Journal of Informatics and Vocational Education (JOIVE)
Vol.7, No.2, July 2024, pp. 42~55
ISSN: 2746-7813

Development of Android-Based Augmented Reality Learning Media Class X SMK Penda 3 Jatipuro

Keken Kusuma Prihantoro*, Endar Suprih Wihidayat, Nurcahya Pradana Taufik Prakisya
Department of Informatics Education, Universitas Sebelas Maret

Article Info

Article history:

Received Nov 15, 2022
Revised Aug 01, 2023
Accepted Aug 01, 2023

Corresponding Author:

Keken Kusuma Prihantoro,
Departement of Informatics Education,
Universitas Sebelas Maret,
Jl Ahmad Yani, no 200,
Pabelan, Kartasura, Surakarta,
Central Java, 57169, Indonesia.
Email:
ireneusmichaela@gmail.com

ABSTRACT

In learning Chemistry at SMK Penda 3 Jatipuro has a limited time and only focuses on textbooks. Interactive learning media based on android technology is needed to help the learning process which can be done as an additional activity outside of class hours. Learning materials must also be projected in 3D form to facilitate students' understanding. The purpose of this study is to develop android-based augmented reality learning media for class X chemistry subjects of SMK Penda 3 Jatipuro, and find out the feasibility of this learning media for users to use. The research method used in this study is Reasearch and Development with 3 stages, namely the preliminary stage, the development stage, and the feasibility test stage. The preliminary stage is through interviews and literacy studies. At the development stage using the Prototype development method. The latter is the due diligence stage using the due diligence of media experts, material experts, and users. From this research, an android-based augmented reality-based learning media software for class X chemistry subjects for SMK Penda 3 jatipuro was obtained. From this study, this learning media obtained the feasibility test results of media experts 88%, for the feasibility test of material experts 89%, and for user feasibility tests obtained results of 78%. It can be concluded that this learning media is included in the category of feasible to use based on the scale of testing used.

Keywords: Augmented Reality, Augmented Reality Learning Media, Android-Based Learning Media

1. INTRODUCTION

Learning media is considered as a physical tool where a person's message will be presented in a certain media (Gagne & Reiser, 1983). In addition, learning media are materials, tools and techniques that can be used in the teaching and learning process whose purpose is to facilitate the learning process and make it more communicative and effective (Mulyani & Johar, 2001). Augmented reality is the merging of virtual world objects projected in real-world time (Valino, 1998). In addition, augmented reality is defined as a technology to combine two worlds (real world and virtual world) projected at the same time / realtime (Azuma, 1997).

In observations on chemistry learning class X SMK Penda 3 Jatipuro, it was found that the usual learning is to use textbooks and practices with limited time. Limited time and learning using less interactive media make students' motivation less good, so that students' understanding of basic chemistry lessons is less than optimal. One of the materials present in chemistry subjects today has difficulty in showing the real form of atomic models and some types of molecules. Objects such as atoms and molecules cannot be seen with the naked eye. Therefore, there must be a media to convey information about the material that has been mentioned. To introduce atoms and molecules to students, it will be difficult to use only 2-dimensional media, as in pictures in textbooks. There is also learning media in the form of 3-dimensional videos. In this case a 2-dimensional medium, it is considered no better than a 3-dimensional medium for conveying information.

As has been revealed by Apriyani (2015), the use of 2-dimensional and 3-dimensional learning media has a significant influence, which results in the use of 3-dimensional media being able to increase students' understanding in learning materials compared to 2-dimensional media. In addition to using 3-dimensional objects, the use of android-based interactive learning media also has a good enough influence to improve students' learning ability. As stated by Wahyuni & Ananda (2022), the use of interactive learning media can have an influence to improve students' learning ability on algebraic form material. In addition, just like 3D

video to 2D media, where 3D video will provide more information than 2D media, augmented reality will also provide more information than 3-dimensional video media. This is because of the interactive learning media, where students can use AR to find out the combination of 2 worlds, namely between the real world and the virtual world, which are interrelated. Therefore, chemistry learning will be more efficient if you use android-based augmented reality learning media, especially in displaying details of chemical materials that have a small structure and cannot be seen using the naked eye and also the need for interactive learning media features through android smartphone media access.

1.1. IT-BASED LEARNING MEDIA

With the development of learning media, it can provide convenience to help students' understanding of existing subject matter in groups or independent learning (Nurbani & Puspitasari, 2022). In its use, learning media has 4 classifications, including audio media, visual media and audio-visual media, besides that there are still all-round media (Muhson, 2010). In addition, the classification of learning media media is distinguished according to the form of information used, ranging from still images, graphics, as well as printed materials, audio media, still audiovisual, mobile audiovisual or film , projection, television and multimedia(Nurseto, 2011) . Learning media, in this case IT-based learning media is a tool in the form of software and hardware as well as all data processors that aim to help teachers as guidelines in the creation of material of interest (Handayani, Yulianti, & Erita, 2022). Learning media that is developing today can be through the internet, which is in the form of educational sites, intranets that are still managed by providers in one network and mobile phones which are also one of the IT media that can be used for learning media, besides that there are also many emerging media in the form of CDs and / or Flash Drives (Son, 2009).

1.2. AUGMENTED REALITY AS A LEARNING MEDIUM

Consisting of 2 languages, if interpreted Augmented Reality has the meaning of the words Augmented and reality where each means plus or adding and reality. Augmented reality means being able to access real-world information into the digital world and combine them in a combination of information and contained in one layer (Azuma, 1997). The use of AR has changed the way user interaction can have a positive effect because it can see an object without having to use the original object in the real world (Fonseca, 2014). AR has the benefit of increasing students' desire to learn because it has a merger of 2 worlds so that learners can immediately imagine the results of the learning process (Mustaqim, 2016) . Augmented Reality is also useful, that is, it has a positive value to support the learning process, with AR, it can help the interaction process for both students and teachers who teach (Lia, 2015).

1.3. ANDROID-BASED LEARNING MEDIA

Android is a term from English which means "Robot that resembles a human", android is an operating system that can be used for free (Saviraningsih, 2022). According to Satyaputra & Aritonang (2014), Android is a derivative operating system of linuk specifically for smartphones and tablets. This operating system is a bridge between the user and the application he runs. In addition, according to Huda (2013) Android is an operating system for mobile devices, for example; smartphones and tablets based on the Linux operating system. Android is included in the list of open source operating systems that allow anyone to modify this operating system.

Mobile base learning is an alternative way to convey learning, so that it can be carried out anywhere and anytime (Darmawan, 2012). Mobile learning is made based on the reason that learning can be done anywhere and anytime. In addition, its wide scope has led to a tendency to create e-learning. In addition, Woodill (2010) also explained about this mobile-based learning media ecosystem, including:

a. Mobile Phone.
b. Smartphone.
c. Notebook and netbook computers.
d. Tablet device and computer.

According to Nurbani & Puspitasari (2022), android-based learning media, not limited to text and images, students can understand the material presented by the teacher through video tutorials.

1.4. BASIC CHEMISTRY

Chemistry is a science that belongs to the Natural Sciences, which has several benefits to learn, this science still has several branches of science, and basically chemistry in SMK is studied fundamentally, and has not yet entered a certain field of expertise. The limited time and achievements in the delivery of this material are felt to make students at SMK become limited in knowledge in the field of Chemistry, moreover this is learned by SMK (Vocational High School) students where some of the class hours have been focused

on their respective fields of expertise, such as machinery, TKR (Light Vehicle Engineering), multimedia, TKJ (Computer and Network Engineering), and many more majors in SMK.

2. RESEARCH METHODS

The research method used in this study is Reasearch and Development (R&D). There are 2 stages in this research process , namely the Preliminary Stage and the Development Stage. The preliminary stage is carried out to find out the needs in the development of augmented reality products. From this stage there is a study of literature, and an interview. Each to find out information related to the development of this product.

The development stage uses research methods of the type of Research and Development (RND) and uses the Prototype development method. The prototype development model consists of communication, quick plan, build, revise and test drive. Figure 1 shows the flow of the prototype development model.

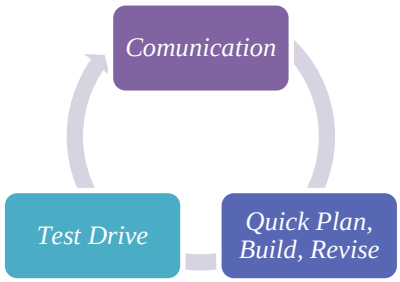

Figure 1. Prototype Development Model

Communication aims to communicate to users about the products they are expecting and know the functional and non-functional needs. After communicating and getting the results of needs, planning is carried out, so that it can be implemented in product development. Product development is categorized in several stages, including model making, marker making, and the last is product development. After the development stage has passed, the revision stage can be carried out if there are obstacles in the running product. Furthermore, after the product is made, the test or in this development model is called the test drive stage to test whether all the features of the product run with good or not. If all stages have been passed then the product can be communicated again with the user. If it has been completed and the product is in accordance with what is expected, then it can proceed to the next stage, namely the product feasibility testing stage.

The product feasibility testing stage has 3 test subjects, namely media experts, as someone who understands and has expertise in technology and media, especially in the field of android development. Then the material expert, as a person who understands the field of matter, especially the field of basic chemistry class X. and the last is a user, here is a person who does not have certain expertise and is expected to be a user of the product in this study. Table 1-4 shows some user instruments.

Table 1. Instrument for members of the media (Cahyana et al., 2017)

No	Assessment Aspects	Number
1	The Value of Beauty, Display and Audio Visual	1,2,3,4,5,6,7,8,9
2	Application Deployment and Design	10,11,12,13
	Number of assessment indicators	13

Table 2. Material expert instruments (Cahyana et al., 2017)

No	Aspects	Number
1	Linkage to Matter	1,2,3
2	Language Use	4,5
3	Application Deployment and Design	6,7,8,9
4	The Value of Beauty, Display and Audio Visual	10,11,12,13,14,15,16,17,18
5	Benefit	19
	Number of assessment indicators	19

Table 4. User Instruments (Cahyana, Suhartono, & Nurhalimah, 2017)

No	Aspects	Number
1	Linkage to Materials, training, and evaluation	1,2,3,4,5
2	Language Use	6,7
3	The Value of Beauty, Display and Audio Visual	8,9,10,11,12,13,14,15
4	Software Implementation and Architecture	16,17,18,19
5	Benefit	20,21,22,23
	Number of assessment indicators	23

In addition, for test analysis, a measurement scale and final value criteria are needed with reference to Table 5.

Table 4. Occasional Measurement

Alternative answers	Scores for statements	
	Positive	Negative
Very appropriate	5	1
Appropriate	4	2
Enough	3	3
Non-compliant	2	4
Very incompatible	1	5

The data obtained from the questionnaire are changed by presentation with the following calculations.

$$\text{Present (\%)} = \frac{p}{q} \times 100 \text{ (Riduwan, 2013)}$$

With, p = assessment results obtained

q = total number of assessments

From the percentage results, a criterion is formed as in the final grade criteria showed in Table 6.

Table 6. Final Grade Criteria (Riduwan, 2013)

Assessment Criteria	Presented
Very worthy	81% - 100%
Proper	61% - 80%
Less feasible	41% - 60%
Not worth it	21% - 40%
Very unworthy	0% - 20%

3. DISCUSSION

3.1. RESULT

Interviews were conducted with users, namely Mapel IPAS class X teachers of SMK Penda 3 Jatipuro and students of SMK Penda 3 Jatipuro. The results of interviews with users include teaching and learning activities in chemistry subjects usually by discussing books as guidelines for this chemistry subject. The lack of practice in chemical maples leads to less student learning motivation. In addition to time constraints in learning, the lack of motivation of students in learning that is less active and relies only on books and exercises, leads to a lack of understanding of students in the material given. Therefore, interactive learning media is needed that is suitable to help the student learning process. In this learning media, it can not only be used in KBM but can also be used in students' free time. The use of this interactive learning media can be done outside

the clock so that it does not interfere with or does not burden the main class hours of students at school. Independent student learning is also needed so that the student's learning process does not stop at school. From the interview, the developer offers android-based augmented reality learning media. AR was chosen by the developer because the subject to be implemented in learning media is Chemistry, so the need for a form or model is needed in this learning media. It is not enough just from the model alone, the advantages that can be obtained in AR are also considered more interactive. So that it can improve students' ability in knowledge.

A literature study to help the development of this learning medium is the 2013 Chemistry TIM Kompas Ilmu curriculum book, which includes several chapters that can be taken 3-dimensional models. Among other things are atomic models, chemical bonds that also include metal bonds, as well as chemical properties of solutions, among which are strong electrolytes, weak electrolytes, and solutions of a non-electrolyte nature. From some of the material that has been summarized, and from the results of interviews with class X chemistry maple teachers, some materials are obtained that can be poured into this android-based augmented reality learning media Class X SMK Penda 3 Jatipuro.

3.1.1. COMMUNICATION

From the interview results, the character of student learning was obtained, where students still use learning media in the form of textbooks. In addition, the existence of time constraints has resulted in less understanding of individual students. Chemical maple is difficult to apply in textbooks alone, and in this functional need several features are obtained, which can be applied in the application of AR learning media to the eyes These chemistry lessons include:

a. There is a main menu that can be used to access all the features in the application.
b. It has an AR Camera for tracking the target image, in this case it is a marker.
c. It has an exit button on the app.
d. It has a content table menu, which can view the contents of the material in the application.
e. There is an additional info facility about the target that has been detected in the form of text so that it can be read by the user.
f. There is an audio that can read out the description of the target.
g. There is a download menu, so that even if they are not the main users (teachers and students of SMK Penda 3 Jatipuro Class X) can also download markers.

In addition there is a non-functional need. The non-functional needs needed include a system of kersa devices and software that can be used to build products, in this study used 6th generation core i3 laptops and 4GB DDR4 RAM with windows 10 operating system to support the product building process, besides that it is also used Unity 3D application program, and uses Vuforia plug in.

Apart from some of the software and hardware used in product development above, some needs are also needed for product testing. For product testing, it has the following specifications , including:

a. Smartphone with android operating system
b. Smartphone RAM 2 GB
c. Main camera 2 MegaPixel
d. Android version Oreo/Android 8.0 (Minimal)
e. Resolution 16:9
f. Storage 112 Mb

The above specifications are recommended specifications with the minimum android version being Android 8.0 because it uses the Vuforia Plug in which can only be run on android 8.0 version.

3.1.2. QUICK PLAN

From the *comunication* that has been carried out, learning media is obtained in the form of an Android-based *Augmented Reality* application to support student learning. Then an application flow is created as shown in Figure 2.

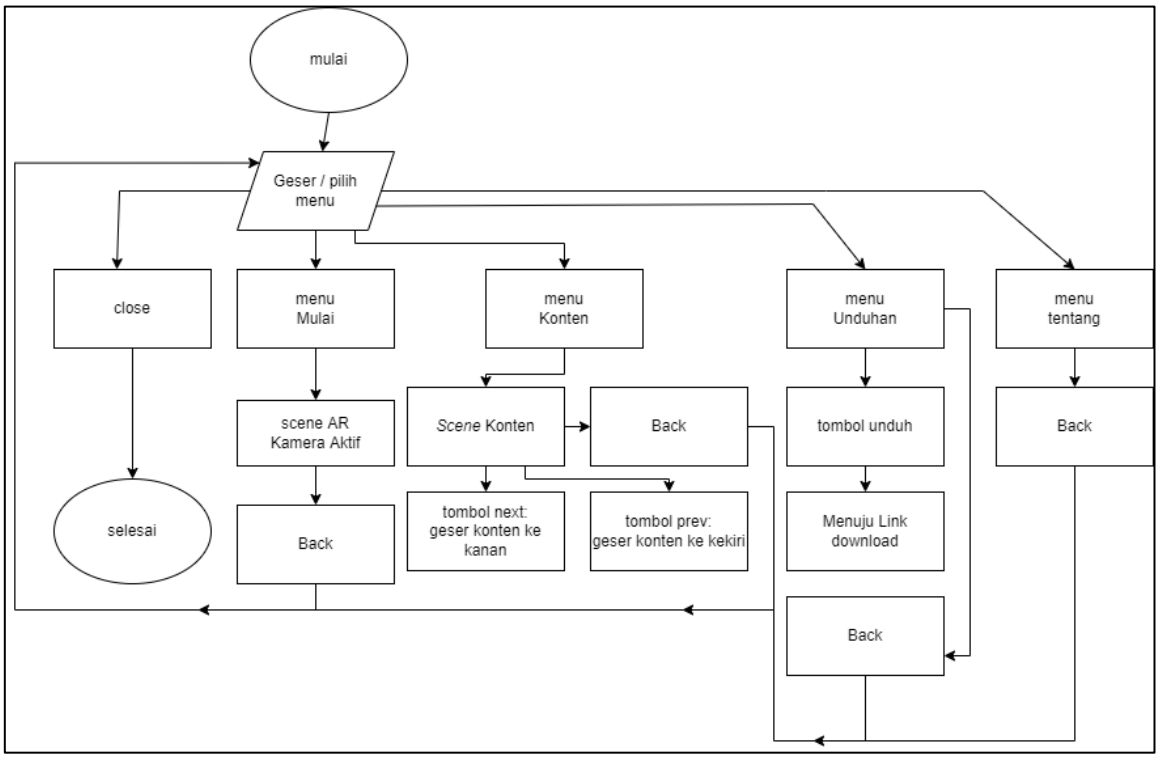

Figure 2. Application Flow

3.1.3. BUILD AND REVISE

Scene AR is the scene used to start this application. In this scene there is 1 back button that can be used to return to the Menu scene. For the code used in the back button, it still uses the same code i.e. the move code. Figure 3 shows the scene flow.

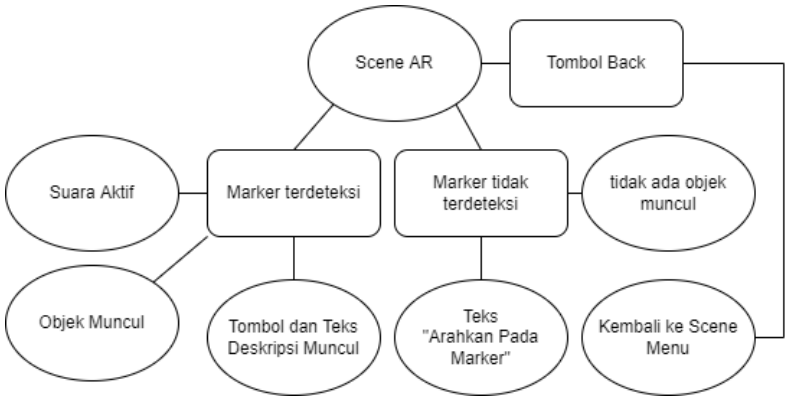

Figure 3. Scene AR Flowchart

For the important Scene, it is also in the Download Scene, because the Marker is dropped in this Scene. Figure 4 shows a flowchart for the Download Scene.

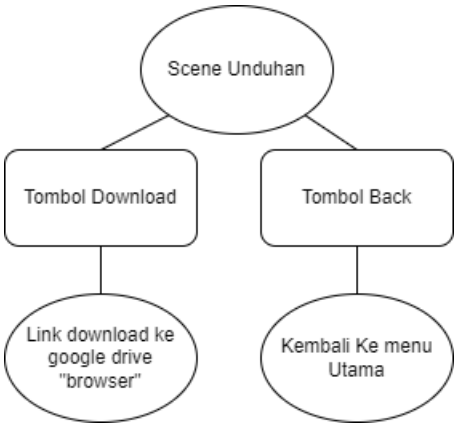

Figure 4. Download Scene Flowchart

From the results of the development, several scenes were obtained and so that a learning media application could be formed with the main menu, AR application, Content Menu, Download Menu , and Menu about Application. Figure 5 shows the start menu scene.

Figure 5. Start Menu

In the picture above is the main Menu scene, where the initial view if the user opens the application. While Figure 6 shows the appearance of the AR application on this learning media.

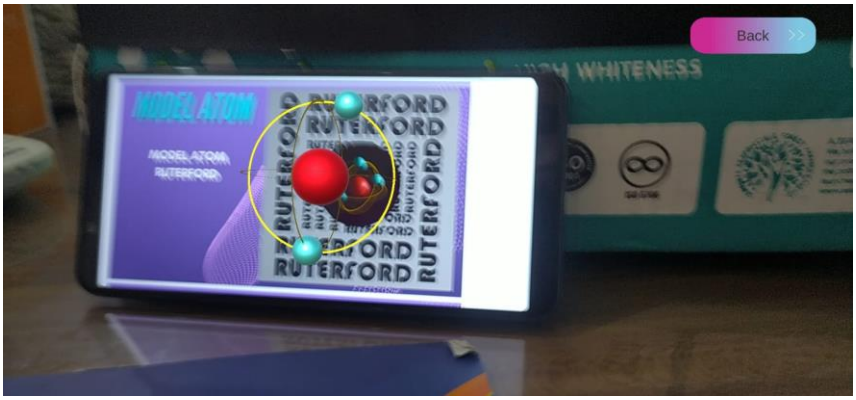

Figure 6. AR Application

When the screenshot is taken, AR is capturing the marker so that the object in the screenshot image is visible.

3.1.4. TEST DRIVE

The test drive phase was carried out by PTIK FKIP UNS students who were limited to testing the buttons and features in this product. This test stage was carried out using an Android 8.0 Oreo smartphone with Quadcore 1.6Ghz processor specifications, 4 GB of RAM, a 2MP main camera, and a screen resolution of 16:9 720p. Table 7-11 shows the testing of the function of the application which is divided into 5 different scenes.

Table 7. Scene Menu

No	Input	Process	Output	Result
1	Start scrollbar button	Move AR scenes	AR Scenes	Appropriate
2	Content scrollbar button	Move Scene Content	Scene Content	Appropriate
3	Download scrollbar button	Move download scene	Download Scene	Appropriate
4	About scrollbar button	Move scene about	Scene About	Appropriate
5	Close button	Close an app	Closed application	Appropriate
6	Next button	Swipe the scrollbar to the right	Scrollbar Shift to right	Appropriate
7	Knob previous	Swipe the scrollbar to the Left	Scrollbar Shift to Left	Appropriate
8	Swipe Menu	Swipe the scrollbar left or right	Scrollbar Bergesers	Appropriate

Table 8. AR Scenes

No	Input	Process	Output	Result
1	Scan Marker with AR Camera	Tracking target	Appears 3D Model in camera	Appropriate
2	Back button	Move Scene Menu	Scene Menu	Appropriate

Table 9. Scene Content

No	Input	Process	Output	Result
1	Back button	Move Scene Menu	Scene menu	Appropriate
2	Next button	Swipe the scrollbar to the right	Scrollbar Shift to right	Appropriate
3	Knob previous	Swipe the scrollbar to the Left	Scrollbar Shift to Left	Appropriate

Table 10. Download Scene

No	Input	Process	Output	Result
1	Back button	Move Scene Menu	Scene menu	Appropriate
2	Download button	Browsing to the file download link	Browsing & download	Appropriate

Table 11. Scene About

No	Input	Process	Output	Result
1	*Back button*	Move *Scene* Menu	*Scene* menu	Appropriate

3.1.5. PRODUCT DUE DILIGENCE

Feasibility testing was carried out by media experts, namely lecturers of Information and Communication Engineering Education FKIP UNS, namely Mr. Dwi Maryono, S.Si., M.Kom., and material experts, namely Mrs. Annisa Lidia Wati , M.Si. who is a chemistry teacher in class X of SMK Penda 3 Jatipuro, and there are users, namely 20 students of SMK Penda 3 Jatipuro, with each getting a score below. The results are showed in Table 12-15.

Table 12. Media Member Assessment

No	Assessment Aspects	Value
1	The Value of Beauty, Display and Audio Visual	91%
2	Application Deployment and Design	85%

Table 13. Material Expert Assessment

No	Aspects	Value
1	Linkage to Matter	87%
2	Language Use	100%
3	Application Deployment and Design	85%
4	The Value of Beauty, Display and Audio Visual	93%
5	Benefit	80%

Table 15. User Ratings

No	Aspects	Value
1	Linkage to Matter	77%
2	Language Use	80,5%
3	The Value of Beauty, Display and Audio Visual	77,6%
4	Software Implementation and Architecture	74,8%
5	Benefit	78,7%

3.2. ANALYSIS

3.2.1. DEVELOPMENT OF *ANDROID-BASED AUGMENTED REALITY* LEARNING MEDIA FOR CLASS X CHEMISTRY SUBJECTS OF SMK PENDA 3 JATIPURO.

The development of android-based augmented reality learning media products for class X chemistry subjects of SMK Penda 3 Jatipuro uses the prototype development method. There are 3 stages in this prototyoe development method, including: communication, development (quick plan, build, and review), and Test Drive. The following are the results of the discussion on the development of learning media in this study.

3.2.1.1. COMMUNICATION

With communication with users, several results are obtained in the form of functional needs and non-functional needs. From the functional needs obtained several main features that can be applied to the product. In addition, additional features are also needed to support application performance and appearance so that the product is not boring when used. In addition, non-functional needs are needed to support some of the things needed in product development. The non-functional needs needed include the tools needed in product development, both software and hardware. The software needed in product development is the Blender 3D software which is used to create 3D models for each agreed model, then uses CorelDraw to create markers,

Vuforia to create the Image Target database and Unity 3D to implement application designs and product builds. In addition, the hardware used is a laptop with specifications that can run software in product development. Next for the trial equipment is an android smartphone that is used to test applications with predetermined specifications.

3.2.1.2. QUICK PLAN, BUILD, REVISE

At the application development stage, by looking at the flowchart and several wirframes that have been formed, as well as the features that have been determined, an augmented reality product can be created that can be used with AR Camera, Content, and Marker Download features. In the process of developing a product through predetermined software, it already has good responsibility, but after building the product in the .apk extension,

3.2.1.3. TEST DRIVE

The test drive was conducted together with a PTIK FKIP UNS student named Aditya nugraha pradana. This stage can be seen that each button works well and can be used. From the test drive results, a decision can be made that this product can be passed on to the user so that users can try this application. After trying this application, it can be communicated again between the developer and the user whether the product can be used en masse. Apart from the button buttons that were tried, there are also markers and tracking, but there are familiarities during the trial process. The obstacle is none other than the camera is less responsive in taking focus, besides that there are also some ARs that lack response to appear. This becomes a product shortcoming and can be corrected in subsequent research.

3.2.2. THE FEASIBILITY OF LEARNING MEDIA IN ASSISTING BASIC CHEMISTRY LEARNING ACTIVITIES IN CLASS X SMK PENDA 3 JATIPURO

3.2.2.1. MEDIA MEMBERS

The results of the media expert assessment obtained a value of 91% from the aspect of "the value of beauty and appearance of visul" and a value of 85% from the aspect of "application application and design" so that an average value of 88% was obtained as shown in Figure 7.

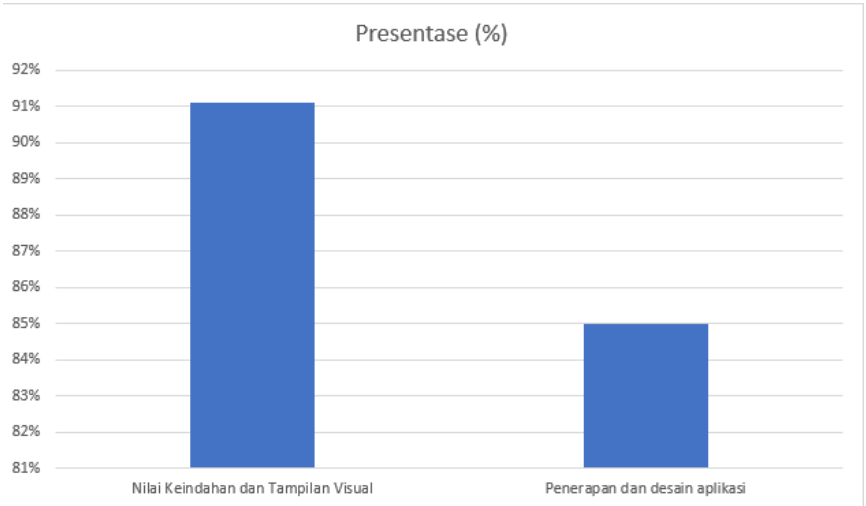

Figure 7. Score by Media Members

From the results obtained, it can be concluded that the application is still very feasible to be used as a learning medium.

As for the shortcomings of the product from the assessment aspect of "Beauty, Display and Audio Visual Value, that is, getting a score of 91% is feasible. From this, it can be seen that media experts still get shortcomings from this aspect, the shortcomings are in terms of appearance that does not increase comfort in learning. The writing is still not entirely good, and it is still lacking in terms of animation.

In the aspect of "Application implementation and design" got a score of 85%, indicating that the application still has some things that have not been achieved. The application response is considered not very good, but it is still tolerable. In addition, media experts gave a comment advice for this application, that there

are some marker responses that are not good. In the menu section, there is a vocabulary that makes users confused about what the menu is made for, so there must be improvements to the menu naming section.

In addition, it is also suggested from media experts that in the explanation of the material can be added. From this it follows that this application is feasible and can be used with improvements.

3.2.2.2. MATERIAL EXPERT

From the results of the assessment of material experts as shown in Figure 8, the average value was 89%. From the value it is said that this application is very worth using. The highest score was obtained on the aspect of "Language Use" where the material expert stated that it was 100% very feasible. In addition, there is the lowest value found in the aspect of benefits that are worth 80% decent. From the aspect of benefits it can be seen in the table that this application gets a score of 80%, which is the lowest value in the instrument. The benefits of this application are quite good, but from other aspects it is a bad aspect. It's good if the learning media is useful, so that it can work optimally as a learning medium. There are several discussions of aspects as follows:

a. Linkage to Matter

From this aspect, getting a score of 87%, some of the points that are lacking are the relationship with the expected user's ability and the relationship between practice and the user's ability, here get a score of 4 each so that it can be seen that even though it is good but still has not got a perfect score.

b. Language Use

From the use of language in this application gets a perfect score, and it can be concluded that the language used is appropriate and can be easily understood

c. Application and Design

From the application and design of the application gets a score of 85%, from the points taken, the application is rated by material experts less lancer, and the specifications are still too high, besides that the interface and navigation arrangement is less attractive but still in good grades. Apart from these points, the application has met the criteria that are perfectly stated.

d. The Value of Beauty, Display and Audio Visual

From this aspect, it gets a score of 93%, where there are several shortcomings of the point of choosing the type and size of letters, writing and images are easy to see and read, as well as images and animations in helping user understanding. Each of them gets a score of 4 (good). The design of the appearance of this aspect can be improved again in subsequent research.

e. Benefit

The benefits of this app are good, with a score of 4, meaning that it has not got a perfect score but this application is useful. From this aspect, get a score of 80%

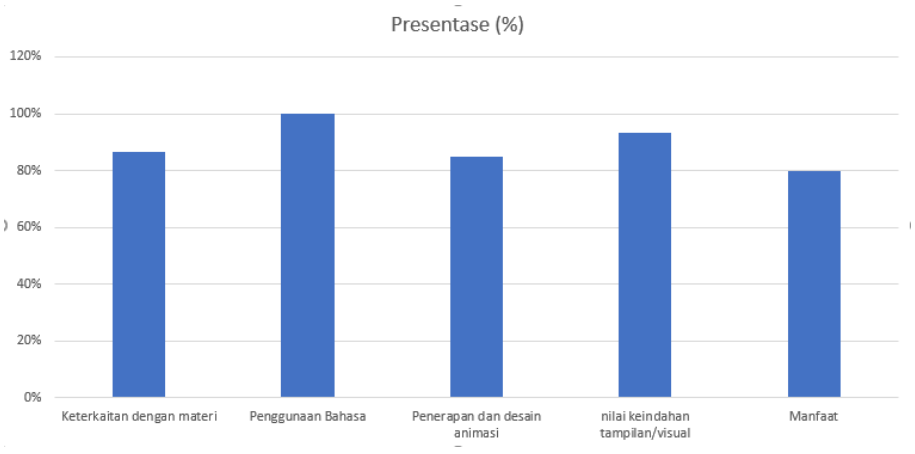

Figure 8. Score by Material Expert

3.2.2.3. USER

From the results of user assessment, the product gets an average value of 78% so that the test results are obtained that are suitable for use and implemented into learning. Figure 10 shows a graph of user ratings.

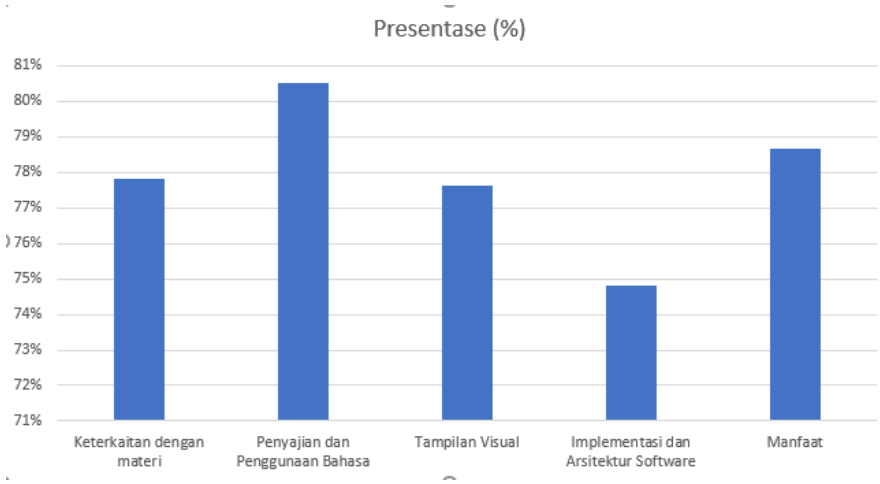

Figure 10. Score by User

The lowest score from users is the aspect of linkage with the material, training and evaluation where getting a score of 77%, from there it can be concluded that according to students, there are some differences between the material presented in the textbook and the material in this learning medium. However, it can be seen that the value obtained is still tolerable because it is still within the limits of product feasibility

There are several discussions from user research in accordance with the aspects that have been given:

a. Linkage to Matter

This aspect gets a score of 77%, each user gives an average score of 3.9. This shows that there are some shortcomings where, the material presented from the application is still not commensurate with the material in normal learning

b. Language Use

The use of language gets a score of 81% so in terms of language there are still shortcomings. The average value obtained from this aspect is 4 points, so the average value of this aspect is good.

c. The Value of Beauty, Display and Audio Visual

From this aspect, a score of 75% was obtained, with the average score of each point being 3.9. From this it can be concluded that from the aesthetic aspect, and audiovisual is quite interesting, it has not yet reached a good word. From this aspect, it gets enough marks because of the shortcomings in terms of audio, and the appearance is less attractive.

d. Software Implementation and Architecture

This aspect gets a score of 74%, as for the shortcomings that are very visible in the minimum device requirements where the minimum android version to run this application is android 8.0 which results in some students not being able to judge, and the smoothness of the application is lacking. This temporary android version cannot be downgraded because the Vuforia application plugin itself requires the use of Android 8.0.

e. Benefit

In terms of benefits, getting a score of 7.9% is feasible. This value has disadvantages in terms of benefits because the use of this application does not think about the allocation of time so that not all users are able to use it properly other than in classroom learning.

4. CONCLUSION

Based on the results of the research on the development of Android-based augmented reality learning media for chemistry subjects at SMK Penda 3 Jatipuro, several conclusions can be drawn. First, the development of augmented reality learning media utilizes Unity 3D and the Vuforia plugin, with minimum technical specifications such as Android version 8.0 Oreo, 2GB RAM, a 16:9 landscape screen resolution of 480p, and a 2 MP main camera. Furthermore, the application was evaluated through tests conducted by media experts, material experts, and users. The results showed that media experts rated the application as 88% feasible, and material experts also provided a score of 88%. Additionally, user assessments resulted in a score of 81%. From these results, it can be concluded that the Android-based augmented reality learning media for class X at SMK Penda 3 Jatipuro is highly suitable for use.

The creation of Android-based augmented reality learning media for class X chemistry subjects at SMK Penda 3 Jatipuro has several important implications. This learning media serves as a tool to facilitate the

learning of basic chemistry for class X students. The presence of 3D representations of basic materials helps enhance students' understanding of the subject. Additionally, the use of augmented reality technology increases students' interest, motivation, and comfort in learning chemistry, making the learning process more engaging and effective.

For future development, several suggestions are proposed. First, the inclusion of additional 3D objects would help provide greater insights into chemistry topics. Second, replacing the existing audio with custom recordings instead of relying on Google Voice would enhance the auditory learning experience. Third, efforts should be made to improve the application's responsiveness to ensure smoother performance. Lastly, upgrading the screen resolution to support a wider range of smartphone screen resolutions would increase the application's compatibility and usability.

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