Guiding Principles for Designing and Content Creation of AR Apps for Primary Children

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Abstract

The research on augmented reality applications in education is still in an early stage, and there is a lack of research on the guiding principles for designing and creating content for augmented reality applications for Primary School Children Education. The purpose of this research is to identify the designing and content creation principles before developing any mobile application. Overlaying virtual content into the real world makes learning methods more interactive and immersive for students while learning any concepts using this technology. AR techniques make the learning process easy and interesting as compared to traditional methods. These methods lack focused learning and interactivity between the educational content. Primary school level for learning purposes of English grammar, numbers, science, geography, and AR Globe for knowing about different countries around the world. These applications can be played wherever and whenever a user wants without Internet connectivity, subject to the availability of a tablet or mobile device and the required target images. Our study investigates the appropriate designing and content principles before developing AR application. In existing literature, there are many designing principles like simplicity, ease of understanding, interactive design etc. are shown but there are no guidelines given which can be followed before designing and developing the content for AR applications.

Keywords—Design, development, AR, education, primary, children, guidelines, principles, pedagogy, design, content.

1. Introduction

Overlaying virtual objects on physical objects for a better experience of reality is called augmented reality (AR) [1]. This technology is based on triggering which can be marker-based, marker less, and position-based AR. Our study is on marker- based technology for primary children. Still many institutions follow the old or ineffective method of teaching which reduces the subject interest amongst students [2]. Teaching concepts to students using game-based environment will enhance the interest and understanding in the subject [2]. AR has big potential in education sector, but proper guidelines and instructions are not specified anywhere on the content and design part for mobile AR. Existing applications have focused

either on designing or basic subject concepts. Missing of proper content leads to improper understanding of the subject and children get confined to app and its features rather than subject knowledge. Therefore, proper integration of both is required to give maximum benefits and effective learning experiences to the students.

2. The Objectives of this paper

- To identify the existing challenges faced by users while learning/teaching through AR
- To develop the content-based principles for mobile based AR application for primary children
- To develop the designing principles for mobile based AR application for primary children

3. Literature Review

Augmented reality is the blending technology that blends virtual and real world on a single platform through various connected technologies like mobile devices, wearable devices, and other immersion technologies. Augmented reality uses triggering to superimpose any 3D material on communication devices. In recent years, augmented reality has shown tremendous interest amongst learners in different age groups. Many researchers have also concluded that very shallow research has been done in AR at an early stage of education [3]. Through our research, we came to know that no proper standards have been used or references have been taken into consideration while adding content and designing AR apps for primary kids. There was a big void and discrepancy that has been found while designing the application. The objective of this paper is to create standard principles in terms of content and design for primary kids in AR apps which will later result in better understanding of subject knowledge.

A. Existing challenges faced by teachers to teach students:

Teachers are not able to create an environment which makes them feel comfortable and creates flexibility in class in the subjects like mathematics [4]. There is a need of proper evaluation techniques for evaluating the children because still more weightage is given for memorizing skills of a student rather than interpretation to the knowledge taught [5]. Researcher[6] has shown the concern in his research that how in subjects at a higher level such as science, technology, engineering, mathematics students face major issues as during their primary teaching they face visualisation challenges and were not able to interpret the concepts they are being taught. So, teaching students with AR at primary level should be focused by teachers. Fig 1.1 showing few of major existing challenges faced by the teachers while teaching through mobile app/digital devices/AR apps: -

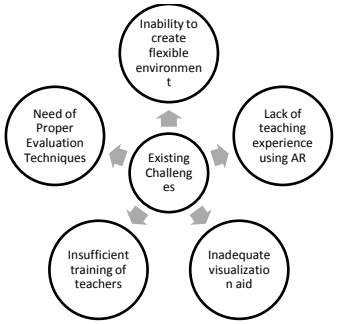

Fig 1.1: Example of a figure caption

B. Existing content principles for designing AR apps:

Content needs to be well driven and well placed to get the crux [7]in subjects such as mathematics and science. Students always have a pessimistic mindset that programming skills are difficult to teach, and with such a mindset, students have a narrow opinion and low feelings towards such learning. So, learning through AR provide ideas for boosting children confidence, morale and visualization. Hakim [8] sheds light on issues such as the lack of scaffold design in children. Thus, he came up with the idea of AR-innovated image communication. So, images in AR apps helped children with autism learn and remember faster. Hamzah [9] concluded that there is a computer knowledge gap amongst children and that they do not have basic computer knowledge. Therefore, AR devices should use tagging systems to aid learning. Fan [10] stated that identifying letters in an app is a very difficult task for young children who do not know much about language at this level. Therefore, he recommended higher AR support in the app. Teachers and parents face lots of challenges while teaching primary children so they recommended teaching students using reward based learning[5],visualization techniques [7], digital literacy at early age[9],performance measurement using activities[11],teaching through design-story based immersion[12] and teacher assistance with AR apps [12] will be valuable if started at early age of child.

C. Existing design principles for designing AR apps

Good design also plays vital role in mobile apps for generating student's interest in the subject. It has been found in the literature that there are no specific guidelines given by any researcher for AR apps. Swan et al. [11] gives exploration of usability principles of AR. They set up only 14.3 of studies on user-centric design under the light of human-computer interaction (HCI) and only 7.9 for general use. Barari[13] had come up with the problems that no such methodology is being used for designing so he came up with the findings that more animations and more visualization tools must be used. Existing mobile apps for teaching students (primary/senior)

There are many applications in the market for teaching students. Following figure 1.2 shows few of the existing apps with some of the identified problems: -

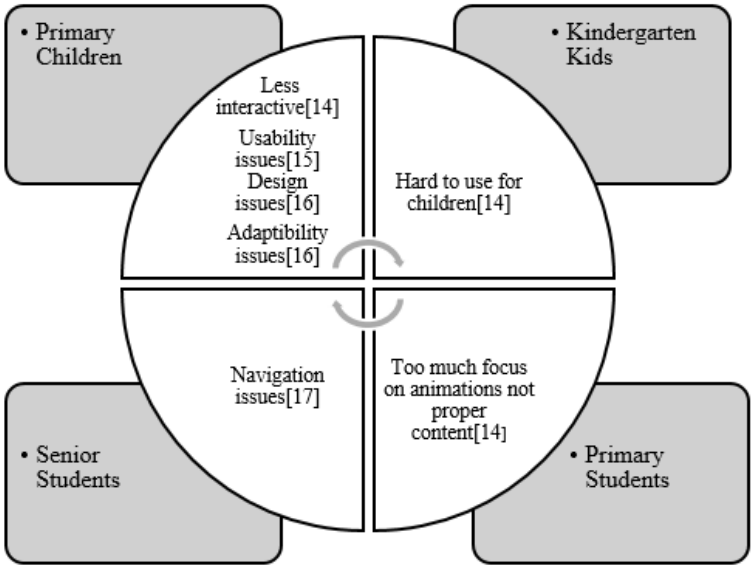

Fig 1.2 Existing mobile apps with some identified challenges

D. Existing problems faced by primary children in learning their subjects:

Primary children face lots of difficulties while learning different subjects from their teachers. Subjects like mathematics, when teacher teaches in traditional method and student with low cognitive skills are not able to visualize and hence, they lose interest and get fear in the subject [3] and in science, they require interactive ways of teaching to generate understanding and interest amongst students [5].There are also language interpretation issues faced by primary kids as they are not able to read, understand or speak properly[18] while study. In our research we aimed to design the guidelines before developing AR apps for primary students. In our research we found that there is a gap in the literature review related to proper guidelines for mobile based AR applications for primary children. Few researchers talk about the look and feel of the application and others about importance of mobile AR applications in various subjects in different age groups. There is no existing mobile application which will entirely satisfy the user (teachers/parents and kids) in terms of design and content for referring in their studies. Therefore, there is a need to do research to find and develop the designing and content principles for building mobile based AR application for primary children. In the first step, literature review was reviewed to find the existing features and problems faced by primary children while learning through mobile and AR applications. In the second step, expert meeting, interviews, and surveys were prepared to identify the needs and challenges required/faced by the school teachers , parents and mobile app developers. In the next step we have categorized the screened features and factors based on factor analysis to identify the final guidelines before developing the mobile application for primary children.

E. Collection from literature review

First step was to identify the existing principles from literature review given for primary children. Principles defined for senior students were excluded in the literature. Few of the principles defined in the existing literature are given as object recognition with pictures, awards should be provided after session, digital literacy, empirical measurement of performance, design-story based immersion.

F. Gathering content and design principles through Expert meeting and questionnaire

Second step was to conduct the survey and expert meetings to find the challenged faced by them and to find the content and designing principles required for teaching/learning and devloping using AR app. Important features provided by them are 3D display, affordable, security, an immersive experience with simple to work with setup is required to get both students and instructors onboard for such apps, AR apps must be from the point of view of users, clarity in content, consumer satisfaction, design, digital, upgraded, mobile, design & content both add values to the applications, make sure that designs and content goes in a balance, design & content should work together and not parallel, easy controls, error handling, fast error correction, flexible, future variables must be considered, futuristic approach, GPS support, image recognition, 3D recognition and tracking, interactive and easy to understand content should be there, interactive and informational, interactive experience, virtual object, interactive learning, easy access for the beginners, less latency rate, make learning fun, more attractive, must be in reality as we think in our dreams, new way, next generation tech, privacy must be given priority, qwerty, recognition, consistency,

predictability, scope in AR, augment, should be storyline based and game based learning to keep students attention while learning, Superficial Design, UI/UX designer, using animations, user friendly, visual representation, well organized.

i. From the survey we interpreted that "AR-projection in classes with projector" is the best device for teaching students through AR. Fig 1.3 shows the comparison of compatibility of different devices.

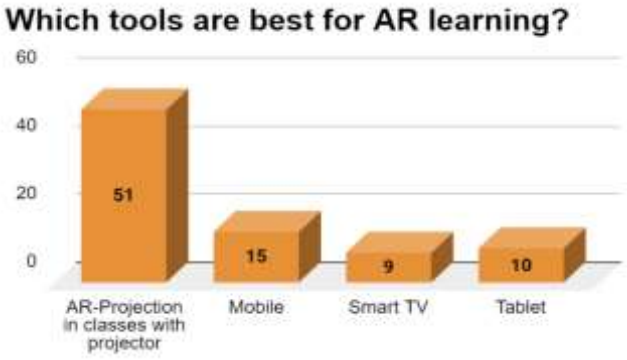

Fig 1.3 Comparison of compatibility of different devices

ii. Then, performance measurement in AR educational app was found through survey. As shown in the below figure 1.4, From the insights we got that "Activity based on concepts" (68.2%) is the most used method to measure the performance through an app. This will help in increasing the adaptability, applicability of students. This was followed by virtual Q&A (20%) and the last option of having both (11.8%)

Fig 1.4 Performance measurement in app

iii. After interviewing 10 experts and having a survey of around 50 developers. As depicted in figure 1.5, we got a result in which content (30) was given more importance over design (20). So, we can say content needs to be a centric force while creating an AR app for children.

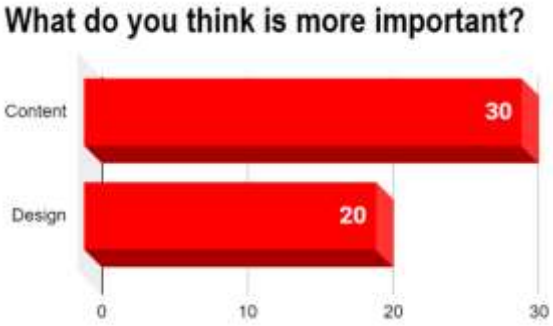

Fig: 1.5 Importance of content over design

iv. With the help of our survey, in fig 1.6 below we also came to know that "self-independent" (78%) has been given a more weightage as compared to "parenting required" (22%). This depicts that the app needs to be highly user friendly, easy to use and have self-reliant features.

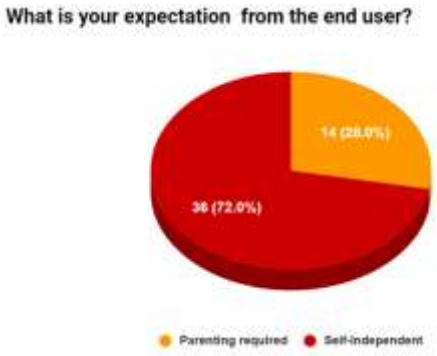

Fig 1.6 Expectation of end user form app

G. Factor analysis (Classifying the final factors in terms of desgining and content)

The obtained principles from literature and survey were put into a classification system. We had surveyed around 80 focus group of primary school teachers/parents and 40 professionals. Using an interconnection matrix, we were able to pinpoint the connections between each principle. The results of the exploratory factor analysis test gave 12 principles that includes precision, efficiency, performance, understandability, satisfaction, reliability, enjoyment, attention grabbing, future variables, artistic design, function ability and budget friendly. Each of the selected factors in our paper had a factor loading of at least 0.50 and rejected with factor loading less than 0.50. The principles were divided into four distinctive categories by principal component analysis comprising cognition, orientation, design, and support. The factors loading values are shown in Table 1.

Table 1. Factors Loading Value

Precision	0.823
Efficiency	0.756
Performance	0.691
Understandability	0.705
Satisfaction	0.557
Reliability	0.695
Enjoyment	0.851
Attention grabbing	0.794
Future Variables	0.541
Artistic design	0.835
Function ability	0.654
Budget friendly	0.556

Further using the factor analysis, we were able to club them into 3 categories:

- Layout creation - Artistic design, Attention grabbing, Function ability, Understandability
- Competency(content) - Precision, Efficiency, Performance, Reliability, rewards
- Catalyst - Enjoyment, Budget friendly, Future variables, Satisfaction

Fig 1.7 Derived Principles

Here we have finally originated the factors which are required to design effective and efficient AR based mobile application for primary children .Principle like layout creation will be focused more on design part as per the user understanding while keeping his/her age into consideration. Factor like competency will be used to provide better content in the application so that this will impact the more understanding of subject knowledge to students. This factor will help students in better understanding of subjects in higher education as well. Factor called "Catalyst" will generate more interest in students through learning.

H. Proposed working model based on guiding principles in AR for primary children.

The following model is proposed for based on the derived principles. Fig 1.8 is showing that based on these derived principles, marker and script will be created using unity 3D and will be stored in the database. After that virtual environment will be created and then scanning from camera will take place to match the script and markers. If markers are matched then object will be superimposed as output. The students will be later on tested and experienced the AR environment and also using without the AR (traditional approach). The results of both tests will be compared and conclusion will be drawn to show the effectiveness and efficiency of the proposed model on primary children.

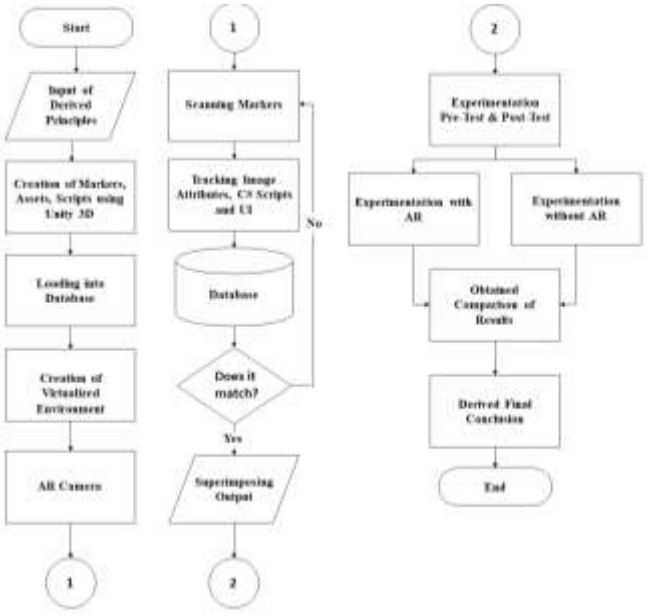

Fig: 1.8 Proposed working model

4. Future Scope

It has been noticed that still there is tremendous scope of AR application in education sector. Lots of work and attention is required to get the maximum benefits of this technology. Integrating AR application with AI will be a great scope in the future.

5. Conclusion

In this study we have proposed 3 major principles for designing mobile application for primary children after literature review and classification method. In future we will develop working model and justify the results stating learning from AR based on the above principles will be more effective and efficient to the students for learning concepts in their subjects. This then leads to better outcomes of students in their higher education.

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