

Development of Augmented Reality Learning Media for Plantae Material in Class X Biology Subjects Using Arttoolkit

Yoga Putra Jaya¹, Agus Efendi², Endar Suprih Wihidayat³

^{1,2,3}Department of Informatics Education, Sebelas Maret University

Article Info

Article history:

Received Sept 20, 2023

Accepted March 25, 2023

Corresponding Author:

Yoga Putra Jaya, Departement of Informatics Education, Sebelas Maret University, Jl Ahmad Yani, no 200, Pabelan, Kartasura, Surakarta, Jawa Tengah, 57169, Indonesia.
Email:
yogajaya8269@student.uns.ac.id

ABSTRACT

A lot of material discusses Plantae, so interesting learning is needed so that students can easily accept and understand the material provided. AR technology can facilitate learning Plantae in the classroom. This research develops AR-based "Plantar" media. The application was developed based on Android to make it easier for students to learn plantae material in biology subjects. Plantar was developed using the Ionic platform and ARToolkit as the AR feature development library. Plantar uses a PWA (Progressive Web App) type to open its use via a browser. Field tests were conducted on 36 Kebakkramat SMA students to assess presence, affordance, and usability. The results showed that the Plantar media received a very good rating and did not require repair. So that the general public can use the Plantar application, especially high school students, to study Plantae material in an exciting way using the AR feature. In the future, it is hoped that the Plantar application will be useful in helping the learning process of Plantae material.

Keywords: Learning Media, Augmented Reality, ARToolkit

1. INTRODUCTION

The process of conveying information is experiencing rapid development using information technology (IT). Recently, AR technology has been widely used in information delivery. AR technology is widely used because it can visualize objects or objects in 2D, 3D, animation, and video. The advantages of AR itself are interactive and can be seen directly at that time (real-time), so it is widely used in various fields in conveying information. AR was introduced as a medium for learning in the field of education.

AR (Augmented Reality) is a 3D technology that projects virtual objects with high similarity in real-time. According to (Haryani & Triyono, 2017) "Augmented Reality (AR) is a technology that simulates artificial objects in the real world. Such as Virtual Environment (VE) or commonly known as Virtual Reality (VR)" which can stimulate the perceptions and senses of its users. The description of AR can provide knowledge about merging the real world with the virtual world that can be seen from the same place by the user. AR characters have three characteristics, which are interactive, real, and direct. The nature of AR can attract students' interest in learning activities or understanding the material.

AR technology is starting to be glimpsed for learning in education. Complex learning can be made more interesting by using this technology. AR technology can display simple 3-dimensional objects that can be seen as a whole and can be used effectively in learning each subject. Subjects that are difficult to understand cause students to be lazy and less enthusiastic about receiving lessons delivered by the teacher in class.

The results of previous observations in a class conducted by Yuliono and Rintayati (2018), the lack of innovative learning media implementation in education causes teachers to experience difficulties conveying difficult subjects and students to have difficulty accepting subjects. The material provided by the teacher so far is less interactive, causing students to be less enthusiastic about receiving the material. The solution that teachers usually use is using visual aids or 2-dimensional image media. These props have weaknesses: they are less attractive, impractical, and easily damaged. (Wardani, 2015). Learning methods using AR technology can help the learning process for both teachers and students. According to (Wardani, 2015) "AR technology is very good when used in a learning media and catalog in the form of objects, both two-dimensional and three-dimensional." AR technology can also combine virtual objects in a real

environment that can be displayed in real-time (real-time) to attract students' understanding of the learning material being taught. In this study, the authors will implement AR into one of the quite difficult materials, namely material about plantae in biology class X.

The reason for choosing biology subjects is because biology subjects have a lot of material that uses memory abilities. By using AR-based visual technology, the application of this technology will be useful to make it easier for students to remember (Fujimoto et al., 2012). Plantae is one of the materials in biology subjects. A lot of material discusses Plantae, so interesting learning is needed so that students can easily accept and understand the material provided by the teacher in class. With AR technology that implements virtual objects in real form, it can facilitate learning in the classroom. If AR is successfully implemented in plantae material, effective and quality learning will be created for teachers and students.

Based on the above problems, it is necessary to develop applications using AR technology that aims to develop augmented reality learning media for plant material in class X biology subjects using ARToolkit.

2. RESEARCH METHOD

This research uses Research and Development (R&D), which refers to efforts to develop a new product or improve existing products in an accountable manner. In this study, Sugiyono's model at the product trial stage was adapted into a feasibility test, namely a small group and a large group feasibility test, so that the adaptation of the Sugiyono model from the beginning to the end includes: (1) Potential Problems, (2) Data Collection, (3) Product Design, (4) Product Validation, (5) Product Revision, (6) Small Group Feasibility Test, (7) Product Revision 2, (8) Large Group Feasibility Test, (9) Product Revision 3, (10) Limited Production.

The instruments used to measure usability, affordance, and presence aspects were adopted from the questionnaire used by Lee & Lee (2016). The three instruments below will be addressed to teachers and students to fill them out. The following are three questionnaires or research instruments follows :

2.1. PRESENCE INSTRUMENT

The presence instrument measures the user's experience level of feeling reality when using AR features. The more real AR objects are integrated with the real world, the higher the user's presence assessment level. Mixed fantasy images of AR objects with real images recorded by the camera can confuse the user. So this instrument is useful for evaluating how real the user experience is. This instrument has an indicator rating scale of 1-5 and questions, including:

- a. The appearance of the real-world environment in AR is realistic and accurate
- b. Smooth and realistic object movement
- c. Representation of real and virtual objects to each other is appropriate
- d. Individuals or objects that appear in the display can be identified with accuracy
- e. The audio provided is quite adequate
- f. The multimedia elements used are quite realistic

2.2. AFFORDANCE INSTRUMENT

The affordance aspect relates to perceptibility or the ability to understand the operation of the media being developed. So that the higher the level of affordance, the user will increasingly understand what actions must be taken in operating or interacting with the media. So this aspect is measured to evaluate the user's ease of operation.

This instrument has an indicator rating scale of 1-5 and questions include :

- a. Different icons and buttons can be recognized easily
- b. The terms that appear in the user interface are clear
- c. User-friendly and familiar interface
- d. The operations or functions that appear in the interface must be predictable
- e. The symbols and displays used can represent the meanings of the existing functions
- f. The level of readability of information and forms is high
- g. Button size has the right size and can be used easily
- h. Interaction feedback from the operation of the interface is under the input device

2.3. USABILITY INSTRUMENT

The usability aspect measures effectiveness, efficiency, and user satisfaction in using the features in the media. So the questionnaire below evaluates user satisfaction with using the media. The statement points were adopted from the SUS questionnaire (Brooke, 1996) which was translated into Indonesian by Sharfina (2017).

This instrument has an indicator rating scale of 1-5 and the statement items include the following :

- a. I think I will use this app again.
- b. I find the app uncomplicated to use.
- c. I find this application easy to use.
- d. I don't need help from other people or technicians in using this application.
- e. I feel the features of this application work properly.
- f. I feel things are pretty consistent in this app.
- g. I feel that others will quickly understand how to use this app.
- h. I feel this application is not confusing.
- i. I feel there are no obstacles to using this application.
- j. I don't need to get used to it before using this application

Before analyzing the results of the respondents, researchers need to test their reliability and validity. The reliability test was carried out by calculating Cronbach's alpha value for each sub-aspect in the questionnaire. Four points for reliability include (Hinton et al., 2014) :

1. *Excellent* with a value > 0.90
2. *High* with a value $0,70-0,90$
3. *Moderate* with a value $0,50-0,70$
4. *Low reliability* with a value $< 0,50,$.

After testing the validity and reliability, the next step is to interpret the quantitative data that has been obtained. Data interpretation is done by adopting data interpretation from usability scale measurement. So that data interpretation is carried out on the aspects of usability, affordance, and presence using the formula developed and adjusted from the SUS Score formula (Brooke, 1996) :

1. *Presence* data analysis formula
Result = $\sum (Scores - 1) * 4.1$
2. *Affordance* data analysis formula
Result = $\sum (Scores - 1) * 3.12$
3. *Usability* data analysis formula
Result = $\sum (Scores - 1) * 2.5$

To use the formula above, you can do it by following these steps:

- a. For each statement, subtract one from the score (X-1)
- b. Add up the results of each item statement
- c. Then the sum of the scores is multiplied by 2.5
- d. Interpret the score using the interpretation table below

Table 1 states the values resulting from the statements in these three aspects. The results are interpreted in the form of letters A to E with the following information (Brooke, 1996) :

Table 1. Score Interpretation Guidelines

Score	Grade	Information
> 80.3	A	Excellent
71– 80.3	B	High

69-70	C	Moderate
51 - 68	D	Low reliability
< 51	E	Very low reliability

Suppose you look at the final score interpretation guidelines above to produce a good predicate. In that case, it is enough for the respondent to give an assessment with a value of 4 or agree on the existing statement points. For grade C it will be quite rare to find in the final assessment results because the range of values is limited to 2 points, namely 69 and 70, so that to get grade C there are at least 2 statements scored with a value of 3 and the rest with a value of 4. If there are more than 3 items of statements assessed with a value of 3 with the remainder having a value of 4, then the final result is grade D. So the grades that can cause a grade to D are grades 3 (CS), 2 (KS), and 1 (SKS).

3. RESULT AND ANALYSIS

Field testing was conducted at SMA N Kebakkramat class X MIPA 2 with 36 students. Respondents were asked to test every feature in the media and then fill out a questionnaire on three aspects: presence, affordance, and usability.

3.1. Presence Aspect

The results of data processing from the presence aspect are as follows. Students who stated results with grade A were 28 people or 77%, while grade B was three people or 8%, then for grade C with a percentage of 0%, grade D as many as five people or 13%, and grade E 0%. Table 2 presents the results of the tabulation data tabulation of the presence aspect :

Table 2. research data from the aspect of *presence*

Grade	Total
ST	28 (77%)
S	3 (8%)
CS	0%
KS	5 (13%)
SKS	0%

So overall, the presence aspect has received a pretty good assessment with the dominance of grade A as many as 28 out of 36 people, or 77%, giving a very good assessment and grade B, or good 3 people, for the aspect of Plantar media presence. So for the presence aspect, there is no need to make improvements because many respondents gave a final assessment with a very good grade. However, there are still 5 respondents who produce ratings with a grade of D or mean not good. Namely the 20th, 21st, 25th, 26th, and 34th respondents. Tracing which part of the statement points to which judgments can be used for consideration of optional or non-mandatory improvements.

3.2. Affordance Aspect

The second aspect is the affordance aspect. The results of the descriptive analysis of the data found that as many as 30 respondents, or 83% of respondents assessed with a final grade of A or very good, then the grade of B or good value resulted in a final assessment of 2 respondents or 5%. Then for other respondents, it produces grade D with 4 respondents, namely as much as 11%. For grades C and E, no respondents produced a final assessment with that grade. Respondents who produced a final grade of B were the 21st and 35th respondents, while those who produced the final grade with a grade of D were the 20th, 25th, 26th, and 34th respondents. If you look at the distribution of the scores given by the respondents in the data tabulation above, the most dominant value is the value 5 (SS), while the value 4 (S) is also quite a lot, then the value 3 (CS) can be calculated as many as 15 assessments, while the value 2 (KS) is only 1 assessment. 15 Dominant 3 score ratings were in respondents with a final assessment with grade D, namely respondents 20th, 25th, 26th, and 34th. The remaining only 1 respondent with a grade of A gave one value of 3, namely the 31st respondent. Respondents who scored 2 were the 21st respondent with a grade of B. So it can be said that the respondent with the final grade D assessment was the respondent who contributed the

most number of 3 points and did not give an assessment of 5 points for all statements. Table 3 presents research data from the affordance aspect.

Table 3. research data from the aspect of *affordance*

Grade	Total
A	30 (83%)
B	2 (5%)
C	0%
D	4 (11%)
E	0%

So because the very good rating is dominant, namely as much as 83% with an additional good rating of 5% even though there are respondents with a final rating of less than 11%, the presence aspect as a whole is very good, so no improvement is needed on the features related to the affordance aspect statement items.

3.3. Usability Aspect

The third aspect is the usability aspect. The results of the descriptive analysis of the usability aspect showed that as many as 36 respondents produced the final assessment results with grade A as many as 28 respondents or 77%, 3 respondents with grade B or 8%, no respondents who produced grade C, grade D as many as 5 respondents or 13%, and grade E no one produced. It can be seen that out of the 36 respondents, 28 respondents made a final assessment with a grade of A. The remaining 3 respondents, or 8%, produced a good grade, namely grade B so that when combined, 31 respondents produced a final assessment or in the form of a percentage of 85%, the remaining 5 respondents gave a poor assessment, namely grade D. So that overall the usability aspect can be said to be very good and does not require improvement for the features related to the presence statement items. Table 4 presents research data from the usability aspect.

Table Error! No text of specified style in document..1 research data from the aspect of *usability*

Grade	Total
A	28 (77%)
B	3 (8%)
C	0%
D	5 (13%)
E	0%

After looking at the data as a whole for the usability aspect, then it is necessary to pay attention to the distribution of assessments for each statement item and for each existing sub-aspect to be able to see which statement items have the most impact on the assessment that results in grade D so that it can be used for solutions to increase the value that allows for statement items that contain grade D.

4. CONCLUSION

Based on the background of the problem and the formulation of the problem that is trying to be answered by following the research principles and the steps in the research procedure that have been determined so that it has produced research results which can be concluded as follows :

1. An application-based learning media named Plantar has been developed by following a series of predetermined research steps. Starting from data collection and literature review needed as a reference for product design; then the product is developed according to the design that has been made by taking into account the design principles of "usability heuristics for user interface design." Then after the learning media has been made, it is tested on media experts and material experts to validate the learning media from the side of the media and the material side. After completing the validation, the researcher revised it according to the suggestions given by the material experts and media experts.
2. At the Plantar testing stage, students carried out a series of feature tests one by one accompanied by the researcher and then filled out a 3-aspect questionnaire. The results of the respondent's questionnaire data resulted in the three aspects having a very good rating, so using the usability

principle in Plantar development can produce applications that suit user needs. The Plantar learning media has been tested on a total of 41 samples with details of the implementation of a limited test, namely three students and two teachers, as well as a field-gaming test with 36 students, which were then evaluated based on filling in the presence, affordance, and usability questionnaires. Based on a review of these three aspects produces the same conclusion, namely, the application or learning media has feasibility with a very good predicate, so no improvement is needed for Plantar.

ACKNOWLEDGEMENTS

This research can be carried out smoothly thanks to the support and assistance of various parties; the researcher is grateful to Dr. Agus Efendi, M.Pd. and Mr. Endar Suprih Wihidayat, S.T., M. Eng, who has guided and provided support to continue the research up to this point, besides that the researcher would like to thank colleagues who directly or indirectly contributed to helping the course of this research.

REFERENCES

- Brooke, J. (1996). SUS: A "Quick and Dirty" Usability Scale. In *Usability Evaluation In Industry* (1st Editio).
- Fujimoto, Y., Yamamoto, G., Taketomi, T., Miyazaki, J., & Kato, H. (2012). Relationship between features of augmented reality and user memorization. *ISMAR 2012 - 11th IEEE International Symposium on Mixed and Augmented Reality 2012, Science and Technology Papers*, 279–280. <https://doi.org/10.1109/ISMAR.2012.6402573>
- Haryani, P., & Triyono, J. (2017). Augmented Reality (AR) Sebagai Teknologi Interaktif Dalam Pengenalan Benda Cagar Budaya Kepada Masyarakat. *Simetris : Jurnal Teknik Mesin, Elektro Dan Ilmu Komputer*, 8(2), 807. <https://doi.org/10.24176/simet.v8i2.1614>
- Hinton, P., McMurray, I., & Brownlow, C. (2014). SPSS Explained. In *SPSS Explained*. <https://doi.org/10.4324/9781315797298>
- Sharfina, Z., & Santoso, H. B. (2017). An Indonesian adaptation of the System Usability Scale (SUS). *2016 International Conference on Advanced Computer Science and Information Systems, ICACSIS 2016*, 145–148. <https://doi.org/10.1109/ICACSIS.2016.7872776>
- Wardani, S. (2015). Pemanfaatan Teknologi Augmented Reality (AR). *Jurnal Teknologi*, 8(2), 104–111.
- Yuliono, T., & Rintayati, P. (2018). Keefektifan Media Pembelajaran Augmented Reality Terhadap Penugasan Konsep Sistem Pencernaan Manusia. *Jurnal Pendidikan Dasar*, 1(1), 65–84.