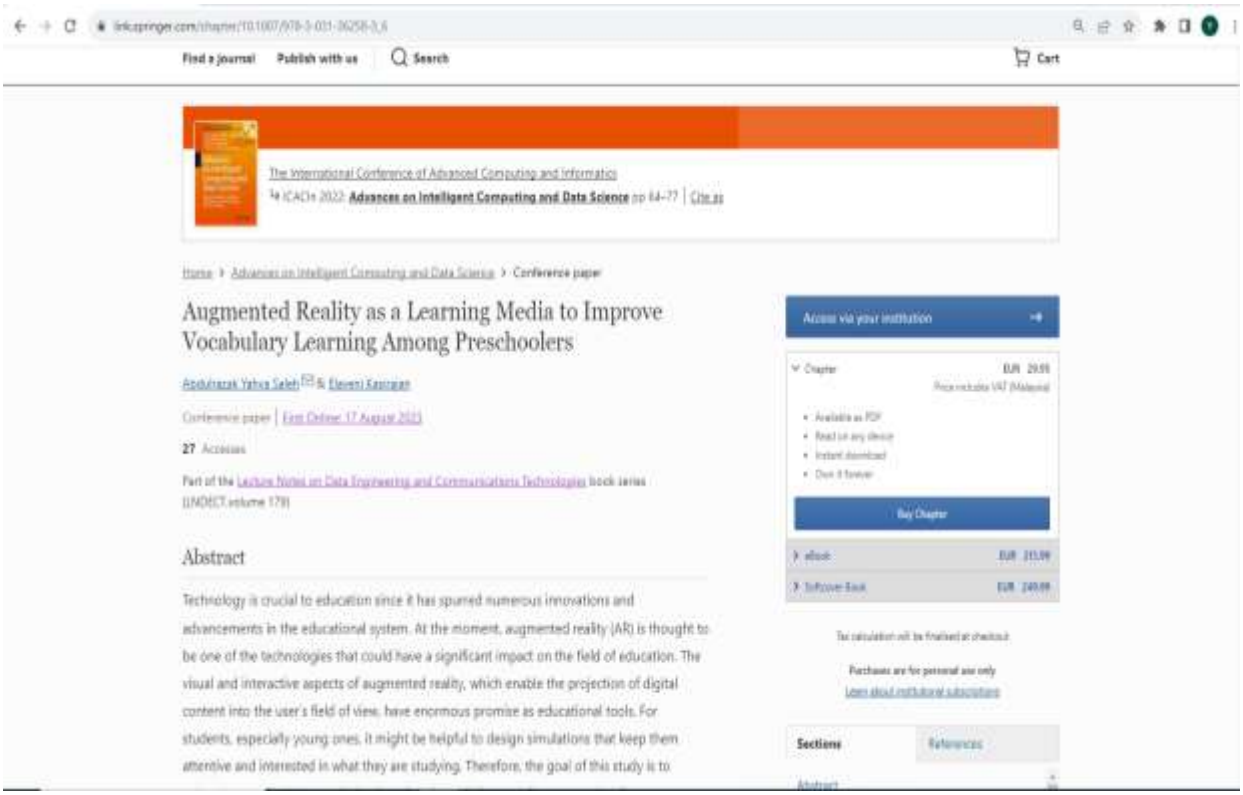
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Abstract
Technology is crucial to education since it has spurred numerous innovations and advancements in the educational system. At the moment, augmented reality (AR) is thought to be one of the technologies that could have a significant impact on the field of education. The visual and interactive aspects of augmented reality, which enable the projection of digital content into the user's field of view, have enormous promise as educational tools. For students, especially young ones, it might be helpful to design simulations that keep them attentive and interested in what they are studying. Therefore, the goal of this study is to
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Augmented Reality as a Learning Media to Improve Vocabulary Learning Among Preschoolers

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Abstract. Technology is crucial to education since it has spurred numerous innovations and advancements in the educational system. At the moment, augmented reality (AR) is thought to be one of the technologies that could have a significant impact on the field of education. The visual and interactive aspects of augmented reality, which enable the projection of digital content into the user's field of view, have enormous promise as educational tools. For students, especially young ones, it might be helpful to design simulations that keep them attentive and interested in what they are studying. Therefore, the goal of this study is to enhance pre-schoolers' vocabulary learning through the use of augmented reality. To accomplish the goal of this study, an AR application called the Home AR is created. The application's focus is on teaching the children between the ages of 4 and 6; the names of everyday objects are in four distinct languages: English, Malay, Tamil, and Chinese. The furniture and appliances that are found in the living room, bathroom, bedroom, and kitchen are chosen to be displayed in this application. To display the images of home goods that can be scanned from the AR application, flashcards are created as markers. The performance of the students utilising the developed application and the conventional learning approach is compared in an experimental study. Additionally, a variety of evaluation techniques are used to examine how parents, teachers, and pre-schoolers feel about adopting augmented reality (AR) as a learning tool for vocabulary development. The findings gathered for this study demonstrated that pre-schoolers can efficiently acquire languages through AR. The results show that AR has a high potential for use as a revenue-generating medium in the future and can be used for learning.

Keywords: Augmented reality; AR flashcards; Household items, Learning media, Preschoolers; Vocabulary Learning

1 Introduction

Malaysia is a land of many races, the three largest of which are Malays, Chinese and Indians. The native Malays form the majority group of the nation, which corresponds to sixty percent of the population. Bahasa Melayu is the Malays' mother tongue, and it is also Malaysia's 'national language', which is often referred to as Bahasa Malaysia. The

Chinese are the second largest ethnic group, making up about twenty-five percent of the overall population; they speak various dialects of the Chinese language, primarily Mandarin and Hokkien. The Indians are the third largest ethnic group of the country, which comprise seven percent of the population. Like the Chinese, this group speaks a subvariety of a language that originated from India, but mostly the Tamil language [1].

The identity of an ethnic group in Malaysia is determined by the language spoken. People of Malaysia perceive a communal language as an essential indicator of a specific culture [2]. However, many people in the current generation not know that vocabulary is an essential tool to learn and speak a language fluently. Effective communication cannot take place without sufficient knowledge of vocabulary [3]. In order to master any language, it is necessary to acquire vast knowledge of vocabulary [4]. It also helps in understanding written and spoken text. Frequent exposure to vocabulary can build confidence in children to understand and interpret unknown terms of a text. Learning new words can help children know the different situations and contexts in which the words can be used. The concurrent and complicated process of extracting and building utterances using appropriate lexical combinations at the right time and place leads to language comprehension and production. It is important for children to learn any language as a tool that helps them to know the utterances that are useful to communicate efficiently, and realise what utterance is or is not suitable to be used in a certain context.

Preschool is a necessary phase for a young child as it plays a major role in vocabulary expansion [5]. Even though growing children's vocabulary is increasingly acknowledged as crucial for learning, it does not come naturally to every child [6, 7]. Whether it is intentional or not, children learn and acquire language through various contexts. For further language development, children learn through their daily encounters with people, things, or animals. They will process the sounds or words and store them in their memory, which eventually act as a basis for the development. Apart from that, a clear knowledge of children's cognitive processes is necessary to support vocabulary acquisition [8]. Thus, For children to improve their vocabulary development, a variety of learning materials and resources are supplied to them [9], which include flashcards-- a popular tool used by instructors for vocabulary learning [10]. Flashcards can be categorised into few types: augmented reality (AR) flashcards, virtual flashcards, and traditional paper flashcards.

AR flashcards are more advanced than both traditional and virtual flashcards [11, 12]. AR flashcards give the experience of holding the card physically, similar to how the conventional flashcard method works. Children can also scan the flashcards with a mobile device to activate the virtual features. After scanning the flashcards, the appropriate 3D virtual visuals can be presented on the flashcards [13]. This allows the youngsters to engage with the virtual objects as if they were immersed in their world [14]. They can observe a specific perspective of the virtual object by controlling the mobile device [5]. In respect to this, many researches have been recommending applying AR tools in the preschool teaching process as in [15-19]. This paper shows how augmented reality application, which uses the flashcards as markers, can be used as a learning media to improve vocabulary learning among pre-schoolers. The objectives of the research are as below: design and develop an augmented reality application which can improve the vocabulary learning among pre-schoolers; evaluate the improvement of vocabulary level when using the augmented reality learning method as opposed to the traditional learning method; and finally analyse the perception of the pre-schoolers, preschool teachers, and the parents towards using the augmented reality as a learning media to improve vocabulary

learning among pre-schoolers.

The organisation of this research paper is as follows: the details of materials and methodology are presented in Section 2; Section 3 explains the findings; while the conclusion is discussed in Section 4.

2 Materials and methods

Methodology is a scientific and structured description of the techniques used in a field of research. It includes theoretical analyses of a variety of methods and concepts related to knowledge. In general, principles such as paradigm, analytical model, steps and quantitative or qualitative methods are included in methodology [20]. Methodology can be defined as a process because it does not give any solutions. Instead, methodology provides the theoretical basis for understanding which technique, collection of techniques or best practises may be adapted to a particular situation, such as estimating a specific outcome [21].

This section contains the methodological procedure used to develop the Home AR application. It provides a clear description of the application system development methodology, and the tools used to develop this application. It also contains a clear explanation of the research design, and the evaluation methods utilised to assess the performance of this application.

2.1 Research Methodology

For this research, an AR application called Home AR is developed to improve the vocabulary learning among the pre-schoolers. A specific mobile application development model is used to develop this application. For instance, each software development is distinct, and needs an effective system development life cycle (SDLC) approach to be followed, based on the internal and external factors. According to [22], there are numerous existing Software Development Life Cycle (SDLC) models that can be adapted to Mobile Application Development Life Cycle. These models are spiral process model, Iterative process model, Agile Methodologies for development of mobile applications, Mobile Application Development Lifecycle (MADLC) and Model-Driven Mobile Application Development. The appropriateness of the current process models that can be adapted to mobile application process models with respect to the development of mobile application, has been viewed in relation to such particular features.

After comparing the various process models adopted in mobile application development, a decision has been made to use the Mobile Application Development Lifecycle Model (MADLC) to develop the Home AR application

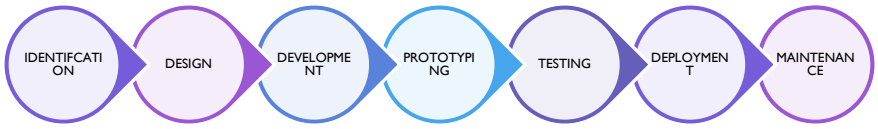

Fig. 1. Mobile Application Development Lifecycle Model (MADLC) [23]

There are many purposes for choosing MADLC to develop this application. The major reason is the activities and tasks mentioned in each stage are clearly described and elaborated by Vithani and Kumar [24]. MADLC consists of seven phases: identification, design, development, prototyping, testing, deployment, and maintenance as shown in Figure1[23]. The very first step of the mobile application development life cycle, which deals with functional and non-functional elements is the identification phase. Ideas are gathered and categorised in this stage. The ideas can be suggested by the users as well as application developers [23]. On the other hand, identification also entails coming up with new ideas in order to solve a problem via a mobile application. Before moving on to the next level, the concepts must be thoroughly examined and the scope of applicability determined [25].

According to [24], the ideas generated by the developer in the previous phase will be transformed into an initial application design during this phase. The viability of designing the mobile application on all mobile platforms will be determined in this phase as well. The crucial aspect of the design process is to build a storyboard (see figure 2) that can clearly explain the user interface design flow of the application [25].

Moreover, the developer has also created a use case diagram to display the complete functional and technical view of the application. Figure 3. shows the complete use case diagram of the Home AR application.

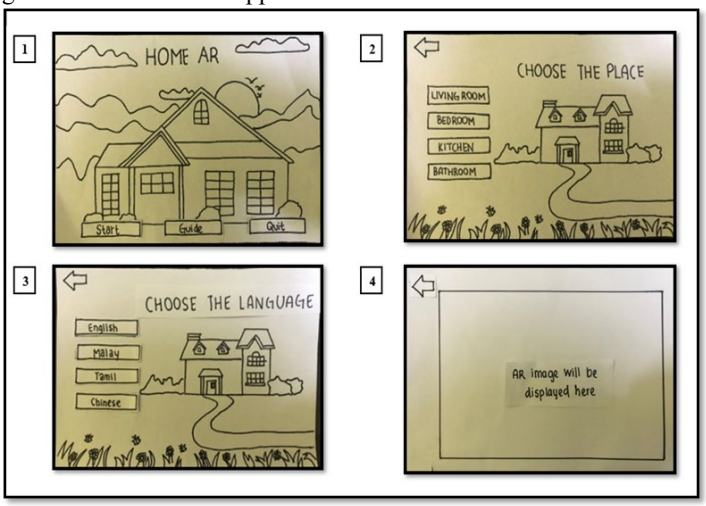

Figure 2. The storyboard to view AR images and listen to the pronunciation

The initial interface design of the application will be combined with the programming language at this stage. Apart from that, the development process can be split into two different parts: programming for functional and user interface requirements. Functional programming describes the application's scope and function. On the other hand, user interface requirement programming describes the development process of multimedia components such as keys, hyperlinks, and pictures. The development of this application is done by using several software packages that contribute to the building of various functions. The software stacks used to develop the Home AR application are Unity 3D, Microsoft Visual Studio, Vuforia Engine, Audacity, SketchUp and Paint 3D. Further descriptions of the functions of these applications are provided. The programming language used to develop this application is C#, also known as C Sharp.

Furthermore, the 2D images and the 3D model are designed during this phase. Forty 2D and 3D images are required to be designed for this application which displays 10 images of things from four places: kitchen, living room, bedroom, and bathroom. Once the images are designed, the 2D images are uploaded to Vuforia SDK, and the 3D model is programmed in Unity 3D. Besides that, 40 flashcards which are the markers of the Home AR application are designed with the 2D images in this stage. Lastly, the pronunciation of the names of the things in 4 different languages, namely English, Malay, Tamil and Chinese are recorded using Audacity and programmed in Unity 3D. The Home AR application consists of six scenes. The first scene contains three buttons: start, guide and quit. The user must click on the start button to get into the application. In the next scene, there are four buttons which state living room, kitchen, bathroom and bedroom, and the users are required to choose one place. Once the users click on the place, the next scene will appear; the users must choose a language from four different languages shown: English, Malay, Tamil and Malay.

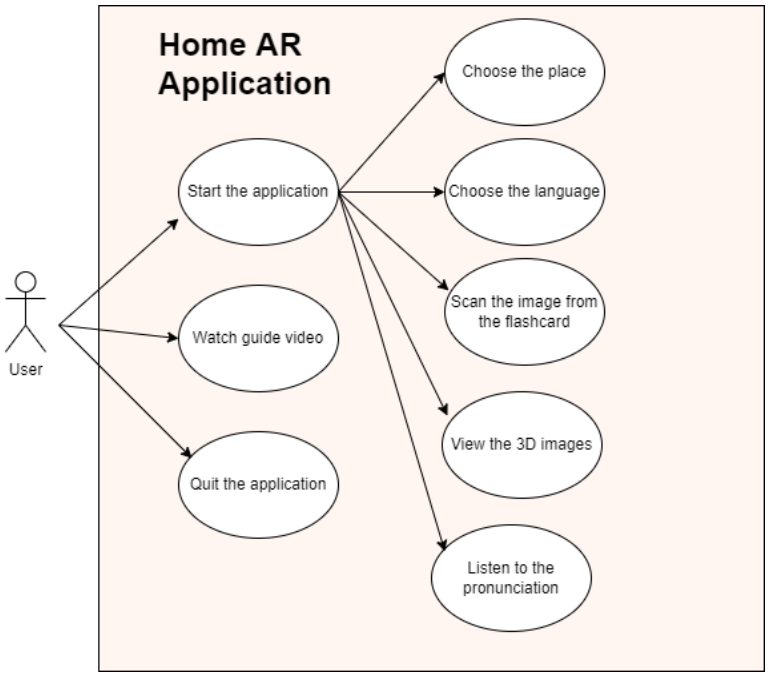

Figure 3. Use case diagram of Home AR application

This scene is followed by the main scene of this application, which is the AR scene. Here the users are required to scan a flashcard that has the image of a marker and they will be able to view the image in 3D form and listen to the pronunciation of the name of the object.

On the other hand, new users can click the guide button on the home page and this scene will move to a scene with a complete guide video on how to use this application. Lastly, users can press the quit button on the home page and click yes in the following scene to quit the application, or click no to go back to the homepage. The user interface of the Home AR application is shown in Figures 4-5 below.

Figure 4. Homepage of the Home AR application

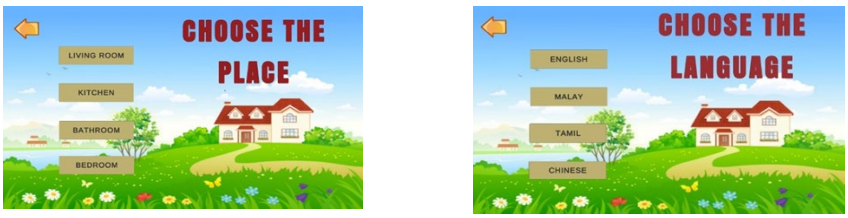

Figure 5. The second and third scenes of the application

2.2 Evaluation

The evaluation of the Home AR application was carried out by using several methods such as user perception survey, system usability scale testing, and interview.

The user perception survey consists of 10 questions, as shown in Table 1; the Likert Scale is used and the participants can express the extent of agreement or disagreement with the statements in the survey. The questions of this survey are adapted from the research conducted by [26, 27]. In this research, the user perception survey would be carried out to gauge the perceptions of the pre-schoolers towards the Home AR Application. 10 pre-schoolers from the AR learning group in the experimental study were requested to answers the questions of the survey. Participants were required to rank the answer of every question from 1 to 5, based on their level of agreement for the given statements as shown below. Before the survey began, the researcher explained each and every question in detail to the pre-schoolers, so that they had a clear understanding of the questions, and hopefully as a result, the data collected would be valid.

Table1. Survey about Home AR application for pre-schoolers

No	Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I like this application	1	2	3	4	5
2	I feel that the application is easy to use	1	2	3	4	5
3	I have gotten used to the application quickly	1	2	3	4	5
4	I think I can learn better by using this application	1	2	3	4	5
5	I could see the images of the things from various positions	1	2	3	4	5
6	I have concentrated more on the words and pictures than on the tablet	1	2	3	4	5
7	I want to own this application	1	2	3	4	5
8	I would invite my friends to use this application	1	2	3	4	5
9	I would like to use this application to learn more vocabulary	1	2	3	4	5
10	I have had a good time while using this application	1	2	3	4	5

The interview protocol was used to ascertain the teachers' perception about using the Home AR application to improve vocabulary learning among pre-schoolers. It was designed with reference to the work of [5]. The interviews for this research were conducted face to face with two preschool teachers from Tadika Eceria, and a teacher from JJ International Preschool.

System usability scale (SUS) test was originally created by John Brooke in 1986. It can be used to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications [28]. It consists of a 10-item questionnaire with five response options for each question; respondents can select one response from Strongly agree to Strongly disagree [29].

3 Findings and Discussion

This section presents the results and discussions of the cognitive walkthrough, usability testing, performance of the pre-test and the post-test, user perception survey, interviews, and the system usability scale test. The results are evaluated based on the methods discussed in the section of materials and methods. Cognitive walkthrough was carried out at the prototyping phase with two main goals: the application must meet all the requirements; there are zero errors in the programming of the application. The results and feedbacks given by the experts during the cognitive walkthrough are stated in Tables 2-4.

Table 2. Results of task 1

No	Questions	Expert1	Expert2	Expert3
1.	Will the user try to achieve the right action?	Yes, it has suitable interface and button for user.	Yes, hopefully the user will try	Yes
2.	Will the user notice that the correct action is available?	Yes, the correct action is available for user to click and explore the application.	Yes	Yes

3.	Will the user associate the correct action with the effect that the user is trying to achieve?	Yes	Yes	Yes
4.	If the correct action is performed, will the user see that progress is being made toward solution of the task?	Yes	Yes	Yes

The results in Table 2 show that all the experts agreed with all the questions given by the researcher after conducting the walkthrough of the first task, which is viewing the AR image. This indicates that there are no errors in this task and the users will be able to understand, as well as carrying out the correct action to view the AR image while using the application.

Table 3. Results of task 2

No	Questions	Expert1	Expert2	Expert3
1.	Will the user try to achieve the right action?	Yes.	Yes	Yes
2.	Will the user notice that the correct action is available?	Yes	Yes	Yes
3.	Will the user associate the correct action with the effect that the user is trying to achieve?	Yes	Yes	Yes
4.	If the correct action is performed, will the user see that progress is being made toward solution of the task?	Yes	Yes	Yes

Table 3. shows the results of the second task which is related to watching the guide video. The results of the second task also show that all the experts agreed with all the statements given, after carrying out the walkthrough of the second task. Hence, it is proven that the users will not face any difficulties watching the guide video when they use the Home AR application.

Table 4. Results of task 3

No	Questions	Expert1	Expert2	Expert3
1.	Will the user try to achieve the right action?	Yes	Yes	Yes
2.	Will the user notice that the correct action is available?	Yes	Yes	Yes
3.	Will the user associate the correct action with the effect that the user is trying to achieve?	Yes	Yes	Yes
4.	If the correct action is performed, will the user see that progress is being made toward solution of the task?	Yes	Yes	Yes

The third task of cognitive walkthrough is quitting the application. Results stated in Table 4 prove that all the questions were affirmed by the experts after performing the walkthrough of Task 3. The results indicate that the users will be able to carry out the correct action of quitting the application easily.

Table 5. Final feedbacks from the experts

Evaluator	Final Feedback
Expert1	Interesting project. My suggestion is to include voice buttons for kids especially for pages "choose the place and language". This is because some of the children 4-6years maybe not yet proficient in reading.
Expert2	It would be better if the buttons can pronounce the name of the places and the languages. This can make the kids to easily choose the correct action.
Expert3	The menu (start, guide, quit) font size is too small and the location is at the bottom, which decreases the visibility and accessibility. Can enlarge the font size.

The final feedbacks given by the experts are stated clearly in Table 5. For the final feedback, two experts gave the same comments: add the pronunciations to the buttons. For instance, if the user hovers over the button that states ‘bedroom’, the word ‘bedroom’ should be pronounced. This comment was taken into account and the pronunciation feature was added to all the buttons in the Home AR application. This added feature will helpful to the users, especially pre-schoolers who are not proficient in reading skills, and they can use this application efficiently and with ease. Apart from that, the size of

the fonts on the home page was enlarged and the positions of the buttons were also brought upwards; this improvement was carried out based on the feedback of the third expert, after the cognitive walkthrough. System Usability Scale (SUS) test was carried out with 20 parents to gauge their perception towards the Home AR application. Apart from that, there is a specific method which can be employed to calculate the SUS form. For instance, for each odd-number question, the score is reduced by 1, and for each even-number question, 5 is subtracted from the score. Then these new scores are added and multiplied by 2.5. The raw scores and the final scores of the SUS test are presented in Table 6.

Table 6. Results of the SUS Test

Sample	Raw Score	Final Score	Sample	Raw Score	Final Score
1	36	90	11	36	90
2	34	85	12	31	77.5
3	36	90	13	36	90
4	32	80	14	32	80
5	37	92.5	15	37	92.5
6	37	92.5	16	39	97.5
7	31	77.5	17	36	90
8	35	87.5	18	33	82.5
9	35	87.5	19	34	85
10	35	87.5	20	35	87.5

An interview was conducted with 3 preschool teachers to find out their perception towards using the augmented reality as a learning media: how useful it is in improving vocabulary learning among pre-schoolers? The interview contains 5 questions, and the perceptions of the teachers are discussed in this section.

The interview started off with the first question which focuses on the teachers' prior knowledge about augmented reality. For the first question, 2 teachers said that they have not heard about AR; 1 teacher said that she has heard about AR but she is not sure how AR works as she has never used an AR application. This shows that all the interviewees have no prior knowledge about augmented reality and how it functions.

The second question is about the comparison of emotional engagement and the level of enjoyment when the pre-schoolers are using AR application. All the teachers gave similar answers to this question. The first respondent said that the children were definitely more emotionally engaged while using the AR learning technique. She felt that the AR application is a 21st century learning technique that can make children's learning more fun and interesting. Moreover, the second respondent gave this observation: there are many differences in the children's emotional engagement as well as different levels of enjoyment when using the AR application. The current generation of kids is more adapted to technology and using a new form of technology such as AR in learning improves the engagement of children; they are excited about the new educational device and enjoy the learning. The third respondent said that the children were happy and excited about using AR application while learning. Children nowadays are bored with the traditional learning methods, which use the normal flashcards. Hence, using AR as a learning media is something refreshing, and definitely makes a difference in the emotional engagement of the children.

The third question is about the advantages and the disadvantages of using Home AR application to learn vocabulary among pre-schoolers. The feedback from all the teachers for this question is quite similar. Here are some advantages cited by the teachers: the Home AR application is capable of grabbing the attention of the children and keep them focused while learning as it is a new and interesting learning method; the application enables the teachers to teach vocabulary to the children easily; it is helpful for the parents to teach the children at home. Moreover, the teachers believed that the children

can learn more than one language from the application, and they can relate the knowledge gained to their real life. Using the Home AR application can also improve young children's creativity and thinking skills in addition to vocabulary acquisition. On the other hand, according to the preschool teachers, there are some disadvantages of using Home AR application in learning. For instance, operating this application for learning on the mobile phone is excellent, but the children might be tempted to open other applications in the mobile device such as games, and at the same time exposed to other unhealthy information. There will be a burdensome task for the teachers or parents to monitor the activity of the children when they are using the mobile phone. To avoid this problem, one of the teachers suggested installing this application on a tablet or an iPad that is dedicated for learning purposes only. Apart from that, using this application for learning will increase the children's screen time, which might eventually affect the children's eyesight. Some software issues may crop up when installing the Home AR application on mobile phones; for instance, the application might not be supported by all the mobile phones such as iPhones, as the application is not programmed for IOS devices. Lastly, the application cannot function continually for a very long period of time-- the device battery may run out.

The fourth question of this interview focuses on the app's practical usage: would the teachers use the Home AR application to teach vocabulary to the students in the classroom? All the teachers interviewed gave an affirmative answer: yes, they would definitely use this application to teach vocabulary to the children in the classroom as it has many benefits and advantages – helpful, useful, easy to use, fun, and exciting. With the implementation of AR in the classroom, teachers can easily capture the attention of the students, and deliver the intended knowledge to the students efficiently and effectively.

The last question of the interview is about the overall perception of the Home AR application and the teachers' views for further improvement to the app. On the whole, the teachers opined that the concept of the Home AR application is excellent, as it is a very suitable and enjoyable tool for the pre-schoolers to learn vocabulary; the slow-paced pronunciation of the words are very clear, and easily understood by the children. Consequently, when the children listen to the clear pronunciation of the words, they can catch it and pronounce the words correctly. One of the teachers has this positive comment about this application: this is a good platform for the teachers to impart knowledge, as they cannot solely depend on books to educate the children. For further improvement to the application, the teachers recommended animation to be added to the 3D objects; it will be an interesting feature that can whet the children's appetite for learning. Here are few other suggestions for improving the app: display the names of objects in 3D once the 3D image is triggered; add colourful pictures that focus more on the cartoon elements in the application.

Based on the answers of the interviewees, it can be concluded that the teachers are fairly confident and optimistic that augmented reality learning tools are practical and workable for improving the vocabulary learning among the pre-schoolers; both students as well as teachers will benefit greatly from the various features of the app.

4 Conclusion

The main goal of this article is to explore the potential of augmented reality as a learning media. Even though there are several other education-related AR applications in the market, it is necessary to continue the innovation and contribute to this relatively new field. Many possibilities in this field are waiting to be discovered, and it is believed that with increasing investigative works being done in AR that show promising results, the research in this field will gain traction and attract more interest from other developers. The successful completion of the application named Home AR has shown that is viable to develop an AR application that serves as a learning media for young children, in the present case, to learn vocabulary. The comments and feedback given by the pre-schoolers, teachers and parents have been very positive and encouraging. This shows that the potential for creating more sophisticated

AR learning tools is tremendous, and the children today can look forward to learning in a fun and engaging way. For instance, the results of this study demonstrate that an augmented reality application is a highly effective instrument for pre-schoolers to learn vocabulary. This statement has been affirmed by the preschool teachers and pre-schoolers' parents. The content and presentation of the AR learning method easily draw the attention of the pre-schoolers, as the 3D images are striking and interesting to them. It improves the pre-schoolers' participation and keeps them engrossed in learning. While listening to the clearly pronounced words from the AR app, the children can grasp the phonetics of the words, and pronounce them easily and correctly. As a conclusion, this study has been conducted successfully and the developed application does fulfil the objectives of this research. Hardware and software constraints are the main limitations of this research. First, the Home AR app is not designed to work on IOS devices; therefore, it can only work on Android phones and tablets. The Home AR application's scope is fairly limited because it only concentrates on 10 items from each room of the house. This is due to software capacity constraint. The children will only learn a small number of words. It will be a step forward if future researchers or developers can expand the project scope of the Home AR application: include more objects like animals, automobiles, fruits, and veggies. Kids using the application will be able to learn a larger number of words. Additionally, this application may be configured to "speak" a variety of languages, including Iban, Bidayuh, Telegu, Malayalam, and many others. That will be fascinating and kids would love it!

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