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THE VALIDITY OF LEARNING MATERIAL ASSISTED AUGMENTED REALITY TECHNOLOGY IN THE TOPIC OF STRUCTURE AND FUNCTION OF PLANT TISSUE

Erti Hamimi*, Sugiyanto, Erni Yulianti, Vita Ria Mustikasari, Novida Pratiwi
Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Indonesia

Corresponding Author's Email : erti.hamimi.fmipa@um.ac.id

Abstract
The Industrial Revolution 4.0 is a comprehensive transformation of all aspects of production in industry through the combination of digital and internet technology with conventional industries. The education sector is an important field that must adapt to the demands of the times so as not to be left behind. In the world of education, especially in subjects such as Basic Biology, there are many objects that are difficult to visualize in real terms, one of which is the topic of the Structure and Function of Plant Networks. The problem can be visualized using Augmented Reality (AR) technology. The purpose of developing AR-based teaching materials is to combine biology material by applying AR technology so that learning is more interesting, meaningful, and interactive, and students can observe objects in biological studies. The product specifications developed were in the form of Basic Biology I teaching materials consisting of the BIOAR application and augmented reality-based supplement books on the topic of Plant Tissue Structure and Function. This method of developing teaching materials used R & D (Research and Development) which consisted of (1) Research and Information collection, (2) Planning, (3) Development of teaching materials based on augmented reality, (4) Validation of teaching materials by experts. The validation results showed that this augmented reality-based teaching material was declared very valid with a value of 4.52.

Keywords*: Learning material, Augmented Reality, BIOAR Application, Supplementary Book*

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INTRODUCTION

The Industrial Revolution 4.0 is a trend of data exchange and automation in industrial technology (Ilyasir, 2019). The word 'revolution' is used to denote a change that is very fast and fundamental and is disruptive (destroying the old order that has existed for many years). The characteristics of the 4.0 industrial revolution are marked by various applied technologies, such as advanced robotics, artificial intelligence, internet of things, virtual and augmented reality (VR / AR), additive manufacturing, and distributed manufacturing. Efforts that must be made to answer the challenges in the era of the industrial revolution 4.0 include: preparing infrastructure, as well as education and skills programs, to increase the capacity of human resources in mastery of technology. The education sector is an important field that must adapt to the demands of the times so as not to be left behind with other countries. And one of the applied technologies that can be applied in the world of education is Augmented Reality. Augmented Reality is a technology that can produce information from actual environmental conditions, then digitally processed and used for specific purposes. In the world of education, especially in subjects such as Basic Biology, there are many objects that are difficult to visualize in real terms due to the size of such as microorganisms, limited specimens, or there are anatomical structures that can only be seen with certain preparations and observation using tools such as microscopes.

Learning is divided into 3 activities, including classical learning (lecturers use the lecture method), independent learning (students use teaching materials) and learning using the practicum method. The use of teaching materials and lecture methods is still considered not optimal for acquiring knowledge and not necessarily in accordance with student interests / learning styles. Apart from this, another reason for the use of teaching materials has not been optimally utilized because in general it only provides two media, namely text and illustration of images or photos (Soepriyanto, et al (2017)). Along with the times and the beginning of entering the Industrial Revolution 4.0, technology is growing rapidly. Conventional teaching materials have begun to develop to integrate technology in them, one of which is Augmented Reality (AR).

Augmented Reality is defined by Julie Carmigiani & Borko Furht (2011) as a real time view, directly or indirectly, the physical environment of the real world that has been expanded / added with virtual information generated by computers to it. Another terminology says that Augmented Reality is Augmented Reality. Thus, AR can mean that real objects in real time are added with virtual objects that appear when using tools or devices on these real objects. AR aims at simplifying users' lives by bringing virtual information not only to their surroundings, but also to a live view of any kind of real-world environment, such as live streaming

video. AR technology is developing rapidly and until now AR has been developed on Android and iPhone operating systems, which have navigation features that support AR. Since the development of AR technology, which can now be implemented on popular devices, such as mobile platforms (iOS and Android), AR opportunities to be accessed by the public, including students, have opened. The use of AR technology on devices such as smartphones that are familiar to students can be used as an alternative to develop innovative learning media that can be accepted by students. Along with the rapid development of the spread of smartphone devices in society, including among students, now research on the use of AR has been mostly focused on mobile learning, where students are not limited to a PC in a fixed room, but learning can be done dynamically. The use of AR technology on cellphones can support user mobility and allow students to be able to carry out learning activities anywhere.

The existence of mobile devices with the Android operating system, for example, has been close to students in their daily lives. According to the results of preliminary research on 100 students from 3 high schools in South Jakarta, 65.90% of students are Android smartphone users, and 57.32% of students on average spend more than 4 hours a day on Android.

Research related to AR, both in terms of development, acceptance, and effectiveness in education, continues to be carried out. Several previous studies have shown that AR has good potential in education. Chen et al. developed AR to provide students with media that is easy to operate, has an interactive and diverse interface, and is attractive to stimulate intrinsic motivation and learning outcomes (Chen, et al., 2013). Chi-Yin Yuen et al. check out the latest studies on the development of AR. Based on the findings, the number of researchers and developers in the field of AR is increasing, and in recent years, the growth and advancement of AR has been significant (Chen, et al., 2013). AR users become more interested and involved in dealing with technology and learning content (Diegmann, et al, 2015).

The development of AR as a learning medium is still not very much in Indonesia. But there have been several studies that show the positive impact of integrating AR in learning. Based on previous research conducted by Qumillaila, et al (2017), it shows that the Android version of the AR application is considered attractive and acceptable to students and teachers as an alternative learning media for the human excretion system and is effective in helping the learning process of biology in the classroom. The results of other studies conducted by Wahyudi et al. (2017) explain that AR-based media can improve students' abstraction power in understanding learning and AR-based media is suitable for use in learning. Soepriyanto et al (2017) concluded that augmented reality can answer the needs of learners when learning in the context of reading textbooks, to understand more deeply the material that is being studied.

The purpose of developing AR-based teaching materials is to combine biology material with AR technology so that learning is more interesting, meaningful, and interactive, and students can observe objects in biological studies. The benefits of developing AR-based teaching materials are providing insights for students to become creative, innovative teachers, and keep up with the times by applying technology in learning, as well as providing experiences for students to learn in a more enjoyable way.

METHOD

The research was conducted at the Science Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang. The research and development (R & D) method which will be used the research and development (R & D) method used in this research refers to the modified Borg and Gall (2003). (1) Research and information collection (research and data collection). The initial stage of development is data collection by analyzing the following: (a) market analysis, (b) user analysis, (c) material analysis (d) analysis of facilities and infrastructure. (2) The second step is Planning, at this stage the plan includes the content of teaching materials that will be made according to needs, product design plans, marker plans made, and media implementation plans. (3) Development (Product Draft Development) teaching materials based on augmented reality. The software used to create AR is Unity, Vuforia AR Extension for Unity, and Blender. (4) The fourth step is validation of teaching materials by two experts. Flowchart of development flow diagram of AR-based Basic Biology I teaching materials development is presented in Figure 1.

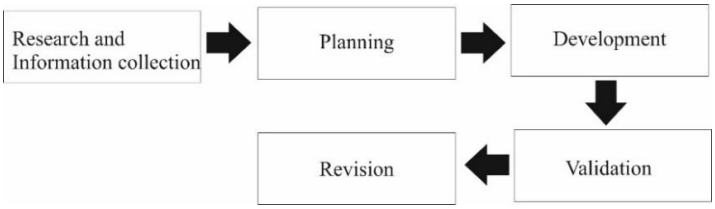

Figure 1. Flowchart of R & D of AR-Based Teaching Materials (Wahyudi dkk., 2017)

The development of the BIOAR (Biology Augmented Reality) application uses a waterfall model which consists of 5 stages, namely: Requirements Analysis, Design, Development, Testing, and Maintenance. The Requirements Analysis stage includes the need to run applications and create applications. The need for making applications is a laptop with an Intel i5 processor, the Unity game engine application, Adobe XD, and a blender. Unity application is used to create Augmented Reality, Adobe xd is used to create display designs, blender application is used to create 3D objects. The need to run the application requires an Android device with a camera with at least 2 GB of ram and 500 MB of storage. At the design stage, it is done by designing the application flow (flowchart), designing the display (UI), and designing the marker. The development stage includes creating an application with unity software based on application flow design and display design, creating 3-dimensional objects in the blender, then integrating markers, 3-dimensional objects, and applications into a single augmented reality application. The testing phase is carried out by testing the application whether there are errors or not, using a usability test or usability test. The last stage is the maintenance stage. The following is a picture of the BIOAR application design flow chart, which is presented in Figure 2.

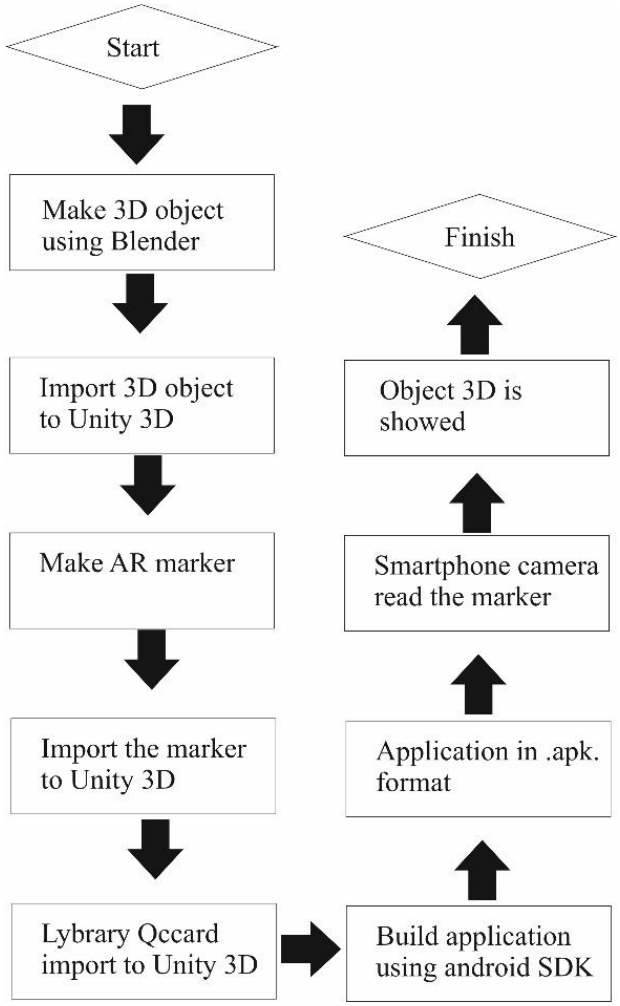

Figure 2. BIOAR Application Design Flowchart (Qumillaila dkk., 2017)

RESULTS AND DISCUSSION

The teaching materials developed consist of the BIOAR application and supplement books. BIOAR (Biology Augmented Reality) is an application based on Augmented Reality that can be used for scanning certain markers to display 3D objects. The supplement book Structure and Function of Plant Tissues contains 27 markers about plant tissue and structure material that can be scanned using the BIOAR application. The following is attached the BIOAR application User Interface (UI) in Figure 3.

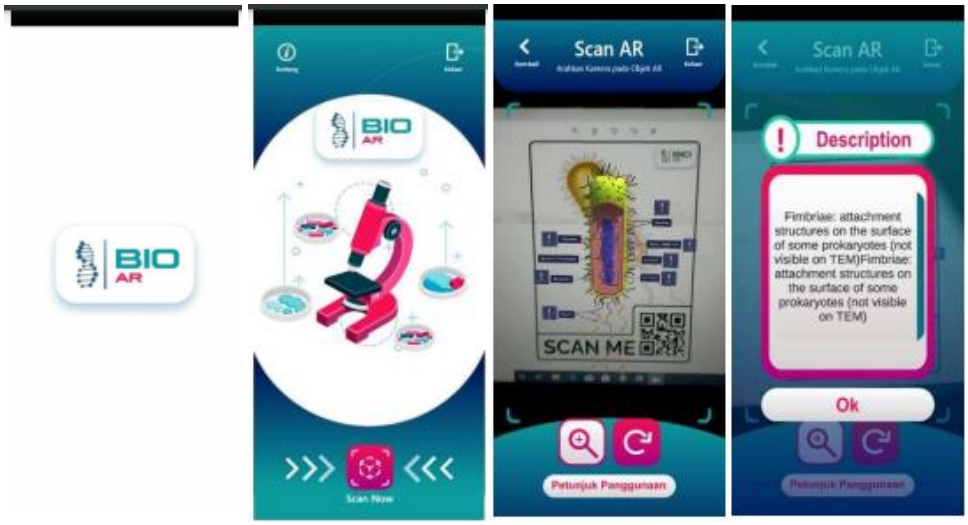

Figure 3. *User Intreface* of BIOAR

The UI design of the BIOAR application consists of an application which, if we choose, will direct the main menu of the BIOAR application which consists of the Scan Now feature to scan markers contained in the supplement book, an about feature which is brief information related to the BIOAR application, as well as an exit feature to exit. BIOAR application. When the user presses the Scan Now button, the camera will automatically turn on and scan a marker to display a 3D animation and information. For those who are new to BIOAR, users can first read the related instructions for use in the application.

The supplement book on the topic of the Structure and Function of Plant Tissues contains an overview of the material and markers for visualizing 27 images in 3D animation. The markers contained in the supplement book only consist of 2D images without information along with barcodes. The markers developed to visualize 3D animation include: *Flowering Plant, The three tissue systems, Parenchyma cells, Collenchyma cells, Sclerenchyma cells, Xylem, Phloem, Three years growth in a winter twig, Primary growth 1, Primary growth 2, Secondary growth 1, Secondary growth 2, Secondary growth 3, Secondary growth 4, Primary growth in length, Primary growth of a eudicot root, Monocots root cross section, The shoot tip, The formation of a lateral root, Eudicots root cross section, Eudicots stem cross section, Monocots stem cross section, Leaf anatomy, Primary and Secondary growth of a woody stem, Cross section of a three-year-old stem, Anatomy of a tree trunk, dan The flower*. The source of the 2-dimensional images used as markers is obtained from Campbell (2016). The visualization of the supplement book cover and marker samples can be seen in Figure 4.

Figure 4. The design of supplementary book cover and Augmented Reality Marker

After the product has been developed, the next step is expert validation. The validation results were obtained from an average assessment of 2 experts. The results of this assessment can be seen in Table 1.

Table 1. Recapitulation of the Results of the Validation of AR-Based Teaching Materials on the Topic of the Structure and Function of Plant Tissues

No	Validity Aspecs	Score of Each Validity Aspects	Category
1.	The display of whole Media	4.5	Very valid
2.	Materials	4.6	Very valid
3.	The display of AR Application (BIOAR)	4.46	Very valid
	Average	4.52	Very valid

Based on the results of the validation of two experts, in general the AR-based teaching materials developed are stated to be very valid with an average of 4.52. This is based on 3 criteria, including: the overall appearance of the media, the suitability of the material, and the appearance of the AR application menu.

In terms of the overall appearance of the media, it gets 4.5 results with a very decent category. This is because the appearance of the teaching material is attractive as well as the combination of colors and image objects with the appropriate background and obtaining a score of 5. The criteria that still need to be improved include clarity and shape of the letters and the suitability of the placement of the text which gets a score of 4. Based on the validation results, it is known that the font size made bigger and the alignment of the text in the book still needs to be adjusted. In addition, the text placement on primary growth markers on dicot roots is still not quite right.

In the aspect of material suitability, the teaching materials developed are in accordance with the material and learning objectives and get a score of 5. The criteria that still need to be improved are the clarity of animation, the suitability of animation with theory, and the material presented can motivate students. This is because some of the image visualizations still look like 2-dimensional, the use of language is less consistent, and the addition of more informative description content.

In the aspect of the AR application menu display (BIOAR), the teaching materials developed are very feasible with an average score of 4.46. This is because the combination of teaching materials is good, the images contained in the Augmented Reality Book are in accordance with the material presented, and the 3D images that are displayed when the scan marker is clearly visible so that it gets a value of 5. Criteria that still need to be improved include the attractiveness of the appearance, the application causes android hangs (stops), the application hangs (stops) during operation, ease of use, the use of learning media by utilizing Augmented Reality fosters the enthusiasm for learning of students, and this application has a clear description of the program flow to get an average score of 4.5. The criteria that still get a value of 4 are the clarity of the type and size of the letters and the scan marker to display 3D images can be operated easily. The criterion that is still lacking is that the installation process is still difficult. Based on this, this application is equipped with a video tutorial for installing the BIOAR application. It is also necessary to add other features such as menu descriptions, audio, and question exercises (quizzes) as a means of evaluating learning with Augmented Reality-based teaching materials.

CONCLUSION

The research products developed include teaching materials in the form of supplement books that are equipped with an augmented reality application called BIOAR. The supplement book consists of 27 markers related to the topic of Plant Tissue Structure and Function. The teaching material developed has been declared very valid with a value of 4.52 based on the validation results of two experts.

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