The development of an electricity book based on augmented reality technologies

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Abstract. This research aims to produce an electricity book using augmented reality (AR) technology. This book can support observation, experimentation, and stimulation activities because AR technology can display animation, sound, and video. The method used in this research is 4D model research and development (RND) whose stages consist of: define, design, develop, and disseminate. The disseminate stage was done by uploading the application to the Google PlayStore. The AR book has passed the validation test stage with the percentage of achievement of 80.44% according to the material expert, 91.75% according to the learning media expert. The test results to 10 students showed the performance of 82.48% with 0.68 of gain value. Based on validation test and field test, give the conclusion that the development of electricity book based on AR technologies has fulfilled the learning process and requirement as physics teaching materials.

1. Introduction

Augmented reality (AR) technology is increasingly becoming a trend in many fields. At the beginning in the field of tourism, AR technology can become a unique and exciting entertainment media. Furthermore, in the field of games, AR technology was causing many users to waste time using a smartphone as a device to play with AR technology. This development makes AR technology as one of the development trends in the world of education today: AR technology offers a more realistic learning environment and uniqueness regarding interaction with users [1].

In the field of education and learning, has been a lot of research that shows that the use of AR can improve student ability. In a study in Taiwan, a digital game-based learning model that integrates augmented reality (AR) technology for elementary school students on marine ecology and water resources, has improved student confidence, improved competence, and improved performance for students with low achievements academic [2]. This achievement because the use of AR-based media in learning activities can ease the cognitive load, provide learning motivation, and provide optimism in learning activity [3-5].

In the field of STEM learning, AR technology has many important roles, especially its superiority in displaying the phenomenon of science and its advantages in displaying the simulation more real. Real-time simulation with the use of AR technology in the anatomical field can provide a more realistic learning experience especially for the preparation of surgical science [6]. Furthermore, in the field of ecology, mobile-based learning with AR integration can improve learning effectively [7]. Increased students’ cognitive abilities also occur in botanical learning using AR-based media [8], students have
better observational skills with AR-based media to significantly improve their cognitive abilities. In the study of physics, the use of AR technology-based media is believed to improve various aspects of learning. Physics as science provides opportunities on many topics to developed into media with the utilization of AR technology. Physical phenomena can pack with AR technology in the form of animation, video, and even virtual laboratory [9].

2. Research method
The research and development method used is 4D Thiagarajan model which consists of Define, Design, Develop, and Disseminate [10].

2.1. Define
We begin by analyzing the purpose of a book based on AR development on static electricity and dynamic electrical topic materials. The analysis conducted on the development of 3D animation models and learning videos. We also analyze several concepts of physics materials accordance the level of student misconceptions, and we choose some 3D animations we made, that are positive charge fields, negative charge fields, positive and negative charge fields, positive and positive charge fields, negative charge fields, electroscope, electric current and electron current. Furthermore, we analyze the instructional to determine the learning indicators. The analysis of the smartphone devices that support AR technology, and resulting in the development is applicable because various smartphone devices support camera readings from applications. We identified the network access for the student when installation process of application and the characteristics of teachers and students on implementation the educational technology. These identification using interview technique.

2.2. Design
At this stage, we prepare indicators based on competencies. This indicator used as a reference in drafting the book script and AR technology to be inserted.

2.3. Develop
At the developing stage, we perform three activities that are a series of units, as follows.

2.3.1. The book based on AR. The development of the book using Ms. Word from Office 365, AR development is done using Unity 3D with version 5.6.1f1 64 Bit, the development of learning video using Power Director application, and the development of icons and application tools by using Adobe Fireworks CS6. The developed books can present dynamic static and electric dynamic phenomena. During the build AR application, we consider various technicalities especially regarding marker readings [11].

2.3.2. Validation. We need the validation after developed book and AR application to determine the feasibility of the book based on AR. The validation tests performed by validators consisting of material experts and media experts. In performing validation test, we used instrument or assessment questionnaire to collect data. Based on the results of this validation, researchers can conclude about the feasibility of products, advantages, and disadvantages of products, and critics or suggestions for product improvement.

2.3.3. Field test. We conducted field tests by high school physics teachers, test legibility by five students and a limited trial of 10 students. Field trials by teachers and limited trials of 10 students using a Likert-scale questionnaire. While the test legibility of 5 students conducted through interviews.

2.3.4. Revision. We revised AR book according to the result of validation test and field trial. Furthermore, the products that have been through the revision, we conclude the feasibility of the product for the use of students as a medium of learning.
2.4. Disseminate

The AR book on the subject of static electricity and dynamic electricity has been through the phases of dissemination through Google Play store under the name of AR-Electric products.

3. Result and discussion

The developed AR book has the same results as textbooks in general, only on some images equipped with AR. The textbook component of the lesson developed follows the major parts of the textbook. Also, AR featured in books in the form of learning stimulation videos, experimental videos, Phet simulation videos, and 3D animations. AR can display with the previously installed apps on a smartphone. The following is the result of developing an AR book on static electricity and dynamic electrical materials.

![Electroscope making process](image1.png)

(a)

![3D animated display of books](image2.png)

(b)

Figure 1. (a) The electroscope making process uses unity to observe static electricity events, (b) The 3D animated display of books displayed using smartphones through the AR apps.
The results of the development of this book have passed the material and media experts validation tests, field tests of teacher and student legibility, and limited tests. The following is the result of validation of static electricity and dynamic electric AR books.

**Table 1.** The validation results of media experts and learning materials.

| No | Aspects Measured | Presentation Scale | Interpretation |
|----|------------------|---------------------|----------------|
| 1  | Book size        | 90%                 | Very Good      |
| 2  | The layout of the book cover | 84% | Very Good |
| 3  | Typography of book cover | 82.50% | Very Good |
| 4  | The layout of the book | 97.77% | Very Good |
| 5  | Illustration of book content | 88% | Very Good |
| 6  | The interface of AR | 100% | Very Good |
| 7  | The content of AR | 100% | Very Good |
|    | **Average of all aspects** | **91.75%** | **Very Good** |

| No | Aspects Measured | Presentation Scale | Interpretation |
|----|------------------|---------------------|----------------|
| 1  | Material conformity | 81.33% | Very Good |
| 2  | Material consistency | 80% | Good |
| 3  | Writing language | 80% | Good |
|    | **Average of all aspects** | **80.44%** | **Good** |

The validation tests for media experts generate some suggestions and inputs to revised the AR book. The use of language should be more easily understood and simple, the order of the material and the book support should sort in a systematically, and some applications still do not match the ratios and sizes that
are eligible for viewing, this fixed by changing the scale and ratio on unity 3D software. As shown in table 1, the results of media expert validation test get average of 91.75%, this value indicates that physics book based on augmented reality for static electricity and dynamic electricity subject materials is considered very good to be used as a supporting book of physics learning activities.

The validation test to the material expert gives some suggestion that the valence electron illustration should use the new illustrations and the consistency of vector symbols and the physics equation expression. The result of the material validation test get the average of achievement result of 80.44% as in table 1, show that this book is considered good to used for supporting learning activity.

The results of field tests to teachers, we get advice on the video shown to be made more innovative and reemployed. While the results of field tests to students conducted without questionnaires in SMAN 105 Jakarta to 5 students of class XII MIPA C, by mentoring in using books and interviews to get information after students using a book based on augmented reality technology. The interviews give the results the size and type of letters are appropriate and easy to read, the book layout is appropriate, the language of exposure is understandable, the length of the book sentence needs improvements to be more concise, and students have understood the concept exposure through 3D animation and learning video.

The limited tests to 10 students of SMAN 105 Jakarta Class XII MIPA C held in July 2017. Technical implementation begins with students doing the pretest then students using book outside the classroom. These tests such as the use of books and AR applications performed at home for one day. Students learn and understand the use of AR applications. Next, the 3rd-day students carry out posttests and fill out the questionnaires. For an explanation of N-gain test, can be seen in table 2.

Table 2. The N-gain results.

| Number of students | Pretest average | Posttest average | N-Gain |
|--------------------|-----------------|-----------------|--------|
| 10                 | 28              | 77              | 0.68   |

A normalized gain test has performed which is useful for measuring the difference of student's knowledge before and after using physics book equipped with AR. The results of the normalized gain test obtained 0.68 which interpreted in the medium category. Based on these result can be concluded that there is an improvement of result learn student before and after using physics book based on augmented reality technology.

4. Conclusion

Several experts have validated the physics book based on augmented reality technology for static electricity, and electrical materials developed. Based on the validation, media feasibility results obtained 92.49% and classified as feasible, material feasibility obtained 80.44% and classified as feasible. This book has also been through limited tests of 10 students with a performance value of 82.48% then it is quite reasonable. It can conclude that the developed AR book is eligible and suitable for use in static and dynamic electricity learning. In the future, physics book development based on augmented reality technology should develop for other subjects. It is necessary to hold the experimental research for the effectiveness of this augmented reality physics book using in learning.

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