

Interactive Spelling Application for Preschoolers: A Journey Towards Playful Language Exploration

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Abstract— This research is to create an augmented reality (AR) spelling application for use in early childhood education. It can be difficult for parents and teachers to teach kids spelling skills because the conventional approaches frequently do not capture their interest. This article provides AR technology as a method to create an interactive and immersive experience that can increase children's recognition and recall of individual letters within words. The main objectives of this research are to identify obstacles to language learning in early childhood education, develop a mobile application using augmented reality technology to improve spelling skills and compare the efficiency of this application and traditional teaching methods in improving children's spelling. The study uses both qualitative and quantitative data and explores the application of a mixed-methods methodology. Parents and preschool teachers from Sri Lanka who take part in surveys and interviews make up the research population. According to the findings of the requirement analysis, youngsters are not sufficiently engaged by traditional teaching methods, and new and inventive methods are required. The study also describes the hardware and software prerequisites for creating AR applications, including ARCore, the Sceneform SDK, the Android SDK, and physically based rendering (PBR). In the suggested solution architecture, virtual 3D objects and the 3D letters of the provided word are displayed using augmented reality (AR) technology. Convolutional Neural Network (CNN) has been used to recognize the 3D letters presented in an AR environment. A trained recurrent neural network (RNN) model has been used to forecast the pronunciation of a letter in the context of the job of tapping on 3D letters. Ultimately, this study highlights how augmented reality technology has the potential to increase educational chances for children by offering a practical remedy for improving language and spelling learning.

Keywords— Augmented Reality, Childhood Education, Mobile Application

I. INTRODUCTION

The development of technology has significantly altered the way we learn, live, and work. Education is one of the fields where technology has had a significant impact. Recently, there has been a rise in interest in using technology to improve education, especially in the early years. While teaching spellings to words using traditional methods, teachers and parents encounter several issues and difficulties. This can lead to a lack of interest in learning and can make it difficult for children to retain the information. Teachers and parents may have limited time to devote to teaching spelling skills. Children may find it challenging to remember the facts as a result, which may result in a lack of enthusiasm for learning. Parents and teachers may be limited in time when it comes to spelling instruction. Kids may also have various learning styles and varied speeds of learning. There is an issue that traditional teaching strategies don't meet every child's needs specifically. And also teaching kids how to pronounce words correctly can be difficult, especially if the parent or instructor is not a native speaker of the language.

So, the main research problem is the lack of interactivity in current methods for teaching letter pronunciation and memorization of word letters in preschool kids.

This innovative solution will address the problem by giving an effective solution for enhancing spelling skills and language learning in young children. One of the newest technologies augmented reality (AR), has the potential to significantly improve educational opportunities for kids. AR is a technology that creates an interactive and immersive experience by superimposing digital content onto the actual world. Applications for augmented reality have been created for a variety of academic subjects, including physics, math, and spelling. This research study focuses on the development of an AR-based spelling application for 3-5-year-old children. The application's potential to improve kids' ability in recognition and memorization of particular letters inside words is specifically explored. Additionally, aim to investigate how the application can improve children's language learning and pronunciation skills.

The main objective of the research is to determine any difficulties or restrictions associated with language learning in early childhood education. Then develop a mobile application using Augmented Reality technology to enhance spelling skills for early childhood education. Finally aims to compare the effectiveness of this application and conventional teaching techniques in terms of increasing children's spelling skills.

II. LITERATURE REVIEW

A comprehensive review of the relevant literature on early childhood education, spelling skills development, and mobile learning technology will be conducted. This will inform the development of this application and the research questions for the study.

Related Researches

Preschool children aged 3 to 5 develop their learning abilities by engaging with their environment. As observe in (T. Yasir, 2018) adults utilizing computers, they naturally desire to do so as well. However, at this tender age, they may not possess the necessary motor and cognitive skills to effectively operate computer systems.

In recent years reliance on computer systems has increased in the fields of entertainment and e-learning. This revolution has made many schools take advantage of computers in early year's education programs. (T. Yasir, 2018) There are many current kids' language learning applications available in the market. Each of these systems has its pros and cons, making it difficult to determine which one is the best option. This review discussed some of the most popular language-learning applications for preschoolers, including their strengths and weaknesses. Some of these systems may use innovative

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technology such as augmented reality, gamification, and voice recognition to make language learning more interactive and engaging. However, these systems may also have limitations in terms of their accuracy, cost, and user experience. Ultimately, the choice of a language learning application will depend on the individual needs and preferences of each child and their parents.

The usefulness of games in enhancing children's learning has long been a subject of interest for researchers in this field. One study proposed the creation of an online multiplayer game as a means of delivering educational content to children. This research (S. Y. Cheung and K. Y. Ng, 2021) postulated that the feedback, challenge, and enjoyable experience provided by the game would improve the cognitive and learning capabilities of children. The study further suggested that these games rely on recall and recognition principles and increase motivation for learning, cooperation, and adaptation. The integration of mobile technology into language education is happening at an exponential pace, providing students with the flexibility to utilize mobile-assisted language learning (MALL) without limitations of time or location. Devices such as cell phones, iPods, tablets, laptops, and iPads are utilized in mobile learning to support language acquisition. There are numerous applications specifically designed for individuals learning English as a second language. (R. Gangaiamaran and M. Pasupathi, 2017) As these applications aim to improve the language proficiency of learners, a major focus should be placed on developing their listening, speaking, reading, and writing skills through the use of mobile technology. (R. Gangaiamaran and M. Pasupathi, 2017)

The research on "EasyMath" application development aims to investigate the cognitive and motor development aspects of preschool children to design an edutainment system that is not only simple and engaging but will also provide them with useful learning content. "EasyMath" application, includes simple interfaces, includes only essential materials, and the ability to give appropriate feedback. Moreover, from this application kids can take little problem-solving experience, handle pointing devices, and use graphical icons. (T. Yasir, 2018).

This study (S. Harous et al, 2017), focuses on the development of an app aimed at teaching the basics of English, Spanish, and German to Arabic-speaking children. The app provides instruction on the alphabet, basic words, and phrases, and uses voice and image recognition to create an engaging and productive learning experience. The application also includes a simple quiz to assess the children's understanding of the material they have learned. The app may only focus on a limited number of words or phrases, leading to limited exposure to the target language. In line with this study (A. Quinn, B. Bederson, E. Bonsignore, and A. Druin, 2023), the "StoryKit" app is a highly effective mobile application designed for children between the ages of 4 and 8. It provides students with a platform to create and share multi-modal stories. The app combines text, illustrations, photographs, and sound effects to make storytelling an interactive and engaging experience. According to the source cited (A. Quinn, B. Bederson, E. Bonsignore, and A. Druin, 2023), "StoryKit" is highly rated among users, making it a popular choice for students looking to bring their stories to life. But the limitations were not improved kids' pronunciation skills and interactive content.

In accordance with this study, the "iWrite Words" app (H. Alkhamis, 2020) is a great app for writing which allows students to practice drawing and writing words by using their fingers. Students can write letters, numbers, and sentences. But this application focuses on improving kids' pronunciation skills and memorization abilities. In this research's conclusion (R. Gangaiamaran and M. Pasupathi, 2017) development of "Kids Learn to Read" is an android application that is built for android to practice pronunciation skills. But this is built for only android devices. The limitations were no use of memorization techniques and lack of interaction. This research (H. P. Parette and C. Blum, 2014) indicates "Starfall App" and its website offer a variety of activities that aid students in reading for Kindergarten and elementary school. The app and website aim to motivate students to learn the sounds of letters by demonstrating pronunciation and encouraging students to learn through exploration and inquiry. But this application doesn't evaluate the student's progression of language development. Then currently explored the most effective preschool language learning apps available in 2023. Per this study's findings, "Duolingo" (M. Shortt, et al, 2014) is an application that provides game-based lessons in over 35 different languages, aimed at helping students practice speaking, listening, reading, and writing. It goes beyond just teaching vocabulary, by also offering written explanations of important grammatical concepts, helping mature learners gain a comprehensive understanding of the target language. The app features a news feed where adolescent learners can learn about additional ways to support language learning, including through TikToks. Parents will appreciate the daily reminders which encourage consistent language practice. Although Duolingo is marketed for children aged 4 and above, users need to have a solid foundation in reading and writing to maximize the benefits of the lessons. (M. Shortt, 2021)

LingoDeer (Techjury, 2020) is a user-friendly language-learning app that offers a customized experience. It allows learners to select their preferred narrators, script style, and dashboard color. The app features flashcards for memory retention and includes interactive stories to practice listening and speaking skills. However, it has some limitations such as limited language options, repetitive content, and a lack of in-depth courses. It is not available on a desktop and some courses may not have enough material to thoroughly learn a language. Additionally, there is a limited opportunity for speaking practice.

This research indicates "Little Chatterbox for Kids" (E. Ltd, 2020) Children can explore and learn a variety of languages with Little Chatterbox, from Spanish and French to German and Mandarin. Through the use of vibrant, appealing visuals and videos of native speakers pronouncing the words to teach vocabulary to young children. There are nine languages available on the app. It is one of the best language applications for kids to aid with vocabulary acquisition in both native and foreign languages, even though we prefer apps that concentrate on interactive features and activities. But these applications are more expensive and also the interactivity of these applications is less. (E. Ltd, 2020) Moving on to technology usage Augmented reality has been integrated into the development of kids learning apps to provide an immersive and interactive experience for children, enhancing their engagement and motivation in learning.

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A review of Augmented Reality (AR) technology as a teaching aid for foreign language instruction is provided in this work (C. G. Karacan and K. Akoğlu, 2021). The analysis revealed that AR technology has several advantages for language learning, but it is not yet prepared for full incorporation into language programs. The report also offers recommended applications and concrete ideas for AR-enhanced exercises in four language skills. For teachers, teacher educators, researchers, and those who create course materials, this review has a number of consequences. A general study (E. Cieza and D. Lujan, 2018) on augmented reality base language learning apps shows that this study aimed to enhance the educational experience and improve the children's understanding of vowel usage and numbers at "Juana Alarco de Dammert" nursery school in Trujillo, using a mobile app with augmented reality and markers in 2017. The specific goals were to boost the academic performance of vowel usage and numbers through the augmented reality app, assess the impact of the app on academic performance, and determine the average usage time of the augmented reality app based on markers. But the accuracy of those applications is at a low level and kids' interaction and learning progress were low according to the evaluations.

In conclusion, the current preschool language learning applications still have room for improvement in terms of their level of engagement and effectiveness for young learners. The integration of technology such as Augmented Reality could enhance the learning experience by providing interactive and immersive environments for children to practice language skills. Additionally, incorporating virtual objects into the learning process could further promote kids' interaction and engagement in language learning. It is crucial for these applications to continue to evolve in order to meet the needs of young learners and provide them with the best possible learning experiences.

III. METHODOLOGY

This methodology aims to address the problem by designing an interactive and immersive augmented reality (AR) application that enhances letter pronunciation and facilitates the memorization of word letters for young children. This research project employs a mixed-methods methodology and uses both qualitative and quantitative data. Parents and preschool teachers from Sri Lanka will make up the fifty sample population, which will be encouraged to take an active part in surveys and interviews.

Requirement Analysis

Researchers have identified two key areas that need concentrated attention through in-depth interviews and surveys: the present teaching tactics used to assist youngsters to recognize and memorize specific letters within a word, and the child's desire for fun and interesting learning activities. The population's responses offer important information about the efficacy of the current teaching techniques and the need for original perspectives that can better cater to the interests and preferences of the kid.

[1] What strategies have you found helpful when teaching children to recognize and memorize individual letters within a word?

What strategies have you found helpful when teaching children to recognize and memorize individual letters within a word?
52 responses

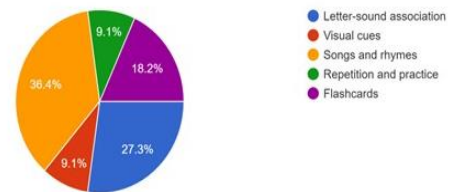


Figure 1. Responses for question 01

The question probably referred to efficient strategies for helping kids identify and memorize the individual letters in a word. Their responses to various teaching methods, such as flashcards, visual cues, songs and rhythms, repetition and practice, and letter-sound association. Considering the results, the response then states that these tactics were applied equally. To ensure that the application is helpful in teaching kids to recognize and remember specific letters within a word, all of these features should be included when developing it.

[2] Do you find that your child is engaged and happy when participating in the activities used to teach letters within a word?

Do you find that your child is engaged and happy when participating in the activities used to teach letters within a word?
11 responses

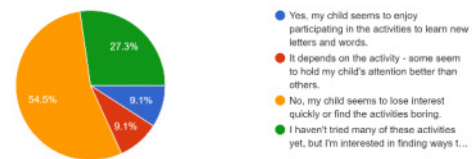


Figure 2. Responses for question 02

According to the responses gathered, it seems that most kids are not engaged in the conventional activities used to teach letters inside a word. Concerns about children quickly losing interest and being bored have been raised by teachers and parents, making it difficult to keep them interested in their lessons. It seems that just a small percentage of kids prefer conventional approaches. In order to engage young minds in the learning process and keep their attention, it is necessary to use a creative and unique approach.

Software and Hardware

Certain hardware and software requirements are necessary for the development of an application. The Android SDK, which comprises SDK build tools, Android emulator and Android device, android platform tools, SDK platform, and Google APIs, is required to create the application. The Sceneform SDK, which enables the development of dynamic AR apps without requiring knowledge of OpenGL, is another essential tool. A physically based renderer, a high-level scene graph API, and an Android Studio plugin make up the Sceneform SDK. The application's scene graph is a data structure that specifies the connections between virtual objects using transformable nodes that anchor the 3D objects into the scene. Physically based rendering (PBR) is a rendering technique that makes sure that all 2D and 3D models in the display have accurate lighting, allowing for realistic representations of various surface types. ARCore,

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which uses object tracking, light estimation, and environmental awareness to project 3D models into the environment, enables Android handsets to access AR features without the need for extra sensors.

System Solution Architecture

The proposed solution application has been designed with a well-defined system architecture, which is depicted in the diagram below. The interrelationship between components and how together function as a group to accomplish their intended functionality is illustrated in the diagram. The procedure of the application was discussed below in detail.

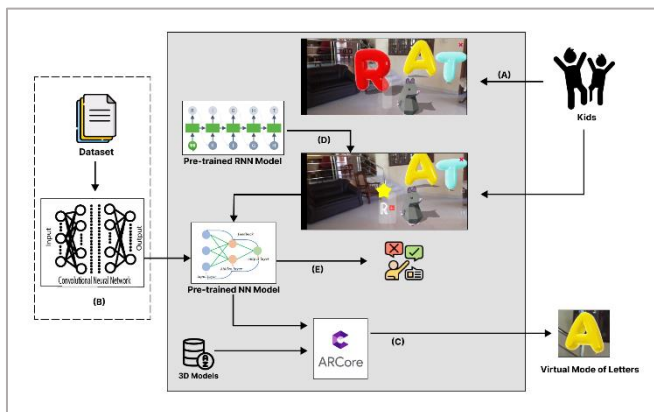


Figure 3. System Solution Architecture

This application displays the virtual 3D item that represents the first letter of a given word along with the 3D letters of the given word using augmented reality (AR) technology. The application utilizes augmented reality (AR) to overlay virtual objects with 3D letters of the supplied word and the 3D virtual item that represents that word on top of the real-world image that was acquired by the camera when the user points their device's camera at a surface.

For example, if the word is "CAT," the application shows "3D virtual CAT" displays on the floor and 3D letters "C" "A" and "T" floating in the air in front of the camera, visible through the device's screen. The child must next learn the proper letter placement for the word "CAT" before clicking on the letters in that order. When a child sees an object associated with a word, it will be easier for them to remember the word's letters. The app will then quickly indicate whether the chosen letters for the phrase are accurate or incorrect. This gives kids a fun and engaging method to participate in the educational process while also assisting them with visualizing the letters in words.

Using Java, ARCore enables developers to create augmented reality applications for Android devices. For a comprehensive AR experience, ARCore tracks the physical environment and precisely positions virtual objects within it using computer vision techniques. For augmented reality apps, developers would create 3D models using Sceneform. They make significant letters and objects using 3D modeling software like Blender to make 3D models of them for this application. Developers used pre-built 3D animal items and alphabetical letters for this project. Once the 3D models have been located, they are exported inside a Sceneform-compatible format, such as glTF or OBJ. After that, the

models are imported into the Sceneform Android Studio plugin, where they can be altered and placed in an augmented reality environment. The procedures to display the AR models through ARCore briefly can be discussed as follows.

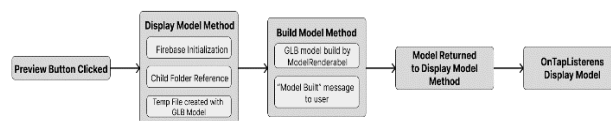


Figure 4. Block diagram to display AR model

When Kids turn on the ARMode button and click on the flashcard surface, users have been directed to the AR fragment page. Next, the display model technique is used, which involves initializing the Firebase database, attaching the 3D model to the scene graph's child node, and creating a temporary file to download the model file. The 3D model is created at runtime using the build model method, provided to the mechanism that displays models and correlated with such a node in the scene graph. When the on-tap listener is enabled, the model is displayed on the tapped node in the AR fragment, and a transformable node is employed to resize and shift the models horizontally over the scene graph.

The process of using CNN to recognize the 3D letters displayed in an augmented reality environment involves several steps. A dataset comprising graphics of individual letters in different lighting and orientations is first gathered and categorized. To increase the generalizability of the model, the images are then preprocessed, which includes scaling, normalization, and data augmentation. The next model is the CNN, which has many layers of dense, pooling, and convolutional layers. The preprocessed image of the 3D letter presented in the augmented reality environment serves as the model's input. The most likely alphabetic letter that the input image represents is produced as an output prediction by the model after it has processed the image as input throughout its layers.

In order to reduce the error between the predicted output and the true label, the trained CNN model is employed, the preprocessed dataset is divided into sets for training and validation, and the trained model uses gradient descent and backpropagation. To make sure the model is not overfitting to the training data, the validation set is used to evaluate the model. The trained CNN model has been used to instantly identify the 3D letters demonstrated in the augmented reality environment after it has been validated. The 3D letter input image is fed into the model, which then predicts the associated letter and displays it in the augmented reality environment for the kid to interact with.

Then the process of tapping on a letter to hear its pronunciation to spell out words should be considered.

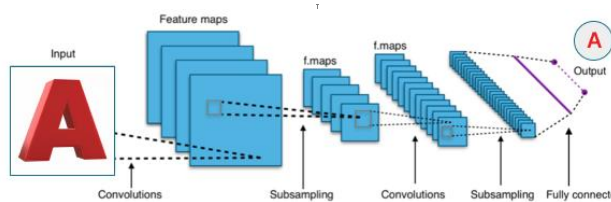


Figure 5. The procedure of the CNN model

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Recurrent Neural Networks (RNNs) have been effectively applied in the task of tapping on 3D letters and pronunciation to model the sequential nature of language and speech. RNNs are a class of neural networks that are designed to operate on sequential data by processing one input at a time and maintaining a "memory" of the previous inputs to inform the processing of subsequent inputs.

A trained RNN model has been utilized to predict the pronouncing of a letter or word given its sequence of taps in the context of the job of tapping on 3D letters and pronunciation. A set of taps that individually match a 3D letter in the augmented reality environment serve as the model's input. Each feature vector in the taps' encoded form indicates a different aspect of the tapped letter, such as its placement, size, and orientation. The trained RNN model processes each feature vector in the input sequence one at a time while changing its internal state. The model then generates an output, which is a forecast of how the tapped letter or word should be pronounced. A softmax layer is used to compute the output, which results in a probability distribution over a number of potential pronunciations. A labeled dataset of taps and their related pronunciations served as the model's training data, and its parameters were adjusted using methods like backpropagation via time. To provide feedback on the accuracy of the letters for a given word, the app likely uses pre-recorded audio to pronounce the word. This feedback can be used to let the user know if they have correctly spelled the word or if there are errors that need to be corrected.

When the app uses pre-recorded audio, it will contain a database of correct pronunciations for each word. When a user taps on the letters to form a word, the app compares the letter order to the word's proper spelling and plays the corresponding voice for the right pronunciation. The app may offer remedial feedback if the user spells the word incorrectly by playing a slow-talking audio clip or by requesting that they try again.

IV. IMPLEMENTATION

- Here it shows the application is deployed in sections as below.

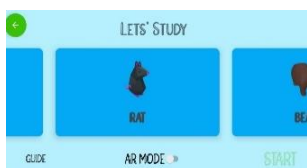


Figure 6. Selection of Animal (RAT)



Figure 7. AR Preview

In Figure 6. It shows the list of animals to be selected for a kid to play the game. When the kid clicks on "RAT" and kid has to move toward to AR Mode of the selected animal. Then Figure 7. Shows the next phase that is archived by the kid. When the selected animal is a RAT, the Word is "RAT," the application shows "3D virtual RAT" displays on the floor and 3D letters "R" "A" and "T" floating in the air in front of the camera, visible through the device's screen.



Figure 8. Click on the letters

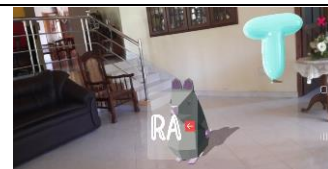


Figure 9. Make letters in order

After displaying all the letters and the object related to the word, here In Figure 8 shows the next phase. Kids have the ability to memorize the order of letters to the word "RAT" and click on the letters in order. When the kid clicks on the letter, the kid could be able to hear the sound of pronouncing the letter loudly. If the letter clicked by the kid is in the correct order it displays in the environment as shown in Figure 3. The application will give a notification if the selected letter is not in the correct order to make the word "RAT". The kid has to continue finding the correct letters for words as shown in Figure 9. When the task is over kids can take feedback on the Letters for whether the word is correct or wrong. figure 10 and figure 11 show the feedback notifications.



Figure 10. Feedback for correction

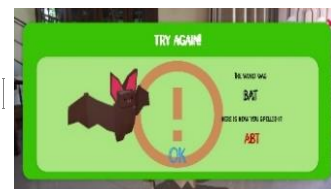


Figure 11. Feedback for wrong

In this application, kids have the ability to make the words without using AR mode also.

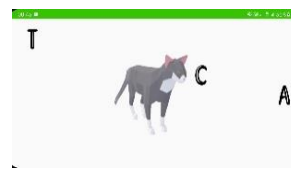


Figure 12. Making the words without using AR mode



Figure 131. Feedback

Here in Figure 12, shows that the kids could see the letters of the word "CAT" and the image of the "CAT". The kid can make the letters in an order to make the correct word. Figure 13 shows that the feedback notifications are generated as the above function.

V. RESULTS AND EVALUATION

In order to study teachers' and parents' cognitive perception and intention to use this application by kids 15 statements on the 7-point Likert scale were listed and utilized for in-depth analysis. The top seven statements are mentioned here. Since "The child is engaged and happy when participating in the activities used to teach letters within a word." was the highest-ranked statement, it was deemed essential to ensure that further elaboration was heard from the teachers and parents.

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• TABLE 1. TEACHERS' AND PARENTS' PERCEPTIONS AND INTENTIONS TO USE THE EDUCATIONAL GAME

Rank Order	Parents' and Teachers' perceptions and intentions to use the educational game for their kids		
	¹ Statement	² Mean (M)	³ D
1	The child is engaged and happy when participating in the activities used to teach letters within a word.	6.02	1.14
2	The use of this app enables the kid to memorize the word related to an object (animal).	5.64	1.54
3	The use of this app enables the kid to memorize the letters within a word.	5.01	1.67
4	The use of this app enables the kid to make the letters in order to make a word.	4.96	1.19
5	The use of this app enables giving feedback to the kid.	4.35	1.68
6	The use of this game makes a real-time interactive environment to make a word.	5.85	1.24
7	This app consists of features that tally with the traditional learning strategies used.	4.98	1.36

The results reveal that the app is useful for teaching and memorization of letters within words as well as the association of words with objects in early childhood. By using the application, which enables them to build words inside a real-time interactive environment and obtain feedback, kids are interested and delighted. The capabilities of the app complement traditional learning methods. The application has the potential to serve as a useful tool for kids who are developing literacy skills overall.

VI. CONCLUSION

In conclusion, the development of an augmented reality learning application provides a unique and interactive way for users to engage with educational content. Users can have interesting and immersive learning experiences thanks to technology like augmented reality, machine learning algorithms, and mobile device capabilities. The application's capacity to offer individualized feedback and advance linguistic abilities can be improved through the use of speech recognition and natural language processing algorithms. Additionally, the application's development process can be streamlined and made more efficient overall by using design patterns and development frameworks. Testing and evaluation are essential to guaranteeing any application's effectiveness and user happiness. To ensure that the application's performance and user experience satisfy the demands and expectations of its users, developers must constantly monitor and update the application. Overall, the development of AR learning applications has the potential to revolutionize the way of approach education and provide new and exciting opportunities for learners of all ages.

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