Developing augmented reality as learning media for learning virus replication on senior high school

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ABSTRACT

Some biological objects are microscopic objects that cannot be seen with the naked eye. These problems cause students have difficulty in building concepts while teachers have limited time and skills in developing renewable media, so it is necessary to develop media to help students learn viral material.This study aims to: (1) develop Augmented Reality Virus (ARVI) as learning media for class X students; (2) determine the feasibility of learning media Augmented Reality virus (ARVI). The method used in this research is Research and Development with the ADDIE model limited to the Development stage. Product assessment is carried out by material experts and media experts which consists of two people. The limited trial was conducted on theacher and 18 students in grade XI. Data were collected using a questionnaire and if necessary interviews were conducted with the informants. The data analysis was done quantitatively. This research produces an Android application that contains an Augmented Reality that can display a 3-dimensional virus illustration. The results of the validation in material experts of 98.71%, media experts of 77.60%, biology teachers 91.31%, and students of 83.96%. Based on the data obtained in this study, the learning media developed (ARVI) was suitable for use in learning biology material for viruses.

Introduction

Biology is one of the compulsory subjects in high school for students majoring in MIA (Interest in Natural Sciences) education in Indonesia which is written in Government Regulation of the Republic of Indonesia Number 32 of 2013 concerning amendments to Government Regulation number 19 of 2005. Some of the biological objects studied are microscopic objects and are difficult to be seen with the naked eye. These problems cause students to find it difficult to build concepts, especially in material related to physiological processes in the body (McClean et al. 2005). Viruses are one of the most difficult and abstract materials to learn at high school level because of their microscopic size (Solomon, Berg, and

Martin 2011). Although the size is very small Viruses play an important role in the survival of organisms in the micro and macro scope, so it is important for teachers to convey this material well (Musyawir et al. 2022). Based on the results of research conducted by Husnifa (2016) students have difficulty in visualizing the virus.

To support the success of the learning process, learning media is needed that can describe the object of the virus. With the availability of media as teaching materials that attract students' attention and are fun, students will find it easier to understand the material presented by the teacher in class. (Nawawi and Kusnoto 2019). Learning media has an important role to increase student involvement during the learning process (Naz and Akbar 2010), increase student learning motivation (Rodgers and Withrow-Thorton 2005; Sardiman 2014), and improve students' ability to achieve learning objectives (Baidawi 2016).

The results of observations made by researchers related to the use of learning media in schools are still in the form of books, PowerPoint slides and videos. The existing media is less than optimal in describing biological phenomena because it only displays information in 2D. The results of research conducted by (Husnifa and Ely 2016) shows that students have difficulty learning the virus material because the material and learning media are less attractive. Teachers have not developed learning media due to limited time and expertise in developing learning media.

To solve this problem, learning media is needed that can display objects in 3D. The selection of media needs to be adjusted so that learning can run optimally (Abidin 2017). Several factors that can be used as media selection including suitability, level of difficulty, cost, availability, and technical quality (Nurhayati 2018). Education is always associated with new ideas about learning and teaching, one of which is by utilizing the latest technology to improve the quality of existing learning (Wilson and Peterson 2006).

Augmented reality (AR) is a digital technology that can display 3D objects digitally. Today Augmented reality technology has almost been used in various aspects of human life ranging from state needs, entertainment, and education (Chen et al. 2019). This technology has been used to solve similar problems in learning geography and physics with satisfactory results (Amalia 2015; Ningsih 2015).

Augmented reality has great potential to be used as a medium for learning biology (Kaviyaraj and Uma 2022; Lai and Cheong 2022; Turhan and Gümüş 2022). Augmented reality encourage students' physical activity, low costs and ensure safety while observing the object being studied especially virus (Fahmi 2020). With AR technology complex phenomena regarding viruses can be displayed more clearly so that students seem to be observing the virus directly. When students get a real visualization of viral objects, it is certain that students will more easily understand the concepts of the material being taught (Ain 2013).

Based on the description above, the authors conducted research with the aim of developing application learning media with Augmented Reality technology as an alternative learning media. The developed media will be named ARVI with features that can display illustrations of the structure and replication of the virus for studying virus material.

Method

The research carried out is a type of research and development or Research and Development (R&D) with the ADDIE (Analysis, Design, Development and Implementation, Evaluation) model developed by Robert Maribe Branch (Branch 2010). There is an evaluation at every stage that can minimize the error rate that occurs (Soesilo and Munthe 2020). Due to limited time and resources, the

research was only carried out until the development stage. Activities in product arrangement can be seen in Table 1.

Table 1. Augmented Reality Learning Media Preparation Activities

Stage	Activity	Instruments
Needs Analysis	Needs analysis is carried out by observing the school environment and interviewing teachers of related subjects	Observation sheet, interview sheet
Material Analysis	This analysis was conducted to determine the applicable curriculum at .SMAN 1 Depok.	
Designing Apps	The design stage is carried out by designing a conceptual learningpedia in the form of making product specifications, storyboards and media assessment instruments	
Developing Media	The development stage is the preparation of materials and augmented reality applications using UNITY.	
Expert Assessment	Expert assessments were carried out on material experts and media experts to test the validity of the media before being tested in schools	Questionnaire for media experts and material experts
Media Revision	Media revisions are carried out based on input from material experts and media experts so that the media is worth testing out.	
Limited Trial	A limited trial was conducted at SMAN 1 Depok as many as 18 students who had participated in learning the virus material to determine student responses to the developed media.	Questionnaire for teacher and student
Product Finalization	product finalization is carried out based on input from field trials so that appropriate media are obtained for use in learning	

This research was conducted from January 2020 to August 2020. The time for making the Augmented reality Android application began in February 2020 to June 2020. The quality test was carried out by reviewers and respondents in August 2020 using on line and Google Forms in June - July 2020.

study were collected through an instrument given to the participants via a google form. The instrument used to collect data was the material expert assessment instrument using the Gutman scale and Likert scale (4 levels), while for media experts, the Biology teacher readability test instrument, and students only used a Likert scale (4 levels) (Joshi et al. 2015; Van Schuur 2003).

The data obtained were analyzed descriptively. Qualitative data obtained from experts, teachers, and student responses were converted into quantitative data in the form of certain scores. The Likert scale used in this study consisted of four scales with scoring guidelines. Product eligibility criteria are determined by converting the eligibility criteria into percentage form. Calculation of the percentage of the questionnaire using the following formula.

Score percentage (%) $= \frac{total\ score}{Max\ score}$ x 100%

(Sugiyono 2019)

The percentage of media scores that were developed was then based on the criteria for interpretation of a 5 scale score according to Arikunto (2010) which was described as follows Figure 1.

Figure 2. Assessment Criteria

no	Percentage	Criteria
1	0-20%	Very inappropriate
2	21-40%	Unfeasible
3	41-60%	Quite feasible
4	61-80%	Eligible
5	81-100%	Very feasible

Results and Discussion

This research produces a product in the form of Augmented Reality-based learning media containing virus material for high school students of class X or equivalent named "ARVI". Development is limited to the Development stage due to

limited research time which requires it to be completed during the study period and limited data collection facilities due to the pandemic.

In the preparation of this ARVI application, three types of analysis were consist of needs analysis; student competency analysis; and analysis of subject matter boundaries. The analysis is carried out to see how far the importance of the product to be developed and see the potential for developing learning media.

In general, learning material on viruses in high school biology subjects is carried out using lecture and discussion methods using media in the form of presentations containing pictures and video. The use of learning media does not attract the attention of students, because the media used is sometimes less clear and not interactive. Based on interviews in pre-research activities, it was found that media or products were needed that could present virus illustrations interactively.

Augmented Reality is one of the media that can display virus illustrations in the form of digital objects interactively (Edwards-Stewart, Hoyt, and Reger 2016). The development of learning media using Augmented Reality technology is expected to facilitate learning on virus material. The

existing facilities and infrastructure at SMAN 1 Depok already support the development of Augmented Reality learning media.

Competency analysis is done by looking at the curriculum and applicable competency standards. The Minister of Education and Culture Regulation Number 24 of 2016 contains the achievement of material competence in the structure and replication of viruses that must be achieved by students in the form of Core Competence (KI) point 3.4 which reads "Analyzing the structure, replication and role of viruses in life". Material developed in this media focuses on the introduction of the virus body structure and the virus replication process. As for there is an opening material to recognize the virus

The next step in the process is to design the product, which includes three sub-steps: creating specifications for the product, developing storyboards for its intended use, and evaluating the feasibility of various media options. The product specifications in this study are Augmented Reality applications that are operated on the Android operating system. There are 8 application pages with different functions. The function of each page is described as follows

Table 2. Media Specifications

No.	Component	function
1.	Main course	The main menu contains buttons that direct to other menus and basic competencies of learning materials.
2.	Instructions for use	Instructions for use contain instructions for using the application and the functions of the buttons in the application.
3.	Theory	This Menu button contains viral material that students can learn
4.	AR camera	The AR camera functions to display objects on the ARVI marker / card.
5.	Exercises	Practice questions contain questions about virus material to evaluate students' understanding of virus material.
6.	Bibliography	The bibliography contains a list of references used to organize the material in the application.
7.	Glossary	The glossary contains terms that are arranged alphabetically to make it easier for users to understand words that are rarely encountered.
8.	Download Marer AR	The download marker will direct the user to the drive containing the arvi card image.
9.	Developer info	Developer info contains the identity of application developers, supervisors, and

product specifications are developed into storyboards to provide an overview of the UI of the application being worked on The Storyboard stages are designing the layout, function and content of the ARVI application.

The development stage is carried out based on the previous two stages, namely the analysis stage and the design stage. The development stage is divided into several parts: drafting, application development, initial editing and revision, limited trial, and final revision.

Drafting is the initial stage of development which aims to collect the materials needed to develop Android applications. There are 4 drafts made in the ARVI application development, including 1) the material draft was developed using MS Word, 2) the marker draft was developed using CorelDRAW, 3) the 3D object draft was developed using blender and 4) the database draft was developed using VuvoriaEngine. The draft will be saved as a file type that can be imported by the Unity application.

All drafts will be developed into an Android application using the Unity Engine with Vuforia SDK. The results of application development carried out by researchers have the characteristics of an Android application with an Augmented Reality feature containing virus material.

The developed application can run on Android Marshmallow system and above. The main page of the application contains buttons that direct the menu to select the features in this application. The application has been published to the play store to make it easier to distribute the application to user.
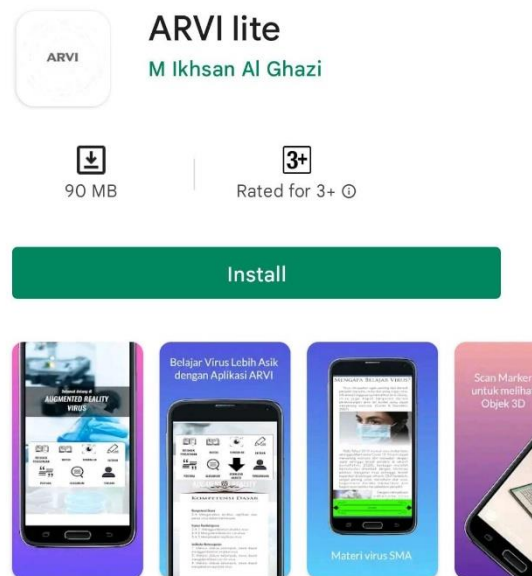

Figure 3. ARVI Lite on Playstore

The Augmented reality feature can be accessed by pressing the "AR camera" button and pointing the camera at the marker so that the 3D animation will run according to the existing material. there are 4 markers containing viral models that can be used to study the structure of the virus and 8 markers containing the stages of the viral replication cycle to study lytic and lysogenic processes that can be downloaded by pressing download menuin the application.

Figure 4. 3D model display of virus replication using Augmented reality

learning using Augmented reality can display 3D models that allows students to seem to interact directly with the in the application that hone their dimensionality and spatial abilities (Krüger, Palzer, and Bodemer 2022). The application is equipped with summary of virus material that are tailored to learning needs to make it easier for students to find virus material studies. In addition, evaluation questions in the form of multiple choice in the form of quizzes were also developed for students to hone their understanding of concepts about viruses (Hadinata 2022).
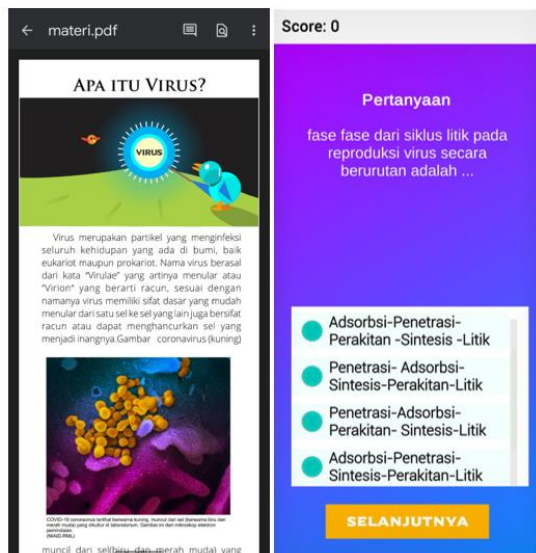

Figure 5. viral material that students can learn and games to hone students' skills

Applications that have been developed are then assessed by experts to assess the feasibility of learning media developed and to get input and suggestions as material for media improvement. input from experts will be taken into consideration to revise the product, so that the product eligible.

The material expert assesses the feasibility of the ARVI application in terms of the quality aspect of the material,

the suitability of the material using the language of presentation of the material. Editing was carried out by two expert lecturers using a Gutman scale questionnaire to assess the quality of the material and a Likert scale to assess aspects of the suitability of the material with the curriculum, use of language, and presentation of the material. The results of the material expert assessment are presented in Table 3 as follows:

Table 3. Assessment of material expert lecturers on the presentation of ARVI application material using a Likert scale

No.	Aspect	Index (%)	Criteria
1	Suitability of the material	87.5	Very decent
2	Language use	78.12	decent
3	Presentation of material	87.5	Very decent
	Average	**98.57**	**Very decent**

The material expert assessment is carried out on the substance of the material (Suitability of the material) getting an assessment index of 87.5%, this indicates that the concepts in the application are correct and have been adjusted for class X student learning, in the Language use aspect, an index of 78.12% is obtained which indicates writing the material carried out is based on Indonesian spelling so that it can be easily understood by students (Wicaksono 2016). The assessment of the presentation of material aspect gets an index of 87.5%, this shows that the 3D model/object contained in Augmented reality is quite feasible to use for learning.

Based on the results of the assessment by the material expert, the aspects assessed on the ARVI application that have been compiled show the results are very suitable for use in accordance with the eligibility criteria according to

(Arikunto 2010). So it can be concluded that the results of the material expert's assessment stated that the material on the application are suitable.

Validation by media experts and Biology Teacher aims to determine the feasibility of ARVI applications as learning media. Good learning media ideally can improve the quality of learning (Susilana and Riyana 2008). Media feasibility assessment is carried out by media experts first before conducting a limited trial to schools. The results of the assessment by Media Experts are presented in Table 4 as follows:

Table 4. Assessment of Media Expert Lecturers on the Quality of the ARVI application

No.	Aspect	Media Expert		Biology Teacher	
		Index (%)	Criteria	Index (%)	Criteria
1.	Suitability of the material	79.16	decent	100	Very decent
2.	Language accuracy	75	decent	87.5	Very decent
3.	Display quality	79.16	decent	86.11	Very decent
4.	use	77.08	decent	91.66	Very decent
Average		77.60	decent	**91.31**	**Very decent**

The results of the media expert's assessment stated that the ARVI application was suitable for use dengan hasil layak dari ahli media dan sangat layak dari guru biologi. The developed media received a positive response from material experts and media experts, Augmented reality is considered to have a great opportunity as a future learning medium (Wu et al. 2013). using Augmented reality media can make teacher easier to deliver learning materials (Raja and Lakshmi Priya 2022).

The assessment of learning media given by material experts and teachers on the suitability of material aspect gets an

index of 79.16% and 100% indicates that the material developed is very suitable to be used for learning biology in the classroom, on the aspect of language accuracy it gets an index of 75% and 87.5%, respectively. This shows that the language used is effective and easy to understand by students. In the aspect of display, the index is 79.16% and 86.11%, which indicates that the display of the learning media has an attractive visualization, the last in the aspect of use is the value of 77.08% and 91.66, indicating that the developed media is easy to use when used for learning. So it can be concluded that the results of the teacher's assessment stated that the ARVI application was very suitable as learning media.

Table 5. interpretation of student responses to the ARVI . application

No.	Aspect	Index (%)	Criteria
1.	Presentation of material	82.89	Very decent
2.	Language accuracy	80.78	Very decent
3.	Use	84.53	Very decent
4.	Benefit	87.63	Very decent
Average		**83.96**	**Very decent**

Based on the results of the limited trial on students, overall aspects of the ARVI application showed very decent results. Students also provide input for the development of ARVI applications. Augmented reality learning media makes learning more interesting for students and brings greater motivation to understand material (Fuchsova and Korenova 2019).

The results of the readability test and the feedback received were used to make final revisions to the ARVI learning media in the form of an Android application. The final product, which can be downloaded from the Play Store, is an Augmented

Reality tool for learning about viruses. (https://bit.ly/GhaziEdu).

The research on the development of augmented reality learning media on the topic of viruses (ARVI) has many benefits in improving the quality of student learning. By using augmented reality technology, students can more easily understand the concept of viruses and how they work inside the human body. Additionally, the use of this media can enrich students' learning experiences by displaying interactive and realistic visualizations of viruses, thus increasing students' interest in learning about the topic. Furthermore, the use of augmented reality technology can also help teachers deliver learning material in a more engaging and effective way. Therefore, this research can make a significant contribution to the development of more innovative and effective learning media in the future.

ARVI makes learning more interactive and engaging for students. By using 3D models and virtual environments, ARVI allows students to visualize and interact with educational content in a way that is not possible with traditional teaching methods. This can help to improve students' understanding and retention of information. provides a more realistic and immersive learning experience for students. By simulating real-world situations and allowing students to explore and discover information on their own, ARVI can facilitate deeper learning and help students to better understand complex concepts.

Conclusion

Based on the research conducted, it can be concluded that:

1. ARVI application has been developed containing virus material and Augmented Reality features that can be run on the Android 6 operating system and above. The recommended hardware for running this application has a minimum specification of Octa-core 2 GHz processor, 4GB RAM, 8 MP camera and 0.71 GHz GPU

2. Based on the results of the assessment of the Augmented Reality Virus "ARVI" application as a whole it is categorized as very feasible to be used as a learning media especially structure and replication of viruses in order to help facilitate students in understanding virus material.

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