The Development of a Physics Knowledge Enrichment Book “Optical Instrument Equipped with Augmented Reality” to Improve Students’ Learning Outcomes

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Abstract. This study aims to develop a physics knowledge enrichment book which is provided with augmented reality focusing on the proper optical instruments as the subject to improve students’ learning outcomes. This physics knowledge enrichment book entitled “Alat Optik yang dilengkapi dengan Augmented Reality” discusses some optical instruments seeing from its history, physics concepts, and types. This study used method Research and Development which is developed as Model Pengembangan Instruksional. In the previous study has been done feasibility test to the material and media experts with the percentage by each experts are 88.50% and 88.90%. In this study, we did the trial run of product use was carried out to a physics teacher and 25 students of SMAN 33 Jakarta. This trial run got the average percentage of 88.10% from the physics teacher while the result of the students was 82.80% and the gain normalized test result of 0.71 which meant the students' learning outcomes had increased in cognitive domain with high interpretation. Based on the result of this study, the physics knowledge enrichment book entitled “Alat Optik yang dilengkapi dengan Augmented Reality” is a proper book in order to improve students’ learning outcomes in cognitive domain with high interpretation.

1. Introduction
Education is one of the benchmarks of nation advancement. Developed countries have excellent education quality in order to produce well-educated, qualified, and competent human resources. High quality human resources will create a high productivity which reflects the nation high competitiveness at last [1].

Indonesia applies learning process as its education method. It is essential that a learning process influences the improvement of education quality. Some components supporting the learning process are curriculum, teaching programs, learning approaches, educators’ quality, learning materials, learning strategies, learning resources and techniques/forms of assessment. Those components can determine the learning success and affect the learning outcomes [2].

Books are one of the students’ main learning sources. The books has been structured very well and generally adapted to the accepted curriculum [3]. Student textbooks are available on the market in big supply with multiple qualities. But then, since some research results found inappropriate concepts and misconceptions, an alternative conception is needed on those student textbooks [4]. Students need other textbooks which can enrich their knowledge mastery and become the complementary of student textbooks.
Enrichment books can be used as learning resources which support the learning process. Besides textbooks, educators have other alternatives for the learning process such as educator handbooks, enrichment books, and reference books. The educators may suggest their students to read the enrichment and reference books in order to improve students’ knowledge and insight [5].

Since its early development in 1920, educational technology has always been associated with multimedia equipments. This development is called as “the enrichment of education through the seeing experiences” [6]. According to Waldopo’s research result, it can be concluded that after watching the utilization demonstrational of interactive multimedia program in learning activity, teachers and students are agree upon the interactive multimedia program assists them to understand learning materials during learning process. This Waldopo’s research also found that the students place physics on the second rank of the subjects requiring multimedia-based material presentation [7].

One of kinds of multimedia-based learning media is Augmented Reality. It potentially improves academic educational and training efficiencies and nearby corporations by giving information at the right place and time and offers well off contents by producing 3D images [8].

Optical instruments are one of the nearest physics materials but people cannot realize it occasionally, or they already realize its existence but they do not understand it deeply. Thereupon, the writers conduct a study of developing a physics knowledge enrichment book entitled “Alat Optik yang dilengkapi dengan Augmented Reality” to improve students’ learning outcomes. This study is expected to give the students a better understanding about optical instruments. Moreover, the implementation of augmented reality in this study will improve students’ understanding and their interest to read books.

2. Method
The research method of this study is Research and Development, a method which develops a product then examines its effectiveness [9]. The development of this study uses an approach system model designed by Walter Dick and Lou Carey [10]. Afterwards, Atwi Suparman modifies Dick and Carey’s model to Model Pengembangan Instruksional (MPI) which is written in an instructional modern design book (2014). The stages of MPI are:

2.1. Identifying the Instructional Requirements and Writing the Purpose of General Instructional (TIU)
In this first stage, the instructional requirements will be analyzed by conducting literature study from previous researches to understand the research gap between previous learning media which has been developed and current learning media which is needed for students and teachers.

2.2. Doing the Instructional Analysis
Instructional analysis is the explanation process of general competence turns into sub-competence, principle or specific competence which are organized logically and systematically.

2.3. Identifying the Students’ Primary Behavior and Characteristics
This third stage will analyze the educators: context analysis of the place where they will study and where they will apply their knowledge. The educators’ skills, choices, and behaviors will be used to design instructional strategies.

2.4. Writing the Purpose of Specific Instructional
The purpose of specific instructional is based on the skills which have already identified in instructional analysis. The writers will identified the skills that must be learned, the condition where the skills must be placed, and the criteria of a great performance.

2.5. Arranging the Assessment of Learning Outcomes
According to the purpose of this research, the writers will develop the equivalent assessment items (standard reference test) to assess students’ skills due to the main purpose which has been predicted. Related main emphasize is placed in the skill types depicting into requested purpose and assessment.
2.6. Arranging the Instructional Strategy
The part of instructional strategy emphasizes components for learning and teaching development including pre-instructional activity, content presentation, students’ participation, assessment, and follow-up activity.

2.7. Developing the Instructional Material
The term of instructional material refers to all instructional forms such as teachers’ guide, module, overhead transparency, video cassette, multimedia-based computer, and website page for far distance instructional or connotation material.

2.8. Arranging the Design and Conducting the Formative Evaluation
There are three kinds of formative evaluations: individual assessment, group assessment, and field test assessment. Every assessment gives the researcher different information which will be used to improve instructional. The same technique can be applied to formative assessment of material or instructional in the class.

2.9. Instructional System
Instructional Strategy is reconsidered until it is ultimately inserted in the instructional revision in order to make it as an effective instructional media.

2.10. The Implementation, Summative Evaluation, and Diffusion Innovative
The results of previous stages will become foundation to write the indispensable equipments. Subsequently, the equipment result is validated and tested or it will be implemented in class by the summative evaluation.

3. Results and Discussion
A physics knowledge enrichment book entitled “Alat Optik yang dilengkapi dengan Augmented Reality” is developed by literature study using some textbooks, internet references information, and journals. Physics and other materials information about optical instruments are acquired from some books such as basic physics book, medicine book, history and invention books, and optical instrument manual book.

3.1. The Knowledge Enrichment Book “Alat Optik yang dilengkapi dengan Augmented Reality”
The book which has five chapters does not only contain with the implementation of physics concept in optical instrument. As a public enrichment book, this book contains the history, types, and other general information of optical instrument. Moreover, according to its title, this book is equipped with augmented reality which will visualize optical instruments in 3D format and its ways of working video (Figure 1-5).
Figure 1. Display of front and back book’s cover

Figure 2. Display of book’s content

Figure 3. Display application menu of Augmented Reality
3.2. The Results of Product Trial Run
In the previous study, this developed book has been tested its feasibility by material and media experts with percentage 88.5% and 88.9% (Figure 6 and 7, respectively).

The trial run of product started with small group test consisting of nine students of SMAN 33 Jakarta (four students from eleventh grade and five students from twelfth grade). This small group test contains with product sample and product effectiveness tests to know how the product influences students’
knowledge improvement. For product sample test, the writers use only one of whole product’s chapters. The writers’ treatments for the students are giving them the pretest then testing the product: they have an opportunity to read the product development book then they will work on a post-test. The small-group test will assess some aspects such as the presentation of cover, contents, illustration, AR media, and material and grammar compositions. The result of small-group test is an average percentage of 89.0%. Further, the average scores of students’ pre-test and post-test are 36.3 and 81.48 from 0-100 scale. Based the pre-test and post-test results, the gain result is 0.67. It can be concluded that the students’ knowledge improvement is in the medium category (Figure 8 and 9).

![Figure 8. Trial run of developed book in a small group](image1)

![Figure 9. Pre-test and post-test result in a small group](image2)

After the small-group test, the writers conduct the trial run test. It involves physics teacher and 25 students of SMAN 33 Jakarta (Figure 10-12). These two tests have the same treatment, but the trial run test uses full product and its assessment aspects are different with the small-group test. The result of trial run test of physics teacher is an average percentage 88.1% while students’ result test is 82.8% and their pre-test and post-test scores are 47.47 and 86.80 from 0-100 scale. Based on the pre-test and post-test results, the gain result is 0.71. It can be concluded that the students’ knowledge improvement is in the high category. Here is the graphic of physics teacher and students’ trial run test result in SMAN 33 Jakarta.
4. Conclusion
According to this study, it can be concluded that physics knowledge enrichment book entitled "Optical Instrument Equipped with Augmented Reality" is a proper book in order to improve students’ learning outcomes in cognitive domain.
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