Educational Application for K-1 Children using Augmented Reality

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Abstract— **Augmented Reality (AR) has changed the style of education, where students control their way of learning and understanding aspects. AR in education has made learning easier and fun. Interactive applications based on AR technology are evolving rapidly. They unite virtual objects into a real environment, which brings a deeper involvement to the users, increasing the interest towards the application. Many people who encounter AR for the first time have an eye-opening experience, but fail to consider classroom applications as important as they are for teaching purpose. The main motive behind developing the application Vision Augmented Reality in Enhanced Education (VisionAREE) is to introduce AR in education for the children of age 4 to 6 years and to enhance their way of learning. This paper provides an overview of AR and the study of the application VisionAREE including its features, design and implementation phases. Survey results are conducted to aid the utilization of AR for children aged 4 to 6 years old.**

Keywords- Augmented Reality; Education; Android Application; K-1 Classroom.

I. INTRODUCTION

AR is the induction of digital content in real world environment. Users discern physical objects enriched with digital content [1]. AR is considered as one of the latest technology that has spread all over the Information Technology (IT) market successfully and is still progressing to achieve more.

AR technology is being rapidly adopted in educational areas. The researchers discussed that technologies are playing an important role in the improvement of learning and teaching criteria in classrooms in the last few years. One of the emerging technologies is AR which is basically the coverage of virtual information on real world environment and is concerned with the objective to enhance and improve the understandability [2]. VisionAREE is an android application that specifically targets children of ages 4 to 6 years. The application aims to reinforce concepts at younger age with educational subjects and fun activities. VisionAREE has a friendly user interface and does not require any technical knowledge. Our motive is to fill the gap between the young generation and technology in educational area.

This paper includes all the features of the application with their brief description. It also includes the methodology used and the people feedbacks as well as the obtained results. Moreover, some future enhancements are suggested for making the application more versatile.

In this study, the implementation of the application and its learning potential is evaluated. The limitations and difficulties of its development and implementation are discussed. Most people are unfamiliar with new trending technology in Pakistan. The first limitation occurred was limited information and help availability. This limitation was overcome through self-study and research. Another limitation was to explain the audience about AR and then inform about the importance of using such tool in education. The rest of this paper is organized as follows. Section II describes the use of AR in education. Section III describes the methodology which is used to evaluate the effects of AR. Section IV describes the experiments and results. Section V, provides future enhancement of the VisionAREE application. The conclusion closes the article.

II. AUGMENTED REALITY IN EDUCATION

AR is a combination of basically two worlds, i.e., Reality and Virtual Reality. AR is not just limited to old books. Through the 20th century, AR became a vast and strained technology. It is extensively used in many contexts such as advertising and IT. Its actual typical use is through AR games that are much obliging for children. The superimposition of illustrations on real world objects is called AR. AR network is simply based on how a person witness digital information on real objects by simply using smart-phone or any other device that can be worn like goggles.

This technology improves experience of viewing the real world and does not make the person feel distant from it [3].

AR is now considered as one of the fastest growing and newest technologies offering new ways of learning in the era in which the technology has changed the view of education. The use of AR into smart phones has been a growing phenomenon because smartphones are gaining so much popularity all over the world [4].

AR technology, having the capabilities of the induction of digital content in real world environment, opens the door for the development of educational fun applications that connect real and conceptual matter [5]. AR has changed the style of education, where students control their way of learning and understanding aspects. More new methods are being sketched and implemented to overcome the gap between the physical and virtual world.

AR provides different advantages in the educational context [2]:
1)   Promoting learning through physical activities.

2) Viewing 3D content from different viewpoints boosts learning.

3) Encouraging students to participate in educational tasks.

4) Yielding information about real world entities concerned with the activities for understanding.

The forms of AR can be described as [6]:
1) Maker based.
2) Object based.
3) Location based.

The devices of AR can be [7]:
1) Mobile devices (smart-phones) enabling to see a 3D model.
2) Personal Computers having a webcam.
3) Glasses and lenses.

There are two main processing architectures in ARS: autonomous and distributed. Autonomous systems carry out all tasks simply in a single device which is generally inexpensive such as mobile phone or computer with webcam. Distributed systems transfer the processing to a server while Mobile AR (MAR) achieved valid significance and acceptance from customers and mobile manufacturing companies [8].

AR has become commonly practical on exclusive smart-phones by 2009. This became possible with the support of advanced features in ubiquitous devices [9]. Figure 1 shows the brands implementing AR and MAR [10]. AR in education can be characterized into 3 main categories of applications, as seen in the article AR in education published in [11].

1) The most deliberated and specialized, best suited for students.

2) Easy and fascinating, created for children to engage them in learning.

3) Best suited for everyone, mainly to improve one's knowledge.

Figure 1. Major Brands Using AR

The article clearly specified that AR in education motivates and engages learners to understand things better and faster. AR helps educators to capture the attention of their students and make them learn in more fascinating way.

The authors of [11] highlighted the main areas where work for pupils has been done. The areas include math, alphabets, animals, insects, fishes, birds and reptiles, life cycle of Monarch butterfly, coloring activities, plants and constructive games. Many educational approaches using AR are better and easier, as the technologies that have made AR possible are stronger than they have been ever before and are sufficiently compactable to deliver AR related experiences to educational places with the help of smart-phones and computers.

By covering the area of school, it was explained how professionals are eager to introduce AR to classroom learning in various subjects and to introduce it into students' guides and augmented books. On the other hand, AR will not be very famous and adopted due to low financial support from the government and less knowledge of AR in educational phase [12].

The researchers explain how feedback can be worthy for teachers as they can provide much insight into children mind. The need for feedback and evaluation sessions with teachers, educational experts and student can pave the way for the development of successful prototypes [5]. The authors of [13] specified that 73% have access to touch-screen devices at their home, whereas in [14] the authors mentioned that 75% of American children under 8 have access to media devices.

A study was done for CPB-PBS in [15] to understand and learn about the AR games. The games are especially being designed for the age group 6-8 years to help them learn in a better way. These games engage children in classroom by providing fascinating activities and developing their interests in technology. Through these activities there is a slight gain in students' enactment. The teachers are also rapidly using these AR games to help students improve their promptness and precision rather than individual teaching tools. The questions to be answered in this context are:

1) Can children learn the targeted math skills in an AR experience?

2) What added value could AR technology bring to class-room settings?

As for results, data was collected by them from the students attending an Out-of-School-Time (OST) program and few of the teachers unaffiliated with the OST program. No remarkable improvement was seen from the result of the students as they faced problems in the usability of AR applications and also the clues were not enough to solve a math problem. Most of the applications lack proper instructions, which might be problematic for children.

According to the results of the above study, WestEd also provided few of the recommendations and conclusions that will surely help in future development of AR technology. Some of the recommendations include that proper hints should be provided according to the given question so that it eases help for children in solving it.

AR games, designed for learning must contain many levels in it and children self-select the level according to their class or age. The game should also include training materials for teachers as well to help them learn. The use of AR must be, in such a manner, gainful over outdated paper-and-pencil or purely computer-based math instruction.

The above study being conducted by WestEd mainly focuses on two of the AR games i.e. Monster Plus developed by Georgia Institute of Technology and Fetch! Lunch Rush developed by CPB-PBS. Both games run on Apple devices and are marker based.

An entire report in the book [16] I am a little monster, Kingston University has been written on the research of how AR books can become fascinating for children. Parents no longer need videos and games to entertain their children. The entire team for a research trip visited Waterstones (leading book retailer in UK). The purpose was to find out what elements engage children fun reading.

Younger children = touch-feel and audio. Older children = audio, video, pop-ups and games

Parents sometimes find it difficult to create imaginative stories in order to make the book more interesting for children. More than 90% of parents have allowed their kids to play with online games and use educational applications. This means that there would be low barrier while trying AR books. AR books are considered as standalone form of entertainment.

The target audience was children of 2 to 5 years as there is less mental pressure on them.

The top educational applications of AR listed through study and research are:
- One of the most popular applications is FETCH! Lunch Rush, which lets the students learn addition and subtraction in an interesting way [17].
- Quiver, a 3D color AR application which allow students to color and play. They also provide educational discounts to schools [17].
- Matching Objects and words (MOW), words from different languages are taught through this application [18].
- Zoo Burst, an AR application which changed a simple story telling to a different world of 3D characters [19].
- Elements4D, an AR application which changed a simple subject chemistry into an interesting world of animation [19].

In order to engage in more cognitive operations, children should operate and read by themselves rather than have their parents do it for them as it may not be constructive. Parents should refrain from controlling and narrating to their children so that their children can gain higher level of understanding and perception during the process [20].

A. Features of VisionAREE

VisionAREE distinct feature from existing educational AR applications is that it just not only includes exercises but it also provides entertainment in the form of coloring book and 3D animations. It brings objects to life and aims to grasp children attention. The features include:

- Mathematics, which includes addition, subtraction, multiplication, even and odd numbers.
- English, which includes grammar (vowels, nouns, verbs), easy sentences completion, poems with 3D animation.
- General Knowledge (Info Bee), which includes infor- mative 3D animation that will help them learn about seasons, flags, plants.
- Coloring Book Activity (Color Me), which includes coloring on paper that will make the 3D animated character being colored the same, comparison with original picture.
- Know Me: Real World environment object recognition, specifically the class room objects.
- Text-to-Speech, playback audio and Demo.
- Evaluation Quiz and Progress Report generation.

III. METHODOLOGY

The whole research has been done by conducting surveys, analyzing the results and reading research papers. During the development process, all four group members of the project tested the application. Around 40 users used and evaluated the final results of the application and tested it in all respects. Evaluation on the basis of comparison with other traditional methods was also performed which resulted in the favor of usage of AR application. By using survey forms, we tried to observe how parents think about the usage of smartphones for their children and whether they are aware of AR technology. We assured to cover and include all those types of questions that can conclude the views and aspects of people for the project. Throughout the development of the project VisionAREE, feedbacks were taken from various people we came across at home, institutes, workplace, exhibitions and competitions. This led to the successful designing and development. Reviews from users were taken under consideration and the application was reshaped each and every time for better UX/UI, so that the main purpose of the application is met. The idea was supported and appreciated. The project VisionAREE was also demonstrated in Montessori Complex High School, Karachi where a class of 40 first grade students was present. The application was not included in a specific course environment. Moreover, it was also presented in exhibitions and competitions several times where it earned top positions.

A. Implementation Phase

VisionAREE is using Vuforia SDK for AR functionality and the marker based approach. The markers are referred to as the image-targets. The user has nothing to do with the knowledge of the image-target but with the cards, pictures and stickers that has the answers understandable by them. The user hovers the phone on cards, pictures or stickers and sees 3D content augmented on them. The 3D content provides more information and insight. The user taps on the 3D model to answer. Figure 2 shows the Winter Card and Figure 3 shows its

corresponding AR model for the visualization of Winter Season. Similarly, Figures 4 to Figure 7 show other implemented 3D models.

Figure 2. Winter Card   Figure 3. Animated 3D model

The user is provided with demo videos, definitions and hints to learn more. VisionAREE also has the text-to-speech feature that opens the door for children to understand more and answer efficiently. The application has two modes to select between, quiz mode and demo mode. Demo mode beings very friendly and helpful with demo videos and other help available while quiz mode has more test-like interface where there is timer and scores are calculated and stored. The modes provide the child with the flexibility to learn and to test. The content of the application is unchangeable, so it is not possible for teachers or anyone to add or update content.

B. Testing Phase

The implementation was tested at each and every stage of the module both during the development and then on the android phone by building and testing. Another important thing taken into consideration is that the 3D model is stable enough on the image-target. This thing is achieved by testing and editing the images and checking their ratings.
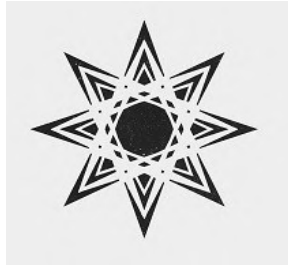

Figure 4. Unstable   Figure 5. Stable

The image-targets are then placed on the cards that are designed and are easily understandable by the users.

Figure 6. Math Card   Figure 7. 3D models on card

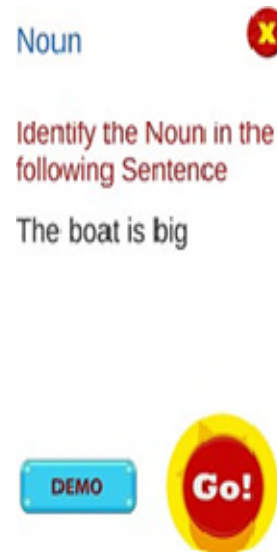Questions should be appearing according to their category.

Figure 8. Question for Noun

Testing has been done for the availability of demo in Demo mode. Figure 8 to Figure 10 show the demo version of the application, 3D models and animations on their respective image-targets in proper size, color being mirrored at run-time on the model in Color Me module.

Figure 9. Demo Video in Math   Figure 10. Demo in English

Figure 11 shows the colored model.

Figure 11. Colored Model

Text-To-Speech activation for better understandability. Scores being properly calculated and stored in memory. The same has been shown in Figure 12.
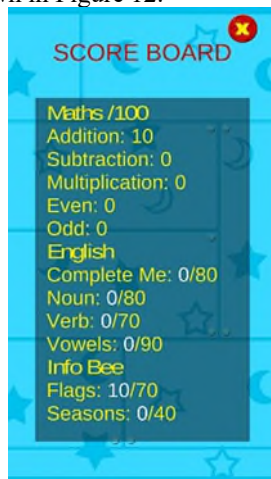

Figure 12. Scores

The other thing taken under consideration is the efficiency and the response time of the application. In interface is designed in accordance with the age level.

C. Evaluation Phase

The evaluation of the project is determined by the completion of each of the sub module specified. Each sub module for example in math, a logical question generation followed by user input and performing system calculations and verifying the answer and also keeping track on the user progress should all work properly. Figure 13 shows the evaluation of the application.

Figure 13. Evaluation

IV. EXPERIMENTS AND RESULTS

According to the survey conducted, 46.2% of the parents in Pakistan do not support the idea that children should use smartphones. 64% of children do not have their own smartphone but 77% of parents do allow them to play with it. The thing which is worth noting is that the same percentage of parents that is 77% said that they have installed educational applications for their children and 74.4% let their children use a smartphone for 1-2hr per day while 20.5% reported 3-4hr and the rest, 5-6hr. Upon asking if the parents have prior knowledge about AR the result was slightly more in favor with the percentage of only 51.3%, but when asked if they have ever used the famous AR applications by name, particularly Snapchat and Pokemon GO, 64% responded saying yes. This shows that many parents are using AR applications but are not familiar with the term. 61.5% parents rejected the view that smart-phones are a waste of time. There was not a single negative response to the question, Do you think smart-phones can be used for educational purpose, with 87.2% saying yes and 12.8% saying maybe. 82.1% that is a significant majority supported the idea that educational application should be implemented in schools and the same percentage of parents that is 82.1% responded that it will not be hard for them to teach their children through smartphones.

77% of the parents reported that educational applications will develop interest in children. On visiting Montessori Complex High school, Karachi we demonstrated VisionAREE to first grade students. Prior to that, we had talked to the school representative who had concerns about the usage of smartphones by children. On demonstrating and explaining the project and idea to the representative we were able to change his thoughts and were appreciated. The project was loved by the children and tremendous amount of interest was shown by them. Every child eagerly and excitedly participated in the activity. However, we noticed a traditional learning way of students where it was hard for them to understand the question in a way other than they are familiar with. Reading out the question as 4 multiply by 4 they were getting confused but after saying "4 4 za" they answered promptly. In a class of 40 first grade students, approximately 80% said that they use smartphones and tablets at home. 62% said that they use educational applications.

Some significant feedbacks that are implemented and must be highlighted are:
•   Adding the feature Know Me so that the children can learn about classroom objects.
•   Adding a demo picture in Color Me so that the child can compare the colored picture with it.
•   Adding timer in quiz mode.
•   Not to let the question change unless it is answered correctly in demo mode.
•   Other correction related to UX and UI for better accessibility.
•   Adding text to speech feature for better understandability.
•   Resetting the scores in scoreboard if another user wants to play on the same device.
•   Demonstration videos and manual are made easily available.

V.   FUTURE ENHANCEMENT

VisionAREE's specialty is that it has flexibility with respect to enhancements. It provides enough space in which it can   be easily enhanced in future.

Extending age limit
Enhancements can be done by upgrading the age group and subjects. As the application is designed according to the level of 4 to 6 years, it can be made for higher grade students.

As a desktop application
The application although uses smart-phones but can be deployed on computers and can be used as a desktop application. Therefore, the students will be able to use this application according to their choice and feasibility. As many parents do not have smart-phones but have computers in their house, so in this way it will be helpful for them.

Modification by adding more subjects
The application targets the pre-primary level of education. Modification can be done for almost any subject so that, students can gain more interactivity with this application.

Building for IOS
The application is currently developed for android devices and can be developed for IOS as a future enhancement so   that the non-android users can also use the application.

VI. CONCLUSION

Technology is endlessly evolving, and the development of new applications sometimes acts as a touchstone to the arrival of a completely new technological paradigm. It is to conclude that our application VisionAREE is mainly designed for the purpose of education using the AR technology. It aims to help students in ways that can strengthen their concepts and boost their skills, making complex information easier to understand and fun. Breaking the barriers of traditional learning is one of the main focus of the application. The apparition behind VisionAREE is of great significance for the betterment of education sector in Pakistan.

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