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ALMUSTRA: An augmented reality application for introducing traditional musical instruments

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Abstract: Traditional Indonesian musical instruments reflect the richness and diversity of culture and are integral part of people's lives. However, in recent decades, they faced challenges in introducing and preserving to the younger generation. Arts and Culture teachers in Junior High School at Salatiga face difficulties in showing examples of the shapes and sounds of traditional musical instruments from various regions in Indonesia. Augmented reality (AR) technology is emerging as an innovative tool to introduce and preserve local knowledge about traditional musical instruments. This research used a mixed-method approach combining qualitative and quantitative data collection. Data collection was carried out through semi-structured interviews with Junior High School's Arts and Culture teachers. For system development, the Multimedia Development Life Cycle (MDLC) method was used with the aim of producing multimedia learning products. This research resulted in an Android application called ALMUSTRA: Introduction to Traditional Musical Instruments Based on Augmented Reality. ALMUSTRA is a learning product that helps introduce Indonesian traditional musical instruments, equipped with 3D images, sounds, and quizzes as gamifi cation to make the teaching and learning process more interesting.

Keywords: *augmente*d *reality, traditional music instrument, education technology, ALMUSTRA*

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INTRODUCTION

Indonesia's traditional musical instruments are valuable cultural heritages. Traditional musical instruments reflect the richness and diversity of each region's culture, and are the integral part of the lives of Indonesian people. However, in the last few decades, Indonesian traditional musical instruments have faced challenges in terms of preservation and introduction to the younger generation. For example, Junior High School students experience difficulties when studying the topic of traditional musical instruments in art lessons. This is because books can only display 2D shapes without producing sounds and 3D shapes. The books cannot display examples of traditional musical instruments from various regions in Indonesia. Technology is often used to help in the teaching and learning process. There have been many examples showing how applications were created to help students learn. Examples of tools included can be in the form of animation (Susanti, Safitri, Listanto, & Permatasari, 2023), Android-based game applications (Murtiningsih, Darsinah, Wulandari, Minsih, & Prastiwi, 2022), or even other applications to assist students (Putri, Azizah, & Jannah, 2023).

In the current digital era, augmented reality (AR) technology has emerged as an innovative tool to introduce and preserve local knowledge. AR is one of the newest and most advanced technological fields. The function of augmented reality is to create a virtual world by utilizing real objects or environments, thus creating a new interface. The implementation of AR can assist in various fields such as education, gaming, entertainment, healthcare, and also in the library sector. This technology can create engaging interactions with users because it allows users to experience virtual objects as if they were in the real world. The methods used in augmented reality consist of two types; Marker-Based and Markerless AR.

First, Marker-Based Tracking. The working principle of this AR system involves the use of markers, which can be images or objects that are recognizable and can be rendered into virtual experiences. These marker images or objects are referred to as markers. With the support of a camera on the device, the captured markers will be projected into virtual form so that users can witness virtual objects from various sides and different angles.

Second, Markerless AR is a method that does not require markers to display digital elements. Examples of Markerless AR include Face Tracking, 3D Object Tracking, and Motion Tracking. The implementation of this method can also be used by leveraging features such as GPS or digital compass on the device, allowing it to display directions and locations we desire in real-time.

The AR application field began in the 1990s and has continued to increase in importance since then, along with technological advances and developments in information and communications technology (ICT) (Rauschnabel, Felix, Hinsch, Shahab, & Alt, 2022). AR technology improves the user experience by superimposing computer-generated information, including graphics, sound, and sometimes tactile feedback, on a real environment. This enables the user to perceive the world in a better way (Aggarwal & Singhal, 2019). AR technology has been applied in various fields, ranging from medicine to education, the automotive industry, health and tourism (Arena, Collotta, Pau, & Termine, 2022). In particular, it has proven useful for the management and preservation of cultural heritage.

There are several main purposes for using AR in Cultural Heritage, namely: enhancing visitor experiences, reconstruction and exploration (Okanovic et al., 2022), as well as conservation and preservation (Merchán, Merchán, & Pérez, 2021) and bringing past events to life (Boboc, Duguleană, Voinea, G.-D., Postelnicu, C.-C., Popovici, 2019). The technology most often applied in all these matters is digitalization. It is used as a complementary method to conserve Cultural Heritage assets and to improve traditional conservation procedures (Salleh & Bushroa, 2022). AR can also be used to introduce traditional musical instruments such as in China (Zhang et al., 2015), Malaysia (Masmuzidin, Hussein, Rahman, & Hasman, 2020) and the Angklung musical instrument in Indonesia (Arifitama, 2016). Apart from AR research, there is also other research that emphasizes technological advances in music, such as The Application of Intelligent Piano Teaching in College Education (Chang, Ismail, & Ying, 2023). Since the pandemic, the adoption of technological approaches in music education has become a necessity (Ismail, Anuar, & Loo, 2022).

In this context, the research question that arises is: "Can the use of Augmented Reality be carried out to introduce and preserve Indonesian traditional musical instruments?" The hypothesis put forward is: "The use of Augmented Reality will increase the interest and understanding of the younger generation towards traditional Indonesian musical instruments, as well as facilitate the digital preservation of local knowledge."

Even though Augmented Reality technology has been used in various fields such as games, education, and art, its application in the context of preserving and introducing traditional Indonesian musical instruments is still relatively limited. There is a gap in research that investigates the potential of AR in increasing interest and understanding of traditional Indonesian musical instruments, as well as building a broader digital preservation of local knowledge. Therefore, this study aims to fill this gap and explore the potential of AR in the context of preserving Indonesian traditional musical instruments.

The purpose of this research is to study the effectiveness of using Augmented Reality in introducing and preserving Indonesian traditional musical instruments. This research will explore the potential of AR to increase the young generation's interest and understanding of traditional Indonesian musical instruments, as well as create a digital preservation of local knowledge that can be widely accessed.

One relevant previous research entitled "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications" (Boboc, Băutu, Gîrbacia, Popovici, & Popovici, 2022) investigated the application of AR in preserving cultural heritage from 2012-2021. The study presented a comprehensive review of the use of AR in the context of cultural preservation and concluded that AR has great potential in bridging the gap between the past and the present as well as enriching user experiences.

Furthermore, research by Arifitama (Arifitama, 2016) entitled "Preserving Traditional Instrument Angklung Using Augmented Reality Technology", is also relevant to this research. The research explores the use of AR in maintaining and introducing traditional Indonesian musical instruments, especially the angklung. The results of this research show that the use of AR can increase the younger generation's interest in learning and understanding of the angklung musical instrument. Furthermore, there is also a research (Arifitama & Syahputra, 2017) regarding the preservation of traditional Sundanese musical instruments by applying AR.

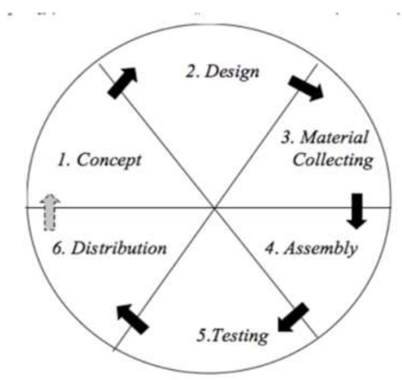
Based on the literature review, it can be identified that although AR technology has been used in the context of cultural preservation and the introduction of traditional musical instruments, the use of AR for the introduction of traditional Indonesian musical instruments and digital preservation of local knowledge is still limited. There are gaps in knowledge that need to be filled through this research. Therefore, this research will further explore the potential use of AR in the context of introducing traditional Indonesian musical instruments and developing digital preservation of local knowledge.

METHOD

This research was carried out using the Multimedia Development Life Cycle (MDLC) method. This method, devised by Luther, consists of six stages: Conceptualization, Designing, Material Acquisition, Assembly, Testing, and Distribution. MDLC was chosen with the aim of producing multimedia learning products.

In concept phase, efforts are made to identify the intended users of the system, which can significantly influence the development of a multimedia system as it mirrors the organizational identity. This stage helps in understanding the user's preferences to tailor the system accordingly, determining aspects such as the type of application (presentation or interactive) and its intended purpose, whether for entertainment, training, or learning. The limitation of the AR application for introducing traditional Indonesian musical instruments

Figure 1. Multimedia development life cycle



Source: Binanto (2010)

is smartphones that provide an Android operating system with a minimum standard, namely 5.0 Lollipop (API Level 21). The concept in this application displays 3D objects of musical instruments using a smartphone camera and marker. The application developed is aimed at introducing traditional musical instruments for junior high school students.

During the design phase, specifications are established concerning the program's structure, visual design, style, and material needs. A storyboard may be employed at this stage to outline each scene, ensuring that every multimedia element is described thoroughly, serving as a guide for the subsequent stage. An application mockup is a picture of the concept or design of the product that will be designed.

The navigation structure serves as the flow within a designed application. As seen in Figure 2, after the loading screen, the user will be directed to choose between play, quiz, guide, or info. If the user selects play, they will be directed to the catalog of traditional musical instruments and AR scanning. If the user chooses quiz, they will be directed to several practice questions related to traditional musical instruments. If the user selects guide, they will be directed to download markers. If the user chooses info, they will be shown the creator and copyright holder of this developed application.

A mockup (Figure 3-5) is a visual representation of the layout or design of a product or application before the actual development stage begins. It typically consists of static images or digital models that depict how the product will look and function, including elements such as page layouts, user interface elements, and navigation structure. Mockups aid in conceptualizing and providing an initial overview of the appearance and functionality of the product or application to be created.

The material collection stage involves gathering necessary materials for the construction of the multimedia system, such as photos, videos, clip art images, audio files, and other relevant resources, tailored to the system's requirements. The data collected was obtained from conducting a literature study from books, articles and scientific journals related to this research.

Figure 2. Navigation structure of the AR Almustra application

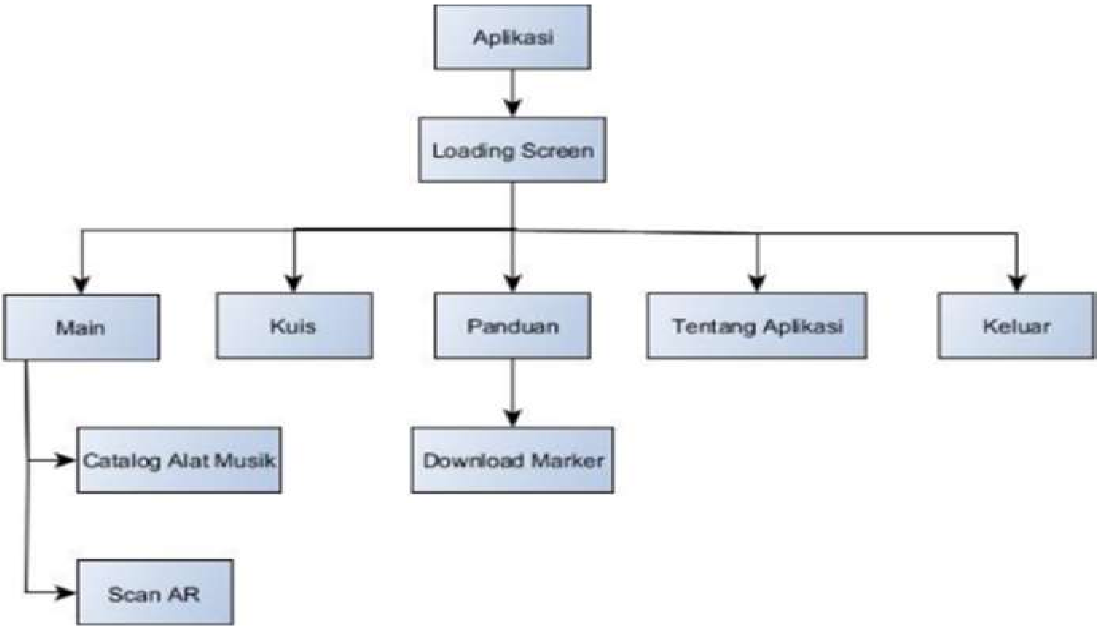


Figure 3. Mockup of main menu

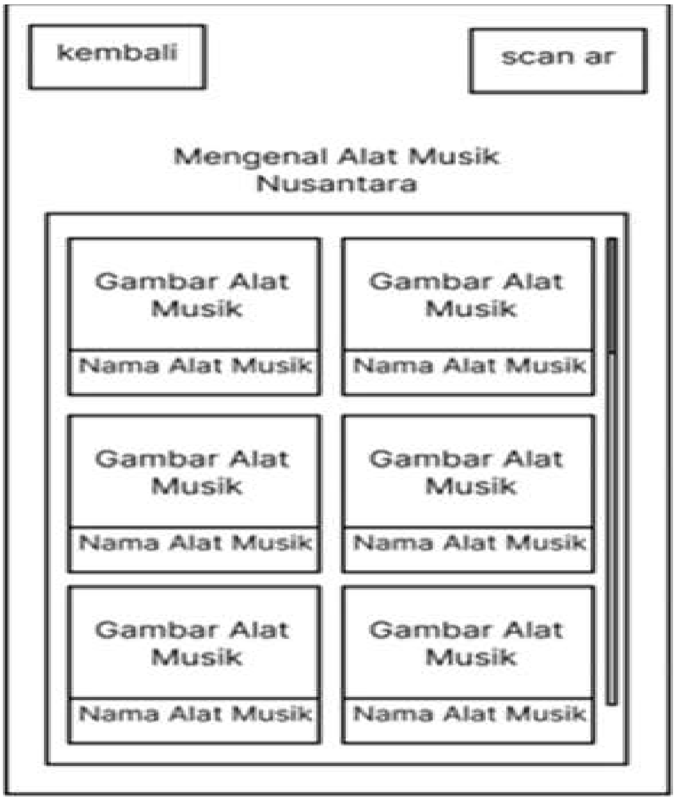


Figure 4. Mockup of quiz menu

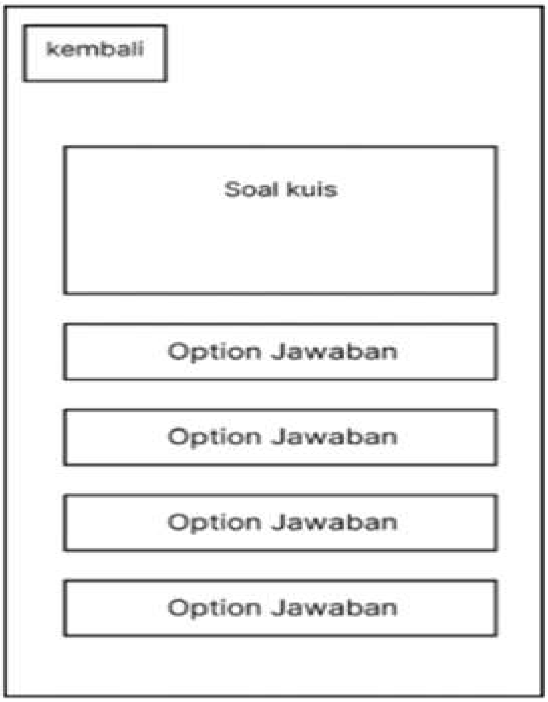
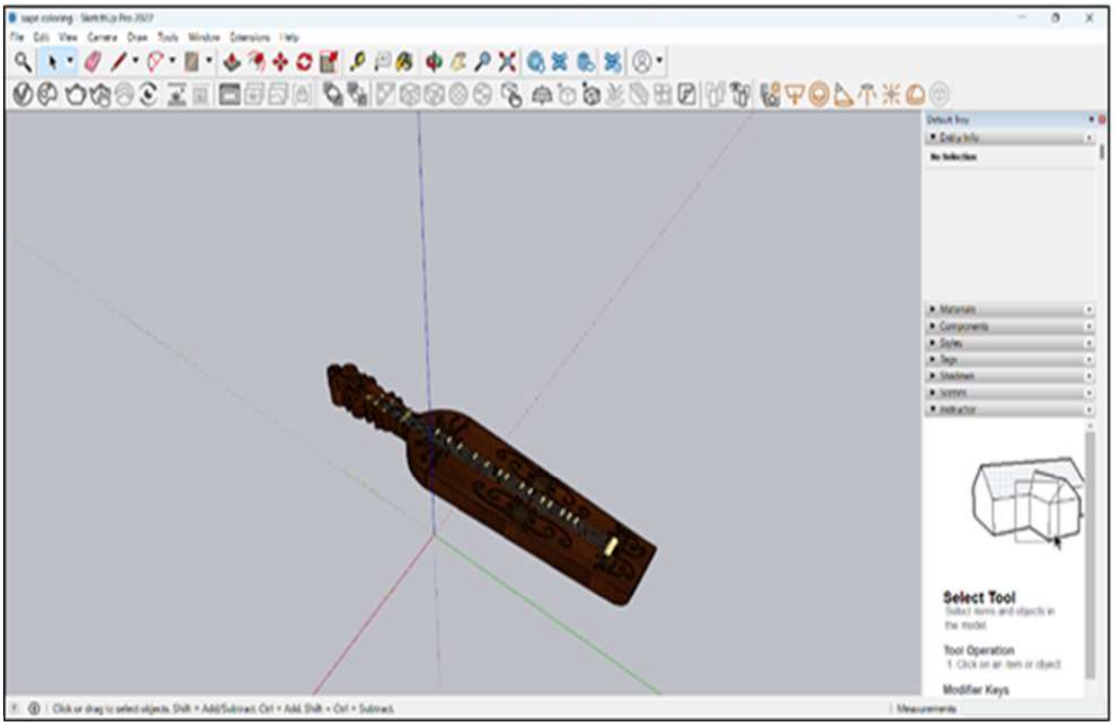


Figure 5. Mockup of exit menu

Figure 6. Creating 3D models of traditional musical instruments using Google \ sketchup.



The assembly stage involves compiling all multimedia elements or resources based on the designs outlined in the multimedia design phase, such as storyboards, flowcharts, or navigation structures. The data obtained from the literature study consists of images, information and functions related to Indonesian musical instruments. Meanwhile, data related to application creation such as icons, images, fonts, photos, sounds and others can be obtained by creating it yourself and also from the internet. The data is then modified using CorelDraw to create a design in the form of a background, icon, and so on. Meanwhile, the 3D objects of musical instruments were created using the Goggle SketchUp application. The software used to develop this application is Unity 3D, Vuforia, Google SketchUp, CorelDraw, and Visual Studio. Vuforia AR provides a way to interact by using the phone's camera as a medium to bridge virtual objects with the real world, resulting in a combination of the real environment and the world rendered by the application.

During testing phase, following the assembly process, the application is executed to ensure alignment with the previously created storyboard. This step aims to identify any potential errors within the constructed multimedia system. Testing at this stage employs two techniques: alpha testing, conducted by the creators or internal stakeholders, and beta testing, involving end-users who will utilize the system. Testing is a stage to test whether the application meets expectations. The ready-made application needs to be tested on various Android devices, to find out whether the application runs as expected. If it is not functioning normally then the system needs to be reviewed so that it runs properly when implemented.

Testing in this research involves alpha and beta testing which are explained in detail in the discussion.

Distribution is the last stage where the application will be stored on storage media. This stage is also often called the evaluation stage. At this stage, the system that has been built will be stored on the storage media, if it requires a large space, compression will be carried out on the system that has been built. After being downloaded, installed and used, users are then asked to provide opinions or suggestions for the application. In this stage, trials were carried out for MGMP Arts and Culture teachers in junior high schools at Salatiga.

FINDINGS AND DISCUSSION

In today's digital era, innovations in AR technology have opened the door to more immersive and interactive experiences. In this context, we developed an AR-based applications, named Almustra, that aims to introduce traditional musical instruments to users in a unique and interesting way. This application utilizes AR technology to allow users to view and learn various types of traditional musical instruments virtually in their real environment, bringing a fun and immersive learning experience about the cultural heritage of traditional music. With this application, we hope to stimulate interest in and appreciation for the diversity of traditional musical instruments from various regions in Indonesia.

The process for using the application is as follows: before starting the scan process, the user selects the main menu. The catalog menu containing various Indonesian musical instruments will appear. If the user selects the AR button, the camera will open, and when pointed at the prepared marker, a 3D musical instrument object will appear according to the marker. The application also contains basic information, uses, and sounds of each Indonesian traditional musical instrument. In addition, this application provides quizzes in the form of gamification for entertainment as well as helping students' understanding of the material being studied.

When a user starts an application, the application will first display a loading page. The loading screen page displays the name of the application and a loading bar which functions to find out the process of getting to the main menu screen. In the main menu there are various buttons, namely the play button, quiz button, guide button, about button, exit button and options button. Each key has its own function in providing information. The front view of the AR application page that is being developed can be seen in Figure 7.

On the play menu, there is a catalog containing several traditional Indonesian musical instruments along with an AR scan button. There are 10 musical instruments provided, namely, arababu, bende, ceng-ceng, gambus, pikon, rindik, saluang, sape', serunai NTB and serune kalee. To see all the musical instruments, users can scroll the screen in the music catalog box vertically.

The Musical Instrument Info Menu (Figure 8) page shows information related to the catalog that has been selected by the user on the previous page. There are photos, sounds, and information about musical instruments on this page. There will be a complete explanation of the name of the musical instrument, the region the musical instrument originates from, and the sound of the musical instrument. If the user wants to listen to the sound of the musical instrument, he/she can do so by pressing the sound button. For a more complete explanation regarding musical instrument information, users can scroll the screen vertically in the explanation box. The sound of traditional musical instruments lasts around 10-30

Figure 7. Loading and main menu page.

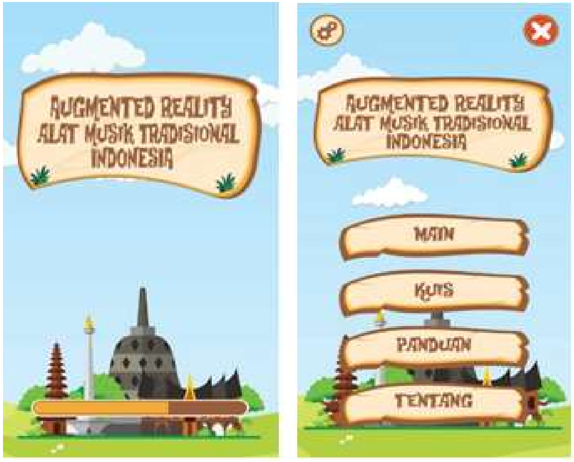


Figure 8. Musical instrument information menu page

seconds. The sound duration is limited so that the data does not become too large and does not become slow to load. The larger the audio data, the heavier it is to load. To go back to the music catalogue, press the back button.

Users can see 3D objects by pressing the AR button on the play menu, which will automatically open the system's cell phone camera. In this menu there is an undetected marker and a "?" button. If the camera recognizes the marker, the system will automatically display a 3D object according to the marker being scanned. Conversely, if the camera does not recognize it, a marker will appear. To view 3D objects of traditional musical instruments, users can do this by pointing the camera at the marker that was previously downloaded. If the marker is detected, the system will display the 3D object and the name of the musical instrument according to the marker. Figure 9 shown Page Menu Scan AR when object not detected and Figure 10 display when an object detected.

Figure 9. Page menu scan AR objects not detected.

Figure 10. Page menu scan AR objects detected

If the user presses the "?" button, the system will display a guide on how the user interacts with the 3D objects that will appear. Interactions that can be done by the user include zooming in and out of the 3D object, rotating the 3D object, shifting the 3D object, and animating the 3D object. To zoom in and out of the object, the user can pinch with two fingers on the phone screen. To rotate the object, the user can make a rotating motion on the object on the phone screen. To shift the object's position, the user can hold and drag the object on the phone screen. To play the animation, the user can touch the marker text.

If the user in the main menu selects the quiz button, the application will switch to the quiz page. Figure 11 shown tth Quiz Menu Button. There are five questions in the quiz provided in this application. The questions provided in the system will later be randomized if the user plays them. When the user has completed the quiz, the system will display the number of correct and incorrect answers, the grade score, and a repeat button. If the user wants to repeat the game, this can be done by pressing the repeat button.

Figure 11. Quiz menu page

System testing needs to be carried out with the aim of detecting errors and shortcomings in the applications created. Alpha testing is a software testing phase conducted by developers or internal teams before the software is released to end users. The purpose of alpha testing is to identify and fix bugs or issues before the application reaches the production stage. Beta testing is a software testing phase conducted by end users in a real-world environment before the application is officially released. The purpose of beta testing is to gather feedback from users on the performance of the application, discover bugs or issues that were not detected during development, and identify areas for improvement that may be needed before the official launch.

These tests are important to ensure that the developed application has good quality, stable performance, and can meet user needs and expectations. By conducting alpha and beta testing, developers can identify and fix issues early on, reducing the risk of errors or failures when the application is officially launched. Additionally, these tests also help build user trust in the application and enhance the overall user experience.

The testing in this research was carried out in alpha testing (testing based on Android version type, functional testing, and marker detection testing) and beta testing (user satisfaction testing).

Testing based on Android version type. The application was successfully installed and worked well on 3 smartphone test samples. Starting from the lowest Android version 5.0.1 to the highest Android version 11.0.0, the application can run smoothly and function properly without errors.

Functional Testing. The testing carried out in this research was black box, carried out by testing the software in terms of functionality, namely by installing the application on an Android smartphone and then continuing by running the application to check the appearance and application buttons that were expected. All features and functions of each menu in the application produce the desired output in accordance with the purpose and function of creating the application.

Marker Detection Testing. Marker testing was carried out to determine how AR technology works when reading markers. Several experiments were carried out on the markers, including the slope limit of the marker reading, the effect of light intensity on the marker, and the maximum distance/limit of marker reading. The slope limit for marker detection is $\leq 60^{o}$. Distance based on light intensity in the room can affect the camera in tracking the marker. At a distance of 45 cm with a 7x7 cm marker, the dimmer the light is, the harder it is for the camera to detect the marker, vice versa.

User Satisfaction Testing. Likert scale is a measurement tool used in research to evaluate an individual's attitude or opinion towards specific statements. This scale typically consists of statements or items that describe a concept or topic, followed by a series of response options that express the extent to which someone agrees or disagrees with the statement. These response options usually range from "strongly disagree" to "strongly agree." Likert Scale helps researchers measure the level of agreement or disagreement of respondents with specific statements and is used in various fields, including social sciences, psychology, and opinion surveys.

Calculating a Likert scale involves summing up the values or points assigned by respondents for each item or statement in the scale. Typically, Likert scales use ordinal values, which can be given in the form of numbers or labels such as "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." The general steps in calculating a Likert scale. *First*, determine the value scale. Decide the number of points or values to be given for each response, for example, 1 to 5 or 0 to 4. *Second*, sum up the values. For each respondent, sum up the values or points they give for all items in the Likert scale. *Third*, calculate the average. Calculate the average of the total values obtained from all respondents. This provides a general indication of the extent to which respondents agree or disagree with the given statements or items. Fourth, additional analysis. Besides the average, you can also perform additional analyses such as median, mode, or standard deviation to gain a more comprehensive understanding of the distribution of responses from respondents.

Testing user satisfaction was carried out by distributing user satisfaction questionnaires to 19 teachers who had tried the ALMUSTRA application. The questionnaire contains 10 questions which will be measured using a Likert scale (Table 1).

Table 1
Likert Scale

No.	Answer	Score
1.	Strongly agree	5
2.	Agree	4
3.	Neutral	3
4.	Don't Agree	2
5.	Strongly Disagree	1

The value of the Likert score is multiplied by the number of respondents' answers to each answer to find out the frequency of each question. The formula for finding the frequency value for each question is as follows: T x Pn, where T is the total number of respondents who answered and Pn is the value of the question score. An ideal score is needed before being converted into a percentage. The results obtained from user satisfaction are shown in Table 2.

Table 2
Data processing results

No.	Question	Frequency	Percentage	Assessment Interval
1.	The appearance of ALMUSTRA is attractive	81	85%	Strongly Agree
2.	ALMUSTRA's is easy to use	84	88%	Strongly Agree
3.	ALMUSTRA's is suitable for its function	84	88%	Strongly Agree
4.	The 3D objects in the ALMUSTRA's are diverse	83	87%	Strongly Agree
5.	Complete 3D object information in application	87	91%	Strongly Agree
6.	The instructions for using ALMUSTRA are easy to understand	87	91%	Strongly Agree
7.	With ALMUSTRA's application, learning becomes more interactive	83	87%	Strongly Agree
8.	Learning with this app can save time	84	88%	Strongly Agree
9.	Learning with ALMUSTRA's save cost	84	88%	Strongly Agree
10.	Learning with ALMUSTRA's can be carried out flexibly	85	89%	Strongly Agree
Average		84	89%	Strongly Agree

Formula to find ideal score:

Ideal Score = Scale Value (Score) x Total Participant

The highest score is Strongly Agree, while the number of respondents was 19 teachers. So, the results of the calculation are: Ideal Score = 5 x 19 = 95. After obtaining the ideal score, it can be processed using the Likert scale formula.

$$Presentase = \frac{Frekuensi\ dari\ setiap\ pertanyaan}{Skor\ Ideal} \times 100$$

$$Presentase\ (\%) = \frac{88}{95} \times 100 = 92{,}63\ \%$$

From the above calculation, a score of 92.63% was obtained for the evaluation of the Almustra application, thus indicating that users' satisfaction with the Almustra application falls into the category of very satisfied.

CONCLUSION

Overall, AR-based applications like Almustra prove that technology can act as an innovative and effective learning tool in the classroom. By utilizing the power of AR, teaching about traditional musical instruments can be made easier and enhanced into a more interesting experience for junior high school students. In addition to providing a more vivid picture of traditional musical instruments, the app also offers interactive elements such as quizzes that help measure student understanding, making learning more fun while providing relevant evaluations.

Through experience with Almustra, it can be concluded that the use of AR in learning not only increases student engagement, but also allows them to understand the material better. With this kind of application, teachers can create a dynamic learning environment and stimulate students' interest in the topics being studied, turning the classroom experience into something more interactive and satisfying for all parties involved.

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