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DEVELOPMENT OF ANDROID-BASED AUGMENTED REALITY TALKING AS BIOLOGY LEARNING MEDIA IN PLANT ANATOMY CONCEPT

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ABSTRACT

This research aims to develop a biology learning media using Augmented Reality technology with added audio features for material explanations, and to test its suitability among students and biology teachers. The development research follows the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. Data were collected through interviews and questionnaire distribution, while data analysis was conducted using descriptive statistical techniques. This study resulted in a product called Talking Augmented Reality (TAR) for plant anatomy, an application designed for smartphones with the Android operating system. The application obtained a satisfactory level of validity in media validation and highly satisfactory results in material validation. The TAR application for plant anatomy was deemed highly suitable in the evaluation conducted with a small group of users consisting of 14 students and one biology teacher. It serves as an alternative learning media for studying plant anatomy concepts and effectively aids the biology learning process.

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INTRODUCTION

The classroom learning interaction is influenced by various aspects, one of which is the use of media by teachers to deliver subject matter (Arsyad, 2015). Communicative delivery of material and the use of engaging media by teachers can make students more enthusiastic about participating in classroom lessons (Dale, 1969). There are many advantages to using instructional media. According to Sanaky (in Suryani, 2018:9), instructional media can facilitate the learning process in the classroom, improve the efficiency of the learning process, maintain relevance between subject matter and learning objectives, and help students concentrate during the learning process.

In the 21st century, it is the right era to utilize information and communication technology in instructional media to achieve successful learning processes (Scott, 2015). Nowadays, teachers must be able to keep up with and understand the rapid development of information and communication technology. This is because teachers play a role in designing and developing digital learning experiences to stimulate students' interest and creativity (Saavedra and Opfer, 2012). This can be done by utilizing learning resources, whether from books, the internet, the environment, or other instructional media, to make learning more effective, efficient, and engaging. One way is by harnessing the technology owned by almost all students today, namely smartphones.

Smartphones have undergone rapid development. The current trend is not only about attractive phone models but also embedded technologies (Creeber and Martin, 2009). This has led to an increase in the number of smartphone users over the years. According to data released by Databoks (2015), the number of smartphone users in Indonesia reached 55 million and is projected to reach 92 million in 2019. According to Gifary (2015), Indonesia ranks fifth as the country with the largest number of smartphone users in the world, following China, the United States, India, and Japan. Data released by the Association of Indonesian Internet Service Providers (2018) stated that smartphone and internet users are predominantly teenagers aged 15 to 19 years. This shows that smartphone users in Indonesia are predominantly teenagers who are undergoing education at the junior high school, high school, and equivalent levels.

The development of smartphones should be approached wisely because although there are many smartphone users in Indonesia, not all of them use it to facilitate work, gain knowledge, or engage in other beneficial activities. Some people even buy smartphones solely for gaming or virtual communication through social media (Unantenne, 2014). However, there are still many other features that can be utilized in various fields to enhance human life, such as in the field of education. One of the benefits is utilizing smartphone technology as an effective, creative, and educational learning media. Technology-based learning media must continue to be developed, and one of them is Augmented Reality (AR).

According to Haller et al. (2007), Augmented Reality is developed with the aim of digitally overlaying computer-generated content onto the real world in real-time. Currently, AR technology has been developed for Android smartphones. AR used as a learning media is expected to enhance students' learning outcomes. Based on Ningsih's research (2018), it was found that the use of AR-based learning media had a significant impact on students' learning outcomes. The average learning outcomes of students using AR-based learning media were higher compared to those without it.

Until now, AR technology has the feature that allows users to see virtual 3D objects overlaid onto the real world in real-time (Azuma, 1997). Additionally, there are already several learning media utilizing AR technology that have additional features such as learning materials and assessment questions to evaluate students' understanding of a concept (Mustaqim, 2017). AR technology used as a learning media will continue to evolve to enhance students' interest and achievements. However, so far, AR applied in education is primarily visual-based (Jaya, 2010).

To enhance the functionality of AR, it is necessary to incorporate audio characteristics, turning it into an audiovisual medium. According to Wulan's research (2015), audiovisual learning media has a significant influence on students' interest and learning achievements in history. Therefore, if AR technology, which is primarily a visual medium, is enhanced with audio features, there is a high possibility that students' interest and learning achievements will significantly improve compared to utilizing only one aspect. Hence, the development of audio features in Augmented Reality media is necessary.

Based on observations conducted at SMA Negeri 1 Kota Tasikmalaya during a preliminary study for three months, the school is currently striving to maintain and enhance both academic and non-academic quality. One of the preparations is to provide high-quality teaching materials to students by utilizing the available facilities and

infrastructure in the school. However, the existing learning media seem to require an update. One aspect that needs improvement is the learning media that supports the plant anatomy concept.

Based on the statement of a biology teacher, one of the challenging topics for students is plant organ tissue. Students find it difficult to differentiate between different tissues found in plant organs. This is because the concept provided orally appears abstract to the students, and the use of images in PowerPoint is considered less effective in capturing the students' interest in learning. The teacher believes that creating three-dimensional models would be more suitable to engage students' interest in learning. Therefore, there was an assignment to create three-dimensional models using plasticine to depict tissue concepts in plant organs. The use of three-dimensional modeling in the learning process can improve students' learning outcomes (Suprapto, 2017). In addition, the use of 3D software in plant anatomy learning is quite effective because students can learn to utilize technology for their future (Suprapto, Ardiansyah, & Chaidir, 2020). To assist teachers in utilizing technology with 3D features on smartphones, an application was developed to support classroom learning.

Based on the aforementioned issues, the solution can be achieved by developing a learning media that utilizes Augmented Reality technology based on Android, with the addition of audio features. The application developed for this purpose is called Talking Augmented Reality. Developing learning media using Talking Augmented Reality technology can enhance the effectiveness of learning. This technology enables abstract concepts to become tangible. The learning media can be used to virtually observe various plant tissues using smartphones. By using Talking Augmented Reality, it is expected to increase students' interest in learning and their comprehension abilities, leading to improvements in their learning achievements.

METHOD

In this study, the researcher used the ADDIE development model. The consideration for using this model is because the ADDIE process is considered sequential yet interactive, where the evaluation results of each stage can inform the development of learning to the previous stage. The end result of one stage becomes the initial product for the next stage. According to Suryani (2018), ADDIE focuses on development for learning purposes, one of which is learning media. According to Branch (2009), there are five stages in the ADDIE model (analysis, design, development, implementation, evaluation).

The analysis stage is the initial stage in formulating the problem and real conditions in the field. The researcher gathered information through interviews and questionnaires. The analysis procedure in this development study includes several stages, such as content analysis, gap analysis, user needs analysis, software needs analysis, hardware needs analysis, and plan analysis.

The Design stage is the second stage of the development procedure. The Design procedure in this development study includes several stages such as material design and product design.

In this development stage, the developed design is translated into a sequence of programs that will form the complete software. After the software is completed, it needs to be tested before being published. Therefore, in this stage, there are six activities: preparation, resource preparation, layout arrangement, coding (using Microsoft Visual Studio), expert validation, and formative evaluation.

In the implementation stage, teachers and students are given the TAR Antum application to operate on their respective Android phones. The selected teachers are biology teachers from the XI grade science program at SMAN 1 Tasikmalaya, who have been involved as interviewees in the analysis stage. The referred students are the XI grade science program students at SMAN 1 Tasikmalaya who have studied plant organ materials in the odd semester.

The evaluation stage conducted is formative evaluation, which aims to improve the analysis, design, and development stages before implementation for users.

According to Sugiyono (2014:168), validity testing is the degree of accuracy between the obtained data and what is happening in the research object. An instrument can be considered valid if it has accuracy and precision in measuring the aspects to be measured. The validity testing is done by expert judgment, where one expert lecturer from the Department of Biology Education, Faculty of Teacher Training and Education, assesses the content, and one expert lecturer from the Department of Informatics, Faculty of Engineering, Universitas Siliwangi, assesses the media.

From the research instrument data, by considering the weight of each selected response for each assessment, the average score of each learning media component assessment is calculated using the formula:

$$\bar{x} = \frac{\sum x}{n}$$

Keterangan :

$\bar{x}$ = average score
n = number of appraisers
$\sum x$ = Total score of each appraiser

The formula for calculating the percentage score is written as follows:

$$persentase\ kelayakan\ (\%) = \frac{Skor\ yang\ di\ observasi}{Skor\ maksimal}\ x\ 100\%$$

Furthermore, according to Arikunto (2009: 44) the division of feasibility categories is classified using a scale as in table 1.

Table 1 Eligibility category based on percentage

Score in percent	Interpretation
0% - 25%	Not feasible
>26% - 50%	Less feasible
>50% - 75%	Feasible
>75% - 100 %	Very feasible

Research on the development of learning media on the concept of plant anatomy with Talking Augmented Reality was carried out at SMA Negeri 1 Tasikmalaya City which is located at Empangsari, Tawang District, Tasikmalaya City, West Java Province. This research took place from January to April 2020.

RESULTS AND DISCUSSION

The trial conducted was expert validation to determine the level of suitability of a development product by content experts and media experts. The validation test in this research and development involved 2 experts, one as a content expert and one as a media expert. The validation results produced assessments, comments, and suggestions that were then used as materials for improving the learning media before being tested on users, namely teachers and students.

The validation test by the content expert on the Talking Augmented Reality learning media can be seen in 10 indicators, namely title, basic competencies, learning objectives, content, questions, authors, references, accuracy, up-to-dateness, and readability. The validation data by the content expert, in the form of scores, will then be converted into percentages. The obtained percentage is 82%, which can be interpreted as the application being highly suitable. The table and graph showing the percentage results of the content expert validation test for each indicator can be seen in Table 2.

Table 2. Material Validation Test Results

Indikator	Skor	Skor Maks.	Persentase	Kategori
Judul	4	4	100 %	Sangat Layak
KD	2	2	100 %	Sangat Layak
Tujuan Pembelajaran	2	3	67 %	Layak
Materi	1	2	50 %	Kurang Layak
Soal	2	4	50 %	Kurang Layak
Penyusun	2	2	100 %	Sangat Layak
Referensi	4	5	80 %	Sangat Layak
Kebenaran	3	4	75 %	Layak
Kekinian	3	3	100 %	Sangat Layak
Keterbacaan	4	4	100 %	Sangat Layak
SKOR TOTAL	27	33	82 %	Sangat Layak

The validation test by the content expert on the Talking Augmented Reality learning media can be seen in 8 indicators, namely navigation, typography, media, color, layout, interactivity, supporting software, and originality. The validation data by the content expert, in the form of scores, will then be converted into percentages. The obtained percentage is 65%, which can be interpreted as the application being suitable for use. The table and graph showing the percentage results of the media expert validation test for each indicator can be seen in Table 3.

Tabel 3 Media Validation Test Results

Indicator	Score	Score Maks.	Percentage	Category
Navigation	3	4	75 %	Feasible

Font	2	4	50 %	Less Feasible
Media	2	3	67 %	Feasible
Color	2	3	67 %	Feasible
Layout	2	2	100 %	Very feasible
Interactivity	1	3	33 %	Less Feasible
Software	3	4	75 %	Feasible
Originality	2	3	67 %	Feasible
Total score	17	26	65 %	Feasible

User response tests were carried out in class XI of the Mathematics and Natural Sciences program at SMA Negeri 1 Tasikmalaya with 14 students and also 1 biology teacher who had an Android smartphone. The data obtained were product assessments by students in the form of questionnaires consisting of 13 statements for students and 15 statements for biology teachers. Data from user response test results in the form of scores will then be converted into percentages. The percentage obtained is 98%, which means that the application is very feasible to use. Tables and graphs of the percentage of user response test results for each indicator can be seen in table 4.

Table 4 User Response Test Results

Aspek Penilaian	Jumlah Skor	Skor Maksimal	Persentase kelayakan	Status Kelayakan
Title	60	60	100%	Very feasible
Basic competence	30	30	100%	Very feasible
Learning goals	30	30	100%	Very feasible
Evaluations	58	60	97%	Very feasible
Compiler	30	30	100%	Very feasible
Reference	75	75	100%	Very feasible
contemporary	29	30	100%	Very feasible
Letter	60	60	100%	Very feasible
Media	43	45	95%	Very feasible
Color	40	45	89%	Very feasible
Layouts	29	30	97%	Very feasible
Legibility	4	4	100%	Very feasible
Interactivity	2	3	67%	Feasible

The revision of learning media products represents a stage of improvement conducted by researchers in response to evaluations, comments, and suggestions provided by material and media experts. The developed product can be utilized on Android-operated mobile devices, specifically through the Marker Book Talking Augmented Reality of Plant Anatomy, which includes usage instructions and markers.

The Talking Augmented Reality application consists of several primary pages that automatically activate the camera of the Android phone. This enables the phone to scan markers and render them as 3D tissue objects present in plant organs. In addition to these pages, there are supplementary sections, including the splash screen, main menu, TAR menu, knowledge and objectives, questions, about, and references.

Figure 5. *splash screen*

Figure 6. Pages on the Application 1) Main Menu, 2) Questions, 3) KD and Objectives, 4) Instructions for Use, 5) About

Figure 7. TAR Menu

The Marker Book TAR is a small book that supports the Talking Augmented Reality application. This book contains instructions for using the TAR application and marker images that are read by the phone camera when running the Talking Augmented Reality Plant Anatomy application. The Marker Book TAR consists of several pages, including the cover page, usage instructions, and marker pages.

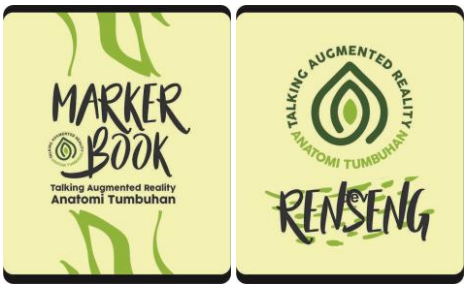

Figure 8. Marker Book Cover Page

Figure 9. Instructions for Use

The markers (Figure 11) contained in the Marker Book will be read by the TAR application of plant anatomy, and translated into 3-dimensional objects (figure 10) on the user's android phone.

Figure 10. 3D Plant Tissue Objects

Figure 10. Dicot Root Markers

The development of the Talking Augmented Reality Plant Anatomy learning media goes through several stages, namely Analysis, Design, Develop, Implementation, and Evaluation. The Analysis stage involves material analysis, analysis of learning process gaps, user needs analysis for the application, software requirements analysis, hardware requirements analysis, and planning analysis. The second stage is Design, which includes the design of the learning material and the design of the learning media product in the form of storyboards. The Develop stage includes

preparation to meet all the necessary requirements, resource preparation, arranging the layout according to the storyboard, coding, validation by content and media experts, and formative evaluation. In this study, formative evaluation was conducted to gather data for revising the previous stages before implementation. Formative evaluation was conducted in a small class with 14 students and one teacher at SMA Negeri 1 Tasikmalaya (Figure 2). The next stage is implementation, where the TAR Plant Anatomy application is introduced and explained to teachers and students during the learning process.

Based on the assessment of suitability by the content expert, it can be determined that the percentage of the obtained assessment is 82%. When converted based on Table 1 regarding suitability categories, the TAR Plant Anatomy application can be categorized as highly suitable, but revisions need to be made according to the comments and suggestions from the content expert. The revisions are intended to improve the suitability of the material and questions, which are categorized as less suitable, while the learning objectives and accuracy are categorized as suitable.

Meanwhile, based on the assessment scores given by the media expert, it can be determined that the percentage obtained is 65%. Therefore, the TAR Plant Anatomy application can be categorized as suitable in terms of media aspects, but revisions need to be made according to the comments and suggestions from the media expert. The revisions aim to improve the suitability of typography and interactivity, which fall into the category of less suitable, while navigation, media, supporting software, and originality fall into the category of suitable (Figure 3).

After revisions based on expert assessments, a formative evaluation was conducted with users, consisting of 14 students and 1 teacher. The test results from each suitability aspect given by the users obtained a percentage of 98%. When converted based on Table 1 regarding suitability categories, it can be categorized as highly suitable, and the majority of users provided positive feedback. All suitability indicators evaluated by the users received the category of highly suitable (Figure 4). Furthermore, all users who filled out the suitability questionnaire rated the TAR Plant Anatomy application as highly suitable for use.

The next stage is implementation, where students and teachers are given instructions and practice using the revised learning media product. This stage was conducted through WhatsApp and Google Meet due to the pandemic situation, which requires physical distancing. The application was provided to students and teachers through WhatsApp and installed on their respective smartphones. All students and teachers were able to install and use the TAR Antum application.

The advantages of the Talking Augmented Reality Plant Anatomy learning media based on Android are: (1) the learning media can be installed on all devices using the Android operating system version 9 (Q) on the Play Store and at least version 6.0 (Marshmallow) with a camera feature, (2) the learning media can be used as a learning tool in schools or anywhere, anytime, and by anyone, (3) Augmented Reality technology allows students to think realistically without the need to present the actual objects because it can display 3D structures of plant organs that resemble their original forms, (4) it presents learning materials in the form of audio explanations of plant anatomy concepts, (5) it displays evaluation tools in the form of questions used to measure user's abilities, (6) it shows the score results in the evaluation feature so that students can assess their level of understanding of the materials.

The disadvantage of the Talking Augmented Reality Plant Anatomy learning media is that the quality of the camera, lighting, and specifications of the Android phones affect the speed of displaying 3D objects when the camera reads the marker.

CONCLUSION

The research and development of the TAR Plant Anatomy learning media used the ADDIE development model. The result of this research and development is a learning media product titled Talking Augmented Reality Plant Anatomy, which is equipped with a Marker Book as a supporting tool. The TAR Plant Anatomy learning media has main components such as the main menu page, Talking Augmented Reality page, Competency Standards and Objectives page, question page, user instructions page, developer information page, and reference page.

The assessment results by content experts based on various aspects of material suitability obtained a percentage of 82%, which can be categorized as "highly suitable." Meanwhile, based on the scores given by the media experts, it is known that the obtained percentage is 65%, indicating that the TAR Plant Anatomy application can be categorized as "suitable" in terms of media aspects. The trial results obtained from each aspect of user suitability yielded a percentage of 98%, which falls under the category of "highly suitable." Furthermore, 100% of the 15 users who

filled out the suitability questionnaire rated the TAR Plant Anatomy application as "highly suitable."

Furthermore, this research has great potential for further development. With the rapid advancement of technology, the Talking Augmented Reality Plant Anatomy learning media can be modified to be more responsive, aided by improved camera quality, which allows for more responsive 3D objects. Additionally, creating a more attractive UI/UX design can be achieved by utilizing software that makes development easier.

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