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Learning Syllables in Malay Language through Augmented Reality Content for Preschool Children

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***Abstract*—The rapid growth and widespread adoption of augmented reality (AR) opened new possibilities for seamless integration into various aspects of human life. In this context, educators increasingly explored the potential of AR to enhance learning experiences. This research focused on leveraging AR technology to address a specific problem encountered by preschoolers in their language learning journey. The problem at hand was that preschoolers often encountered difficulties in blending consonant-vowel and consonant-vowel (CV+CV) sounds to form words in the Malay language. While they could easily sound out individual consonants and vowels, they struggled with combining these sounds to create new words, hindering their reading and language development. To tackle this challenge, the proposed solution involved the development of an AR prototype aimed at making learning Malay language syllables engaging and enjoyable for preschoolers. The research's output allowed children to practice forming syllables and improved their pronunciation through interactive AR experiences. Moreover, it offered quizzes to test their knowledge of Malay language syllables, providing instant feedback for a positive and effective learning experience. The survey presented the results of system testing, which revealed that a significant number of respondents had prior exposure to AR and found the research output's instructions clear and understandable. The integration of AR elements, such as 3D objects and marker detection, received positive feedback from most participants. However, some users expressed a desire for additional training, and there was potential to further enhance the app's level of excitement. In conclusion, this research demonstrated the promising role of AR in addressing preschoolers' challenges with language learning. By leveraging AR technology to create interactive and captivating learning tools, educators could better equip young learners with the necessary language skills, fostering a solid foundation for their reading and communication abilities in the Malay language.**

***Keywords*–Augmented Reality, syllables, Malay language, preschool**

I. INTRODUCTION

As is commonly understood, reading is one of the basic achievements of students. The basic reading skills that are implemented start with recognizing the letters, sounding out the letters and syllables, and finally reading the words and sentences [1]. Reading skill is one of the backbones of Malaysian language communication that need to be achieved by preschool children [2]. Preschool children are taught to have their reading skills, including reading and creating the syllables and words.

Nowadays, preschool children are able to recognize the consonant and vowel alphabets and are also able to sound out the single syllable. But when the syllables are combined consonant vowel + consonant vowel (cv+cv) to form a word, some of them are unable to sound out the word correctly. They usually forget the first syllable when they want to sound out the whole word [3]. As an illustration, consider the initial syllable as "*MA*" and the subsequent syllable as "*TA*." On occasion, they would occasionally overlook the "*MA*" syllable, resulting in their inability to pronounce the complete word. The failure of these children to sound out the cv+cv syllables makes it hard for them to achieve their basic reading skills. To encounter this problem, AR is one of the best solutions to gain interest from preschool children and motivate them to learn Malay language syllables because it is more fun and interactive. In the context of preschool education, Augmented Reality (AR) serves as an invaluable tool. It injects an element of enjoyment into the learning process while significantly enhancing children's memory retention capabilities. AR's adaptability allows for individualized learning experiences while ensuring a secure environment for exploration. Moreover, it fosters critical thinking and problem-solving skills in young learners. Furthermore, AR plays a pivotal role in preparing children for the rapidly evolving digital landscape, where technology assumes ever-greater prominence. Other than AR technology, by developing a game based application to learn syllables is one of the other solutions that can implemented to motivate pre-schoolers to learn Malay language syllables.

II. LITERATURE REVIEW

This section discusses about the previous works and the technologies related to AR based learning especially for pre-school children AR learning experiences.

A) Augmented Reality (AR)

AR is a technologically improved version of the real world that is created using digital visual elements, music, or other sensory stimulation [4]. Based on other sources, AR also can define as one of technologically trends that rapidly gaining traction [5]. This technology allows users to see the real-world environment through a digital augmentation overlay which is a highly visual and interactive way that uses digital content such as noises, movies, image, and GPS on real-world making situations [6]. Nowadays, there are a lot of research output that using AR technologies. It can be stated that AR finds applications in various fields including medical, retail, repairing and maintenance, design and modelling, business logistics, tourism, education, entertainment, and more.

B) Type of AR

This sub section explained the types of AR. AR can be categorized into different types based on how it overlays digital content onto the real world. The two types discussed in this section are marker-based AR and marker less AR.

a. Marker Based

In order to position objects in a specific location within AR, markers are used [7]. These markers are images or patterns that determine where the 3D digital content will be displayed in the user's field of view. Early AR technology relied on the use of markers [8, 9]. In simpler terms, this research prototype was connected to a specific physical image or pattern in the real world, allowing them to add a 3D virtual object onto it. To enable this, the camera continuously scans the input and identifies the marker through pattern recognition as shown in Figure 1. It is important to ensure that the camera is properly focused for the virtual object to appear accurately.

Fig. 1. Marker based AR [9]

b. Marker Less

Marker less based describes where it can remove the necessity for users to print a specific shape, image, or barcode to access the AR content [10]. Instead of relying on markers, this technology analyzes real-time data to insert virtual 3D objects into the user's real-world environment as demonstrate on Figure 2. The success of marker less AR software depends on the capabilities of smartphones, including features like the camera, GPS, and more [11-13]. With advancements in camera technology, sensors, and AI algorithms, there is no longer a need for an object tracking system. Advanced camera capabilities serve as an example because modern cameras, especially those integrated into smartphones and AR headsets, are equipped with high-resolution sensors and sophisticated image processing capabilities. This technological prowess enables them to capture and intricately analyze the surrounding environment, eliminating the need for supplementary tracking hardware. This type of AR seamlessly combines digital data with real-time data, all registered to a specific physical location.

Fig. 2. Marker less AR [13]

C) AR in Education

The rapid advancement of technology has led to its extensive use in various sectors, including education [14]. Technology is increasingly being utilized in education worldwide, as it has shown its ability to engage and motivate students, resulting in more effective learning experiences. AR has gained significant attention as an innovative tool for educational settings [15]. AR research output have also found success in preschool education, particularly among children aged 5 to 6 years old [15]. One advantage of AR technology in education is that it does not require expensive hardware like

Virtual Reality (VR), which relies on devices like Google Glasses [16]. AR's affordability and simplicity have made it accessible for learning and teaching across various subjects and educational levels [16]. AR facilitates seamless interaction between the real and virtual environments, enhancing the learning experience [17]. These outputs offer an engaging and fun learning approach, providing a sense of reality and colourful visual information.

D) Malay language Preschool Curriculum

In kindergarten, it is essential for students to achieve basic language skills, including listening, speaking, reading, writing, and communication with others. Proficiency in these skills instils confidence and active participation in studies. However, some students may struggle in their studies and social interactions due to a lack of speaking, reading, and communication abilities. This is because pre-schoolers had small word collections, so they sometimes found it hard to say everything they wanted. They often said words wrong because they were still learning. Reading and understanding letters and words was tricky for them too. Having long conversations or asking lots of questions was tough because they got distracted easily. Parents also play a crucial role in developing these basic skills among their children [18]. If parents did not give enough attention in their child's growth development, it will lead to having difficulties in achieving basic skills for pre-schoolers such as reading and speaking. On the other hand, pre-schoolers usually have good listening skills because they hear and understand words from a very young age. They might not speak perfectly yet, but they can still understand what people say. Listening skills are like building blocks for speaking and reading. When it comes to writing, preschool activities help them practice holding and moving a pen or pencil to make shapes and letters. It's important to know that kids develop at different speeds, so some may be better at certain things than others. Giving them the right support and guidance is essential to help them grow and learn.

The key principle of language instruction is to integrate listening, speaking, reading, and writing skills [19]. Listening skills involve differentiating sounds and understanding spoken content. Speaking skills focus on correct pronunciation, effective expression of thoughts, and ethical communication. Reading skills enable students to recognize and comprehend written words and sentences. Writing skills develop fine motor abilities for letter and word formation, eventually leading to writing simple sentences [19].

As the official language of Malaysia, it is crucial for all Malaysians to master the Malay language from an early age. Malay language is a mandatory subject in primary and secondary schools. Pre-schoolers should be able to comprehend and communicate in Malay language, using proper pronunciation and ethical language. The curriculum emphasizes understanding and recalling reading materials and the ability to write letters, words, and simple sentences accurately [19]. Learning Malay language in preschool includes activities such as syllable and word creation. Students learn to identify syllables formed by combining consonants and vowels (cv) and combine them to form words (cv+cv) [19].

III. METHODOLOGY

The research utilized the Rapid Application Development (RAD) model, known for its flexibility in software development. Unlike rigid models like the Waterfall, RAD allows for changes and new features throughout the development process, leading to faster results due to continuous prototype testing [20].

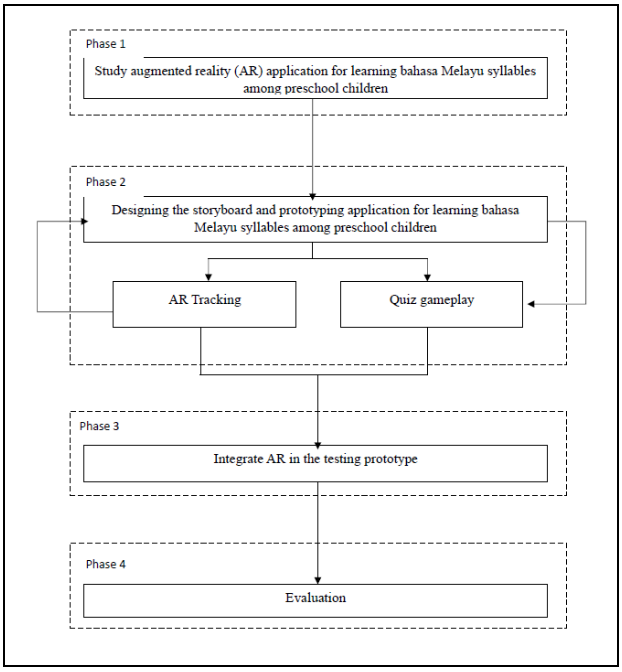

Fig. 3. Research methodology

The first research activities that were involved in this research was conducted an analysis and a study to determine the research's requirements, objectives, scope, and problem statements. It was crucial to conduct a thorough analysis to ensure that the study achieved its intended objectives. Additionally, since the study revolved around AR technology, a comprehensive literature review on AR studies was conducted to gather relevant background knowledge. The existing products available in the market were also examined as a starting point for the study and for future enhancements.

The prototype cycle step was the most important in the RAD approach. It was the research's first development phase. Designing the storyboard and prototype assisted the developer in creating a visual map of the program. The finished prototype was subsequently delivered and exhibited to potential end-users for evaluation, feedback, and product enhancement ideas. The prototyping process was repeated, and all improvements were documented until a full prototype was built that met all the end-user requirements. The AR tracking used in this application involved utilizing the AR camera feature. Users could scan markers, and as a result, 3D objects would appear on the screen. Additionally, the application featured a quiz section that enabled users to respond to questions related to the syllabus they had studied through the app.

After the AR tracking and other features were sufficiently established, the AR output was linked with the Malay language curriculum for preschool. This AR output contained two parts: an AR environment for learning Malay language syllables and a knowledge assessment using a quiz mode to measure their grasp of syllables. That is because gamified learning content may motivate the users in the learning process [21]. The prototype was completed in this phase and was used to meet the second goal of this research.

The last phase for this research was the evaluation phase, also known as the implementation phase. Users utilized the AR prototype for preschool children to study Malay language syllables during this phase. This phase occurred throughout the PSM2 research development. During this phase, there are two type of testing that were conducted. Usability and user acceptance tests were conducted to collect feedback based on comments and ideas on the output. As a result, 20 preschoolers were chosen to test the prototype. To gain access to the AR software for learning Malay language syllables, each respondent was given a pre-test and post-test questionnaire. Furthermore, at this phase, any significant distinctions between the AR ways employed in this study development and the other approaches for this output were discussed.

IV. IMPLEMENTATION

This section provided an explanation of the implementation of the AR prototype designed to help preschool children learn syllables in Malay language. This application was tested and found to be compatible with Android mobile devices running Android version 13.

A. *Implementation of Marker in AR*

This section explored the details of implementing marker-based AR into the prototype. This involved utilizing the Vuforia Software Development Kit (SDK) and incorporating marker-based interaction.

i. Vuforia SDK

The significance of the converted image targets became evident as they facilitated the showcasing of the AR experience in the actual environment. This accomplishment was made possible by integrating the Vuforia developer mode's database onto each image target, as demonstrated in Fig. 4.

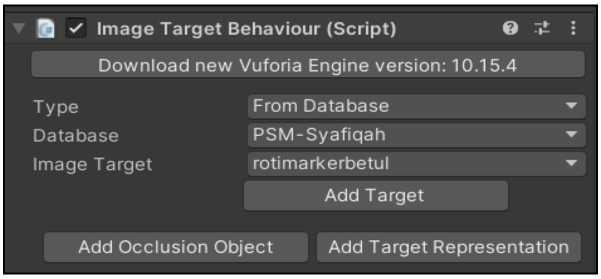

Fig. 4. Implementation of Vuforia SDK towards the image target

ii. Marker Based Interaction

The AR scene utilized a 2 dimensions (2D) marker, which enabled the direct display of a 3 dimensions (3D) object on each specific image target. In order to selecting the 2D markers there are few processes that need to considered. The processes listed as below:

1) Marker identification

Initiate the process by discerning particular 2D markers or images intended for utilization as triggers for augmented reality content. These markers should possess distinctive and readily discernible characteristics.

2) Marker preparation

Ensure that the chosen 2D markers undergo meticulous preparation to facilitate marker-based tracking. This preparation may encompass the refinement of their quality, resolution, and contrast to elevate recognition accuracy.

3) Marker integration

Incorporate the selected 2D markers into your AR application's database or asset management system. In the context of this study, the database employed was the Vuforia Engine developer portal. This phase entails establishing connections between digital content or experiences and each respective marker.

4) Marker deployment

Distribute the physical 2D markers as necessary, which can involve their inclusion in educational materials, affixation to posters, or deployment in contexts where users will engage with them through the AR application. In this study, the marker was printed and cut it into card size form.

Additionally, Table 1 shows a comprehensive list of the marker-based approaches that were utilized in this research. The study comprised a total of 20 markers, consisting of 10 pairs of syllable markers.

TABLE 1. List of 2D markers

2D Markers	**Description**
	These markers needed to be paired with each other and produced a 3D object of “vase”

2D Markers	Description
	These markers needed to be paired with each other and produced a 3D object of “ball”
	These markers needed to be paired with each other and produced a 3D object of “eye”
	These markers needed to be paired with each other and produced a 3D object of “cheese”
	These markers needed to be paired with each other and produced a 3D object of “table”
	These markers needed to be paired with each other and produced a 3D object of “bread”
	These markers needed to be paired with each other and produced a 3D object of “rock”
	These markers needed to be paired with each other and produced a 3D object of “book”
	These markers needed to be paired with each other and produced a 3D object of “wood”
	These markers needed to be paired with each other and produced a 3D object of “dice”

a) AR Markers

The research was based on marker technology and supported marker interaction. Canva was utilized for designing 2D markers, which were then exported in RGB JPEG format and uploaded to the Target Manager within the Vuforia Developer Portal. After the upload, the image targets were assessed for their suitability for augmentation based on their features and details. Each image target was assigned a unique ID that was used to identify the markers. Figure 5 shows the markers that had been created and used for this research.

Fig. 5. Example of a pair of AR markers used in this research

b) 3D Object

Every image target served as a platform for projecting 3D objects onto it, creating an immersive AR experience through the mobile camera. The implementation's outcome, as demonstrated in Figure 6, depicted the successful display of the predetermined 3D objects on the image target. Additionally, an error sign object appeared if users matched unpaired markers, as illustrated in Fig. 7.

Fig. 6. 3D object displayed onto the 2D marker

Fig. 7. The error sign object when paired unmatched markers

B. *Game-Based Learning*

The implementation of quiz gameplay as game-based learning was described thoroughly in this sub section. In the quiz game, there are five questions, and when the user clicks the *cuba lagi* button, the sequence of these questions is randomly arranged. All the questions are related to the syllabus covered during the AR experience.

i. *Implementation of Quiz Gameplay*

Users were allowed to click on the "KUIZ" button in the main menu whenever they wanted. The quiz game would only spawn when the user successfully performed and answered all the questions given until the end. Figure 8 shows the interface of the quiz. Figure 9 shows that users had to answer all the questions given, and the score was displayed at the end of the quiz session.

Fig. 8. Quiz interface

Fig. 9. Score for the asnwered quiz

C. *Interface Design*

The design of an interface was crucial since it could affect user behaviour and how users interacted with the features and functions in the output itself in terms of functionality and user experience. Figure 10 shows the main menu of this prototype.

Fig. 10. Main menu of research's output

V. EVALUATION

This section provided an explanation of the evaluation processes of the AR prototype designed in this research.

A. *Experimental Setup*

The experiment involved users using an android mobile device to access the prototype, along with the incorporation of 2D markers to interact with the AR scene within the research's prototype, as shown in Figure 11.

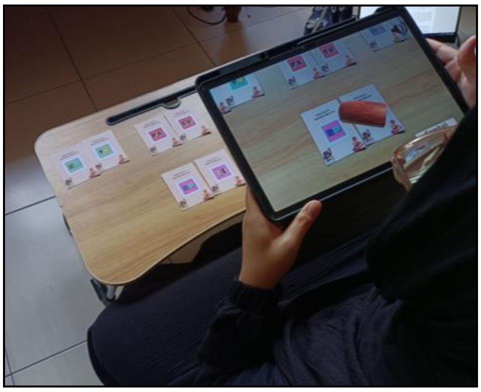

Fig. 11. Experiment setup

B. *Pre Testing Survey*

In order to gather feedback on the AR prototype for Preschool Children to Learn Syllables in Malay language, a series of questionnaires were distributed to the respondents. Figure 12 shows a total of 20 respondents were selected. These respondents consisted of preschool children aged 5 to 6 years' old who had a fundamental understanding of Malay language syllables. This feedback collection occurred once the participants had engaged with the research's prototype.

The respondents were queried about their previous experience with AR. As depicted in Figure 12, a majority of the respondents (70%) reported having prior exposure to AR, whereas the remaining 30% indicated no previous experience in this domain.

Fig. 12. Respondent's experience with AR

Further exploration of their AR background revealed that among those with experience, 60% had familiarity with the game industry, while 30% had not been exposed to AR within any particular field, as illustrated in Fig. 13.

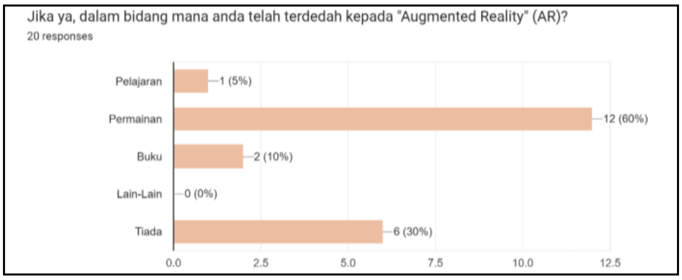

Fig. 13. Respondent's experience's field in AR

After the pre-experiment phase, participants were given a designated period to test the application on their own, without any instructions. The data collected was presented using a linear scale, enabling quantitative analysis and evaluation.

C. User Acceptance Testing

The black-box testing of the research prototype was conducted on 20 participants. All participants were not given any instructions prior to interacting with the prototype. Black box testing assessed how 20 users, aged 5 to 6, interacted with an app without instructions.

VI. RESULT AND DISCUSSION

This section provided the results related to the evaluation done on the research prototype. Two parts are presented here which are usability testing result and also the black box testing result.

A. Post Survey Result

In this context, the linear scale used to assess the application's performance ranged from 1 (strong disagreement) to 5 (strong agreement). After exploration, 30% agreed and 20% strongly agreed to regular app use. 25% were neutral, while 10% disagreed, and 15% strongly disagreed, as shown in Fig. 14.

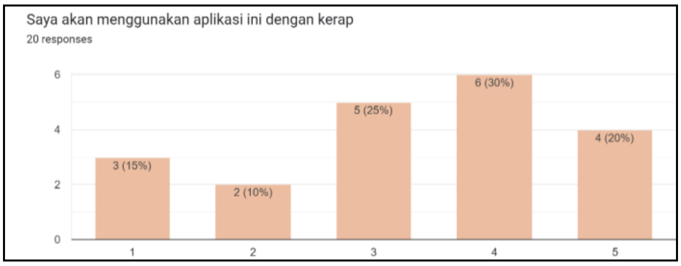

Fig. 14. The result of frequently use of this research prototype

Concerning the application's learnability, participants were queried about their view of the provided instructions. As depicted in Figure 15, a significant majority, 6 respondents, strongly agreed, and 5 agreed that the instructions were comprehensible. Nevertheless, a subset of 5 individuals remained neutral, while 2 respondents disagreed or strongly disagreed, highlighting the necessity for more time and training to utilize the prototype proficiently.

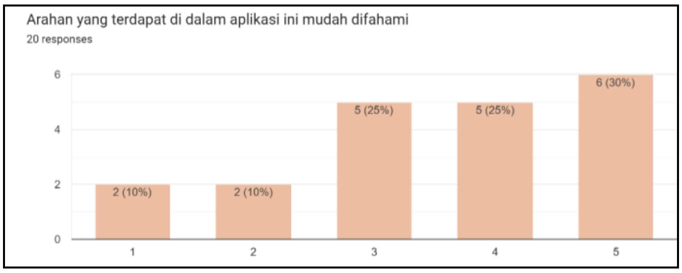

Fig. 15. The result on instruction provided in this research prototype

The subsequent inquiries focused on the integration of AR within the application. Figure 16 portrayed the respondent feedback concerning the incorporation of 3D objects in the app. A significant 40% expressed strong agreement with the prototype's capability to seamlessly display 3D objects. Additionally, 15% agreed, while 35% remained neutral on the matter. Conversely, 10% disagreed with the prototype's ability to smoothly showcase 3D objects.

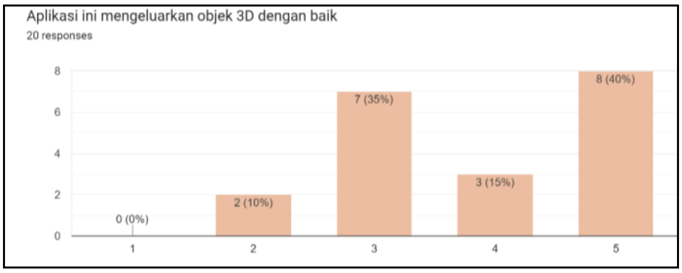

Fig.16. Result on this prototype's capability to display the 3D object smoothly

Transitioning to the next question, 35% respondents strongly agreed, and 15% agreed that the provided markers were easily detectable by the camera. Meanwhile, 35% neither agreed nor disagreed, and 15% disagreed with that statement, as depicted in Fig. 17.

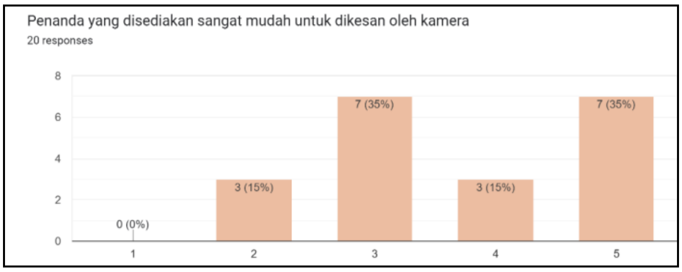

Fig. 17. Result about AR markers used on this testing prototype for easy detection by the mobile device's camera

Moving forward, Figure 18 displayed that a considerable 30% of participants strongly agreed, and another 25% agreed that the application provided immediate feedback after quiz responses. Meanwhile, 20% of respondents held a neutral stance on the matter. Concluding this aspect, 20% of participants disagreed, and 5% strongly disagreed with the notion that the research prototype was capable of offering swift feedback after completing all quiz questions.

Fig. 18. Result on question related to the instant feedback receiving afteranswering quizzes

Concluding the questionnaire, the final query pertained to respondents' sentiments about using the research prototype. In reply, a notable 40% (8) strongly agreed, and 20% (4) agreed that they experienced enthusiasm in learning Malay language syllables through the research prototype. Likewise, only 10% of participants remained neutral on this statement. Similar trends were observed in the strongly disagree category, where 10% indicated a lack of excitement in learning syllables using the research prototype, while 20% disagreed with that assertion, as depicted in Fig. 19.

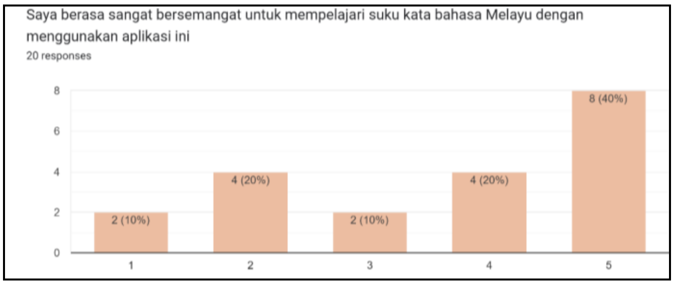

Fig. 19. Result on respondent's experience using this research prototype

The results indicated that a notable proportion of participants had prior familiarity with AR and found the research prototype's instructions understandable. Nonetheless, some respondents expressed interest in more training. The incorporation of AR, specifically the presentation of 3D objects and marker detection, garnered favourable responses from the majority of participants. The practice of offering immediate feedback after quizzes was generally positively received, reflecting a constructive learning encounter. However, there was room to heighten the level of enthusiasm among respondents. These insights suggest opportunities for further enhancement based on the gathered feedback.

As previously mentioned, the respondents in the study fall within the age group of 5-6 years old. It is worth noting that these young participants occasionally encounter challenges in comprehending the questionnaire. The author has also outlined several methods to assist these respondents in better understanding the questions. One of the way that has been implemented by the author was explain by using simplified language. Author used a clear and simplified language to the pre-schoolers when explaining what is the question about. Breaking down few information that are relatable with them also implemented during explaining. Next, this testing also was conducted in a small group so the pre-schoolers easy and comfortable to ask if the face with challenges throughout the evaluation. Author also implemented repetition method if the pre-schoolers having difficulties during answering the questionnaire. Author repeat the key information or the instruction multiple times until all the pre-schoolers respondents understand.

As summary, the findings suggested that a significant portion of the respondents had previous exposure to AR and perceived the application's instructions as comprehensible. However, a subset of respondents expressed a desire for additional training. The integration of AR, particularly the display of 3D objects and the detectability of markers, received positive feedback from most participants. The provision of instant feedback after completing quizzes was generally well-received, indicating a positive learning experience. However, there was potential for enhancing the level of excitement among the respondents. Further improvements could be made based on these insights.

B. Black Box Testing Result

Table 2 shows the details events, expected/actual results. The aim was to observe user interaction without knowledge of the app's structure. The table shows 11 actions, tick (√) for success, cross (x) for failure. This analysis gauged user ability to use the app's features without guidance.

Based on Table 2, 20 participants evaluated the usability elements of the research prototype. In the first event, all participants accessed the AR scene via "Imbas AR" button. Five of them had trouble viewing 3D objects due to AR unfamiliarity. This underscores future need for user tech familiarity or introductory instructions. After exploring the AR scene, all navigated back to the main menu via "Kembali" button. Testers used audio features by tapping the speaker icon, displaying adeptness with interactive elements.

During the quiz, all participants entered and answered smoothly, showing ease with quiz functionality. Retry ability ("*Cuba Lagi*") was used, showcasing flexibility. Users accessed instructions via "Cara Bermain" button, implying clear and discoverable instructions. Four users had trouble locating "Info" button, suggesting visibility improvement.

TABLE 2. Black box testing

No	Event	Expected Results	Actual Result																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Users will experience AR scene	Choose “Imbas AR” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	Appear the 3D object	Place the camera to markers	/	/	x	/	/	/	x	/	/	x	/	/	/	x	x	/	/	x	/	/
3	Go back to main menu from the AR scene	Press “Kembali” button in the AR scene	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	Listen the audio from AR scene	Tap speaker icon in the AR scene	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
5	Answer quiz	Tap to “Kuiz” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	Try again answering the quiz	Tap to “Cuba Lagi” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
7	Back to main menu from quiz scene	Tap to “Menu Utama” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	Get to know on how to use this application	Tap to “Cara Bermain” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
9	Get to know what application is about	Tap to “Info” button	/	/	/	/	x	/	/	/	/	x	/	/	/	/	/	/	/	x	x	/
10	Go back to main menu from the info and “Cara Bermain” scene	Tap “OK” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
11	Exit from the application	Tap “Keluar” button	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

In conclusion, the outcomes of the testing highlight the overall positive engagement of the testers with the prototype. Their successful navigation into the prototype and exploration of the AR scene through the "*Imbas AR*" button demonstrate the intuitive design. Nonetheless, it's worth noting that a subset of six testers encountered difficulties in experiencing the AR scene due to their lack of familiarity with AR. This suggests the need to consider user familiarity in future testing phases.

Throughout the other black box testing events, the majority of testers interacted successfully. However, a minor setback was observed, with four testers failing to engage with the button intended to provide information about the research output. This points towards a potential area for improvement in terms of making the button's purpose more evident.

Overall, these findings provide valuable insights into the prototype's effectiveness in guiding users through various interactions. The positive outcomes underscore the user-friendly nature of the prototype, while the challenges encountered offer opportunities for refinement, particularly in addressing user familiarity and enhancing the clarity of certain interactive elements.

VII. CONCLUSION

In a nutshell, this paper had discussed the achievements of this study including the study of conventional technique used to teach syllables and how it can be effectively transformed using AR technology, the development of this study’s prototype and the evaluation of the research prototype with its target users. The AR prototype is backed by strong evidence, demonstrating its entertaining and captivating nature.

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