and inspires students to think critically, analytically and precisely in identifying, understanding, solving problems and applying substance or learning materials [7]

In optimizing the role of practicum worksheet, a learning approach is necessary as a basis for practicum worksheets. One approach that can be implemented in the worksheet is an inquiry approach. Inquiry is an approach to learning that involves students in finding and using a variety of sources of information and ideas to increase their understanding of a specific area of the curriculum” [8]. And Inquiry learning is a constructivist pedagogy and curriculum approach that is student centered and authentic” [9]. Based on the interviews with three UNJ Physics lecturers from three types of inquiry, namely guided inquiry, modified inquiry and free inquiry, the most suitable or appropriate to be used for first-year students is modified inquiry. This is because the thinking ability of the first-year student is already at the level of independent finding without much guidance, but they still need guidance in order to work on findings. Modified inquiry: This is in between the guided inquiry and free inquiry. The teacher provides the problem and asks the students to carry out the investigation which might be in groups. The teacher acts as a resource person giving assistance to avoid frustration or lack of progress by the students” [10].

Based on the facts above, to fix the shortcomings in the pre-existing practicum guidebook, the researcher will develop a physics practicum worksheet (PPW) in electricity based on modified inquiry approach. In developing PPW, the researcher limits the scope of material which includes electrical circuits that applies Ohm’s law and series of obstacles, incandescent lights characteristic, Kirchhoff’s law, oscilloscopes, alternating current circuits and transformers.

2. Research Method

The research method used in this study is research and development. Research and Development (R&D) is the process of researching consumer needs and then developing product to fulfill those needs. The purpose of R&D efforts in education is not to formulate or test theory but to develop effective products for use in schools” [11]. The research method used is research and development (R & D) with the ADDIE models (Analysis, Design, Development, Implement, Evaluation).

The analysis phase is carried out with preliminary studies and requirement analysis. On the design stage, the selection of teaching materials is in the form of Practicum Worksheets, development of draft model and compiling instrument grids. Furthermore, the development phase includes activities for drafting the development model, develop PPW based on the design of the model that has been made. After the practicum worksheets have been completed, the validation test by experts is carried out by media experts, material experts and learning experts. Then, a field test is carried out at the implementation test.
Data in this study were collected from the requirement analysis data obtained from lecturers, students and laboratory assistants before product development as well as the data from the results of media expert validation, physics experts and learning experts on the practicum worksheets that have been developed. The collected data then interpreted into scores. The limitation of whether or not the product is used as an alternative material for the practical course of Electricity in Physics is based on the following criteria:

| Percentage | Interpretation |
|------------|----------------|
| 0%-25%     | Very less      |
| 26%-50%    | Less           |
| 51%-75%    | Good           |
| 76%-100%   | Very Good      |

### Table 1. Interpretation of Likert Scale

3. **Analysis**

The Physics Practicum Worksheet (PPW) in Electricity based on Modified Inquiry Approach developed was used as teaching material for Physics practicum courses at Universitas Negeri Jakarta. In this study, the research and development methods used were ADDIE model.

During the analyze phase, product development begins with observations on the existing Physics practicum teaching materials. In the observation results, the facts of the existing practicum teaching materials have not been able to make students determine their own research steps. In the previous teaching materials, the final question could not stimulate students to build the concept they wanted to implement.

In this phase, the researcher also collected data through requirement analysis by observing the existing teaching materials of Physics practicum. The initial data collection was also carried out by interviewing lecturers of the Physics Study Program and Physics Education Program of Universitas Negeri Jakarta, then distributing questionnaires to laboratory assistants and students of the Physics and Physics Education of Universitas Negeri Jakarta. The initial data collection aims to determine the level of the needs of Physics Practicum Worksheet as teaching material for Physics practicum courses at Universitas Negeri Jakarta. Furthermore, this step also includes student characteristics analysis, subject condition and characteristics, teaching material analysis as well as determine the learning outcomes and learning indicators.

After the requirement analysis, the process continue to design phase. During this phase, researcher determine the types of teaching materials that will be used. Based on the result of the analysis, the suitable teaching material is practicum worksheet. The selection of practicum worksheets as teaching materials that will be developed was because PPW is a teaching material which contains material, summaries and instructions to examine something so that users can find and develop concept. Next, the draft development of development model was conducted, including: (1) determine the materials included and the name of the practicum activities in the PPW; (2) determine the content of the learning through modified inquiry approach. The learning process in the PPW is proposing questions or problems, formulating hypotheses, collecting data, analyzing data, making conclusions; (3) determine learning management strategy. In addition, the researcher also conducted preparation of a test strategy for validation of media, material and learning experts.

The display of the Physics Practicum Worksheet in Electricity based on modified inquiry is as follows:
Figure 1. PWW cover display

Figure 2. Introduction display

Figure 3. Sub cover display

Figure 4. Orientation problem display
The develop phase comes after the design phase. During this phase, the drafting of the development model is carried out. The drafting was carried out by determining sections of PPW, namely: (a) title; (b) introduction; (c) general safety guidelines; (d) multimeter use instructions; (d) statistical methods in data processing; (e) Learning activities that contains: learning resources, learning prerequisites, problem orientation, experimental objectives, tools and materials needed, supporting information, problem formulation and hypotheses, experimental steps, experimental data, data processing, final questions and conclusions.

On the development phase, the researcher made PPW designs to see the form of the initial stage of PPW, then creating PPW and print the PPW. After the PPW is printed, the expert validation is carried out to material experts, media experts and learning experts. The form of validation assessment and student trials were conducted by giving PPW questionnaire assessment based on the aspects of assessment.

The three material experts in this study are professors of Physics at the Universitas Negeri Jakarta. The assessment of the test as material expert consists of three aspects, namely (1) aspects of content consist of 12 questions; (2) aspects of presentation consist of 7 question; and (3) aspects of language consist of 3 questions. From the result of material expert validation obtained in the aspect of content, the score of 84.72% was obtained which based on the score of Likert scale, the assessment of PPW quality of electricity material based on the modified inquiry approach in terms of content aspect was considered very good. Then, the presentation aspect, the score obtained was 78.57% which is considered very good. The Language aspect, the score obtained was 86.11% which is considered very good. The average score of the material expert validation score was 83.13%, which based on the Likert scale score obtained by the assessment quality of PPW electricity material based on the modified inquiry approach was considered very good.
The two media experts in this study are lecturers of Physics at the Universitas Negeri Jakarta. The assessment of the media expert feasibility consists of three aspects, namely: (1) aspects of content consist of 12 questions; (2) aspects of presentation consist of 15 questions; and (3) aspects of language consist of five questions. From the result of media expert validation obtained in the content aspect, the score of 91.67% was obtained based on the score of Likert scale, the assessment of PPW quality electricity material based on the modified inquiry approach was considered very good. Then, the presentation aspect obtained, the score obtained was 96.67%, which is considered very good. While the Language aspect, the score obtained was 92.50% which is considered very good. The average score of the media expert validation score was 93.61 %, which based on the Likert scale score, the assessment quality of PPW electricity material based on the modified inquiry approach was considered very good.

The two learning experts in this study are lecturers of Physics at the Universitas Negeri Jakarta. The assessment of the learning expert consists of three aspects, namely (1) aspects of content consist of 13 questions; (2) aspects of presentation consist of 17 questions; and (3) aspects of language consist of two questions. From the result of learning expert validation in the content aspect, the score of 95.19% was obtained based on the score of Likert scale, the assessment of PPW quality electricity material based on the modified inquiry approach was considered very good. Then, the presentation aspect, the score obtained was 95.31%, which is very good. While the Language aspect, the score obtained was 91.67%, which is considered very good. The average score of the learning expert validation score was 94.06%, which based on the Likert scale score, the assessment quality of PPW electricity material based on the modified inquiry approach was considered very good.

Field test aims to gather information from the students on the final product that has been developed as teaching material for Physics practicum courses. The test was conducted at the Universitas Negeri Jakarta to 24 students. The assessment given by the students consists of 3 aspects, namely (1) aspects of content consist of 10 questions; (2) aspect of presentation consist of five questions; and (3) aspects of language consist of two questions. From the result of field test in the content aspect, the score of 81.67% was obtained based on the score of Likert scale, the quality assessment of PPW electricity material based on the modified inquiry approach was considered very good. Then, the presentation aspect obtained a score of 88.75%, which based on the Likert scale score, the assessment of PPW quality of electricity material based on the modified inquiry approach in terms of the aspect of presentation is very good. While the language aspect obtained a score of 81.25%, which based on the Likert scale score, the assessment of PPW quality of electricity material based on the modified inquiry approach in terms of language aspect was considered very good. The average score of field test was 83.89 %, which based on the Likert scale score, the quality assessment of PPW electricity material based on the modified inquiry approach was considered very good.
Based on the results of the feasibility test to material experts, media experts, learning experts, the overall percentage was 88.32% and the average score of field test was 83.89 %, with a very good interpretation. So, the developed Physics Practicum Worksheet in Electricity based on Modified Inquiry Approach is suitable to be used as teaching material in the Physics practicum course.

After the development process, PPW has its own advantages and disadvantages according to researcher. The advantage of PPW Physics in electricity includes: (1) the developed PPW has experienced adjustments to the Modified Inquiry approach that is suitable with the characteristics of the first-year students; (2) there was a problem orientation, problem formulation and hypothesis as well as final question in PPW that guides the students in understanding electricity concepts that are not in the previous Physics practicum teaching materials; (3) in the previous Physics practicum teaching materials, practicum activities were not adjusted to the order of Physics material, but the PPW developed by the researchers filled the activities according to the sequence of Physics material; (4) the developed PPW assist the students directly in understanding electricity concepts that emphasize student-centered learning; (5) PPW fosters curiosity, critical thinking ability, logical and analytical thinking; (6) the developed PPW can train students’ comprehension in using practical tools.

Aside of its advantages, PPW Physics in electricity also has its own limitations, namely: (1) This PPW is a little difficult to make students design experiment phase independently because they are not used to learn independently; (2) practicum on PPW is limited; (3) the images presented on PPW have not been maximized due to researchers’ limitation in designing images.
4. Conclusion

- Practicum worksheet is designed for six practicum activities namely: (1) Ohm’s Law; (2) set of obstacles (3) Kirchhoff’s Law experiment; (4) oscilloscope; (5) alternating currents; and (6) transformer.
- The practicum worksheets developed are feasible to be utilized with the results of media expert validation of 93.61%, means that the practicum worksheets are considered very good. Furthermore, the result of material expert validation is 83.13%, which means that the practicum worksheet was considered very good, while the learning expert result reached 94.06%, and the field test result for 83.89%, which means that the worksheet is considered very good.

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