Developing optical instruments encyclopedia based on problem based learning

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Abstract. The aim of this study to develop optical instruments encyclopaedia based on problem-based learning. The research method used is research and development (R & D) with the ADDIE models (Analysis, Design, Development, Implement, Evaluation). Data collection techniques used through interviews, observation, and questionnaires. The development of optical instruments encyclopaedia is done in State University of Jakarta’s physics laboratory. This encyclopaedia has been validated by experts, that is content experts, media experts, graphic experts, and learning experts by providing validation instrument. Optical instruments encyclopaedia is structured by problem based learning approach stage that is problem orientation, organize student to learn, investigation, problem solution result, analysis and problem solution evaluation. Overall, this encyclopaedia deserves to be used as a learning resource for students.

1. Introduction
Learning in the 2013 curriculum aims to develop the talents, interests, and potential of learners to become a person of character, competence, and literacy. In addition, the principle of learning used in the 2013 curriculum is learning based on various learning resources [1]. One of the learning resources that learners can use in the learning process is the book. However, the books used must be a suitable need with learners in the learning process, both formal education, and non-formal education.

Refer to the results of the questionnaires, 73% stated that physics textbook used less helpful and motivate learners in learning physics. This is because the language used is elusive and more formulas than concepts. Limitations of learning resources used to cause learners less understand the material of physics in the learning process. 96% of learners at school stated that they needed additional learning resources to complete the physics textbooks used in the physics learning process. To support the learning process learners, learn independently, the encyclopedia can be equipped with a learning model tailored to the characteristics of learning materials. Optical instrument material characteristics enable learners to solve problems related to optical tools that are contextual.

An encyclopedia is one of the reference books that contains explanations of science from various fields or one branch of certain science compiled in a comprehensive, systematic, and based on certain categories. “The focus of an encyclopedia is generally found in its prefatory remarks” [2]. The optical encyclopedia includes one type of specialized encyclopedia. “Subject encyclopedias are classified by subject and are dispersed throughout the reference collection. General encyclopedias are usually classified together” [3]. The coverage of one subject's subject in the special encyclopedia is more
profound and widespread. Encyclopedia of optical devices with problem based learning model can be used as a learning resource for physics textbook companion that is used by students.

“Problem Based Learning (PBL) is learning that results from the process of working toward the understanding or resolution of a problem” [4]. PBL is one model of learning that requires learners to play an active role in thinking both inductively and deductively to find solutions to problems that have been presented at the beginning of learning. It is an instruction method which consists in the utilization of the “real world” problems like a necessary context [5]. Based on the result of research by Ahmed, PBL helped students to improve their science process skills [6]. The syntax of learning models used in the encyclopedia of optical devices, namely orientate learners to the problem, organize learners to learn, assist in the investigation independently or in groups, develop and present the work, analyze and evaluate the results of problem solving.

The development research entitled “Development of Wave Based Encyclopedia of Scientific Approaches to Improve Student Learning Outcomes of High School Students” conducted by Anida shows that a wave based encyclopedia of scientific approach is very well used as a learning resource of physics and this encyclopedia can improve the cognitive learning outcomes of SMA / MA learner [7]. The research conducted by Jules under the title "Development of digital encyclopedia of electrical technology based contextual teaching and learning (CTL)" is obtained that the use of the digital encyclopedia in the learning process can improve students' understanding of the material being studied [8]. Development research was conducted by I Made Astra and Fahrurozi produced “Physics Knowledge Enrichment Book: Optical Instrument Equipped with Augmented Reality” is proper book in order to improve students’ learning outcomes in cognitive domain [9]. Encyclopedia equipped with Problem Based Learning model is predicted to support learning activities of learners because it will lead learners to find solutions to issues raised in relation to optical instrument.

Based on studies of encyclopedia development research which has been done by the previous researcher, there is no research of encyclopedia based on problem based learning. So need to do research development with the title of research "Development of Encyclopedia of Optical Instrument Based Problem-Based Learning".

2. Research Method
This research was conducted at the Faculty of Mathematics and Natural Sciences, Jakarta State University. The research method of this study is Research and Development with ADDIE (Analyze, Design, Develop, Implement, Evaluate) models. The phases of ADDIE models are sequential, each depends upon the successful completion of the preceding phase [10]. This R & D method is used to produce an encyclopedia product and test the feasibility of the encyclopedia in the learning process. Stages of encyclopedia development using model From five steps the development of ADDIE model is adapted into three development steps: Analyze, Design, Develop.

Instruments at the validation stage of the expert use Likert scale with score 4 = very feasible, 3 = feasible, 2 = not feasible, and 1 = very infeasible. Further validation test results are calculated in the following manner:

\[
Percentage \ score = \frac{\text{Score of objective}}{\text{Maximum score}} \times 100\%
\]

Table 1 The percentage scores obtained by the measured using score interpretations for the Likert scale and for Guidelines Eligibility Criteria:

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\[
Percentage \ score = \frac{\text{Score of objective}}{\text{Maximum score}} \times 100\%
\]
| Percentage | Interpretation  |
|------------|----------------|
| 0% - 25%   | very infeasible |
| 26% - 50%  | not feasible    |
| 51% - 75%  | feasible        |
| 76% - 100% | very feasible   |

Source: adapted Riduwan [11]

3. Results and Discussion

3.1. Optical Instruments Encyclopaedia based on Problem-Based Learning"

The product developed is an encyclopedia in print form. The encyclopedia of development outcomes consists of several components, cover, introduction, table of contents, the basic competence of optical instrument materials, usage manuals, concept maps, material presentations, bibliography, glossary, and index. The optical instrument encyclopaedia is arranged alphabetically and each material presentation comes with a problem based learning stage. Below is the product picture of optic instrument development of optics (Figure 1-2):

![Figure 1 Display of front and back encyclopedia cover](image)
Figure 2 The material page views on the encyclopedia of optical instrument based on problem-based learning. Second stage of problem-based learning is organizing learners to learn.

This product is inspired by what Anida did. When compared to the encyclopedia developed by Anida, this encyclopedia is equipped with a learning model that matches the characteristics of optical instruments material. This encyclopedia has six titles, eyeglasses, camera, magnifying glass, microscope, periscope, and telescope, also includes history, types, instructions for making simple optical instrument, and quizzes.

3.2. Validity
The encyclopedia development stage in this research is carried out until the expert validation stage. Validation result of encyclopedia to be evaluated before product trial run. Expert assessment results are presented in tables 2, 3, and 4 as follows:

| No | Indicator                                                                 | Feasibility Test Result (%) |
|----|---------------------------------------------------------------------------|-----------------------------|
| 1  | Conformity cover with encyclopaedia contents                              | 87.50                       |
| 2  | Conformity of content with basic competence                               | 75.00                       |
| 3  | Conformity of content with high school learner's thinking level           | 75.00                       |
| 4  | Material upgrades in the encyclopaedia of optical devices with the development of science | 81.25                       |
| 5  | Conformity of the material in the encyclopaedia of optical devices        | 87.50                       |
| 6  | The accuracy of writing                                                  | 91.67                       |
| 7  | The precision of the concept presentation sequence                        | 87.50                       |
| 8  | The suitability of the image with the material                            | 75.00                       |
| 9  | Image source clarity                                                     | 75.00                       |
| 10 | The suitability of the literature sources with the material               | 81.25                       |
| 11 | Diversity of library resources                                           | 75.00                       |
| 12 | Literature update                                                         | 75.00                       |
Table 3. Assessment Indicator by Media Expert

| No | Indicator                                                                 | Feasibility Test Result (%) |
|----|---------------------------------------------------------------------------|-----------------------------|
| 1  | Conformity cover with encyclopaedia contents                              | 100.00                      |
| 2  | Conformity of content with the encyclopaedia component                     | 91.67                       |
| 3  | Accuracy of composition and colour combination                            | 87.50                       |
| 4  | Consistency of spacing                                                    | 87.50                       |
| 5  | Conformity type and font size                                             | 87.50                       |
| 6  | The suitability of the image with the content of the material             | 93.75                       |
| 7  | Image source clarity                                                      | 87.50                       |
| 8  | Conformity of image and text layout                                       | 87.50                       |
| 9  | The suitability of the literature sources with the material               | 93.75                       |
| 10 | The variety of library resources                                          | 87.50                       |
| 11 | The Attractiveness of display design                                      | 95.83                       |
| 12 | The Accuracy of language                                                  | 90.63                       |
| 13 | The usefulness of the encyclopaedia                                       | 93.75                       |

Table 4 Assessment Indicator by Learning Expert

| No  | Indicator                                                                 | Feasibility Test Result (%) |
|-----|---------------------------------------------------------------------------|-----------------------------|
| 1   | Conformity of content with basic competence                               | 96.67                       |
| 2   | Conformity of content with high school learner's thinking level           | 83.33                       |
| 3   | The appeal of illustrations / drawings                                     | 83.33                       |
| 4   | Typeface appeal                                                           | 83.33                       |
| 5   | The suitability of font size                                              | 91.67                       |
| 6   | The appeal of display design                                             | 91.67                       |
| 7   | Ease learners understand the material                                     | 93.06                       |
| 8   | The precision of the concept presentation sequence                        | 83.33                       |
| 9   | The suitability of the illustrations with the material                     | 91.67                       |
| 10  | Conformity of encyclopaedia contents with problem-oriented stages         | 83.33                       |
| 11  | Conformity of encyclopaedia contents with the stage of organizing learning| 91.67                       |
| 12  | Conformity of the material content with the PBL model inquiry stage       | 91.67                       |
| 13  | The suitability of the material content with the stages of developing and presenting problem solving | 91.67                       |
| 14  | The suitability of the material content with the stages of analyzing and evaluating the results of problem solving | 95.83                       |
| 15  | The accuracy of writing language                                          | 95.83                       |
| 16  | The usefulness of the encyclopaedia                                       | 100.00                      |

The average result of the quality assessment of optical encyclopaedia by the content, media, and learning experts is expressed in graphical form as follows:
Figure 3 Appropriateness of the chart result by content, media, and learning experts

Figure 3 show that aspects assessed by a content experts include material suitability, illustrations, literature sources. Aspects assessed by a media expert consist of the display, color selection, language, and the usefulness of the encyclopedia. While the aspects assessed by the expert of learning, namely the conformity of the content with basic competencies, PBL stages, and the level of thinking of learners. Based on graph 1 and table 1, the quality assessment of the optical instrument encyclopedia is considered "very feasible". So, the encyclopedia of optical instrument based on problem-based learning is very feasible to be used as one of the alternative learning resources companion textbook lesson.

4. Conclusion
Based on the results of research and the feasibility test that has been done, it can be concluded that the product of the encyclopedia of optical instruments based on problem-based learning has been successfully created and this encyclopedia belongs to the category is very suitable to be used as a learning resource physics companion textbook lesson and this encyclopedia can enhance students’ learning outcomes in high school.

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