Chapter 63
User Expectations of Augmented Reality Experience in Indian School Education

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Abstract Emerging technologies are lately being welcomed in Indian schools to enrich the quality of teaching and learning. Augmented Reality (AR) is one such technology that can be introduced in the classrooms. For a fruitful acceptance, it is required to design the AR interactions in schools as per the expectations of students, teachers and parents for a satisfactory user experience. In this paper, we present our study that was conducted with 47 participants belonging to three user groups of 6 parents, 7 teachers and 34 students. The broad goal was to understand the outlook of students toward technology as well as the expectations of the three user groups from an AR experience in Indian school education. Based on the mapping of the user stories, certain inferences were obtained which suggested the user requirements pertaining to AR experience in classrooms. We posit that these characteristic expectations of user experience can be used to develop AR applications for classrooms in future.

63.1 Introduction

With the accelerating pace of evolution of technology, many schools in India are adopting different technologies to enhance the learning experience of students. From projector screens to interactive whiteboards, from online learning management system to introduction of Virtual Reality (VR) cardboards, there are various technology trends that have been accepted and are used in India and worldwide. One such technology is Augmented Reality (AR). With the help of AR, computer-generated graphics can now be superimposed on to the real world in

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one's field of view. Certain aspects of AR such as superimposing vector graphics, concept visualization, annotations, virtual instructions and X-ray vision [1] can be used in present classroom scenarios to provide an interactive and spatial learning experience.

In education, various stakeholders are involved in the making of an efficacious institution. Teachers, students and their parents are among the top-level entities who hold certain expectations from the services provided in the schools for effective learning of the students. With the advent of technology inside and outside classrooms, it has become quite essential to provide a satisfactory user experience to these user groups, for which it is required to meet their expectations. Based on the prior expectations of the end users, the experience of using a service or product can be enhanced further. Hence, to bring up the use of AR applications in classrooms, it is required to study the expectations of these user groups to provide them an enriching user experience and enhanced learning of the students.

We thus sought to investigate the expectations that the different user groups may have toward the experience of using AR in classrooms in future for the students. For this purpose, we interviewed few parents, teachers and students of different standards to get a varied range of opinions. This study is broadly aimed at identifying the characteristics of user expectations that can be used to develop AR applications for classrooms in future to satisfy the learning experience of students.

63.2 Background

63.2.1 Technology Trends in Indian Schools

The advent of technology is evident enough in many sectors. Education being one of these sectors, various technologies across the world have been used to bring an impact in the way of teaching and learning. In many schools in India, the traditional method of blackboard teaching is now getting supported/replaced with several digital means. Simple blackboards are now getting replaced with interactive whiteboards where online shared contents (images, videos, audios, animations, etc.) can be projected and explained simultaneously [2]. Several schools are providing digital devices like tablets, laptops, desktops etc., to the students to help them learn advance concepts through online modules [3]. It also helps parents and teachers to regularly monitor the students' performance. Several mobile applications are also being used as a means of practice modules [4]. Thus, rapid acceptance of technology is now being observed in and reported by many schools in India where the students are being encouraged to enhance their learning skills.

63.2.2 Augmented Reality (AR) Technology in Education

Augmented Reality (AR) technology is one of the emerging technologies which interactively combine the virtually generated computer graphics on to the live scenario in real time [1]. AR experience can be obtained using immersive AR glasses or on a mobile device [5] where the device's camera first scans the environment to map the spatial information and tracks back in real time to superimpose the related virtual data onto the real surrounding [6]. Due to the different advantages of AR like overlaying vector graphics, display of virtual instructions, annotations, visualization of concepts, X-ray vision of human body parts etc., researchers have suggested various domains of application of AR including education and learning, medical, manufacturing and repair, entertainment, etc. [1, 7, 8].

With the help of AR technology, teachers and students can do lab experiments and activities safely and securely which are otherwise not advised to do in classrooms [3]. This is possible due to the interactive overlays of virtual objects on to the real world. Hence, applications of AR can be majorly seen in Science [9], Mathematics (Geometry) [10] and Humanities [11] where complex and abstract concepts can be effectively taught in AR [12]. Some studies have reported the advantage of AR in motivating and enhancing the performance of learning [13]. With the help of AR, students are also able to learn in collaboration [14]. However, the challenge comes in the way of introducing AR in the course content. Thus, it is required to see how the teachers, students and parents look forward to the acceptance of the working of AR in classrooms.

63.2.3 User Expectation and User Experience

The increase in use of mobile- and web-based applications necessitates the need for providing intuitive and flawless interaction to the end users. This leads to the users anticipating a consistency across all interfaces. According to ISO, user experience (UX) is defined as "a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service." The manner of perceiving the use of an interface by the user depends on the three levels of user expectation [15]: (1) entrenched expectations: formed in the mind's subconscious due to the use of multiple similar interfaces over a long time period; (2) formative expectations: formed due to the experience of a particular aspect; (3) on-off expectations: formed at the very moment the user sees an interface. To provide a satisfactory user experience, it would be required to meet the maximum possible expectations in all three levels. Thus, user-centered design can be obtained by knowing the target user well and their prior experiences. The user experience with the emerging technologies plays a key role in their successful acceptance. Work by Olsson et al. [16, 17] has been done to evaluate the user expectations from mobile Augmented

Reality in different contexts. To further evaluate their work in the field of education, it is required to understand the user expectations from AR interactions to provide a satisfactory user experience while learning.

63.3 Research Methodology

On the lines of the work done by Olsson et al. [16, 17], the research questions that we are addressing in our study in the context of education are as follows:

RQ1: What is the outlook of students toward technology?
RQ2: What are the characteristic user expectations of Augmented Reality experience in Indian school education?

63.3.1 Participants

We conducted the study with 47 participants who belonged to three different user groups—parents (6), teachers (7) and students (34). We performed convenience sampling for both parents and teachers and random sampling for students. Six parents who were there in the mall along with their children, experiencing the AR display put up there, were interviewed.

The teachers belonged to a private school and had been using one of the smartclass solutions—interactive smartboards in the classroom, along with the regular textbook teaching. Seven teachers teaching students of standards 6–10 were interviewed. Each taught a different subject—English, Mathematics, Geography, History, Biology, Physics and Chemistry. All of these teachers were using smartphones out of which three at times were referred to other educational applications complementing their teaching style.

The third user group was that of 34 students of a private school from standards 4–9, where 17 were male students and rest 17 were female students. These students are regularly taught using smartboards. Four students from standard 4 and six students each from standards 5–9 were interviewed in groups. Their individual responses to the interview questions were recorded.

Our aim was to come up with the characteristics of expected user experience to develop AR interactions for students in classrooms in future.

63.3.2 Procedure of Study

The exploratory study was conducted in two metropolitan cities of India and in three phases with three different user groups. The first user group was that of

parents who were interviewed at a mall in Mumbai, India, where the visitors could get the experience of the AR display on a huge screen placed at some height.

The parents who were there with their kids to get the AR experience were interviewed with their consent, there and then in that environment. All these parents were unaware of the name of the technology that they were experiencing. They were therefore first explained about the technology and then given certain educational scenarios. To answer RQ2, their views on the AR technology use in those scenarios were then audio and video recorded.

The second user group was that of the school teachers from a school in Delhi, India. The teachers were interviewed individually. In the contextual interview, they were first asked about their acquaintance level with the current smartclass solution they were using in the classrooms and other educational applications. This was followed by giving them an introduction about the AR technology and showing a demo of the same using an existing AR-based mobile application. They were then given the similar educational scenarios in classrooms, and their expectations from the use of AR technology in these scenarios were audio recorded and logged to answer RQ2.

The students belonged to the same school. The students of each standard were interviewed in groups of 4–6 as limited time was available to interview them in the school. Each group of students was made to sit in a round table in an empty classroom. To address RQ1, they were first asked turn by turn, general questions on demographics and their outlook toward technology. They were then given introduction to AR technology and demo of some existing AR educational applications. Four students of higher classes were familiar with AR technology but had not explored any AR-based mobile application before. To address RQ2, based on their understanding of AR, they were encouraged to "think aloud" about their expectations of using AR in the classroom as per the suggested scenarios. They were allowed to give vague and highly futuristic responses. Responses from each group session, conducted for 50–70 min, were logged and video recorded.

63.3.3 Data Source and Instruments

The instruments used in the study included:

Contextual Interviews. The interviews were conducted in two phases. The first phase involved general questions based on the demographics, acquaintance with current technologies and any existing knowledge about AR. This was followed by a demo of an AR-based mobile educational application. The second phase of interview, conducted post-demo, involved questions about their understanding of AR and their expectations of using AR interactions in classrooms in various educational scenarios. In these interviews, participants were encouraged to "think aloud" while suggesting their expected user experience of using AR in future in classroom education. These interviews were audio and/or video recorded.

Observation Log. This comprised of a detailed log of responses of each participant in the two phases of interviews. Observations during the first phase included the responses given to the demographic questions and familiarity with common technologies and mobile applications. The log for the second phase consisted of responses of their views and expectations of using AR in classroom scenario.

63.3.4 Data Analysis

To address the research questions, we analyzed the qualitative data obtained from the interviews and observations. The data sources used were the audio–video recordings and observation logs of the responses during the interviews. The log data was used to answer RQ1. For RQ2, the audio–video recordings were transcribed to obtain the user stories. The user stories from all the three user groups were jotted down on sticky notes as it is. Using affinity mapping in multiple levels, the user stories were grouped further and brought down to certain themes. Inter-rater validity was performed by two researchers on the themes generated. Based on the mapping, certain inferences were obtained which suggested some characteristics of expectations pertaining to AR experience in classrooms.

63.4 Results

A. **Results related to outlook of students toward technology**

To answer RQ1, semi-structured interview was conducted with the students where their responses were logged for the questions pertaining to their attitude toward technology. Figure 63.1 summarizes the responses of the 34 students of classes 4–9.

All these students were exposed to the use of smartboard in class. As can be seen from the graph (Fig. 63.1), most of the students used smartphones to play games. It was observed that the students were very rarely using any additional educational application at home. Only 11 participants out of 34 (32.3%) were using an educational application for practice purposes. As the class standard increased, more students were using WhatsApp [18] on their own and had class-related discussions on different WhatsApp groups. They also had their own accounts in one or more social media applications. When asked about the popular AR-based game PokemonGo [19], 44.1% of the participating students had heard about or played the game. However, only four students of classes 8 and 9 knew what AR is, but they had not played the game or had not used any other AR-based application.

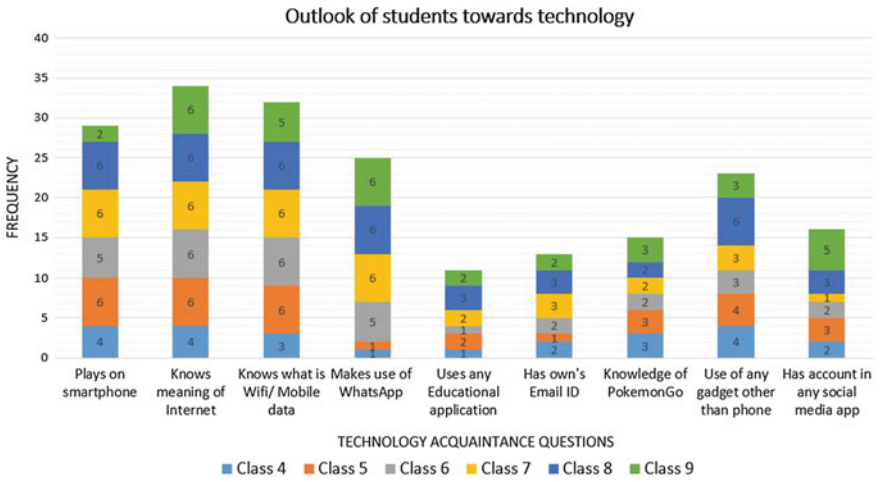

Fig. 63.1 Responses of students on their outlook toward technology

B. Results related to characteristics of expected AR experience in schools

Through affinity mapping of the user stories, valuable insights were obtained on the way the user groups perceived the AR experience in schools in future. The themes obtained from affinity mapping were then categorized under the three dimensions of learning given by Knud Illeris [20]: (1) *Content*—focuses on what is learned to develop one's functionality; (2) *Incentive*—focuses on maintaining the mental balance to develop one's sensitivity toward learning; and (3) *Interaction*—focuses on the interaction of content and incentive to help in one's integration into society. Thus, the description of 12 characteristics of expected AR experience in school, based on the themes generated under the three dimensions of learning, has been summarized in Table 63.1.

63.5 Discussion

Olsson et al. [16, 17] had considered the scenario of shopping to find out the expected user experience of mobile Augmented Reality services. Drawn from this work, our study has been done in the field of Indian K-12 education. We conducted an exploratory study to understand the current extent of use of technology in schools, the acceptance of technology by the key stakeholders, i.e., parents, teachers and students and their perception of introducing Augmented Reality technology in classrooms in future. RQ1 focused on finding the acquaintance level of the students with the emerging technologies. We conducted semi-structured interviews to know their outlook toward technology. The results on their attitude toward technology mainly captured how independently they were using the latest gadgets and

Table 63.1 Summarized characteristics of expected AR experience in schools based on the themes generated under the three dimensions of learning

Themes	Instances of user statements	Characteristics of expected AR experience
Dimension of learning: content (*functionality*)		
Conveying information	"Degree of angle rotation can be seen while moving an object," "popping of 3D figures while reading a textbook"	*Visual Cues*: Enabling indication of AR elements in the mediums *Informative*: Prompting related details and information with the 3D graphics *Situational Regeneration*: Explaining the working of past events and situations *Dynamic*: Displaying the interactive motion of contents
Reconstructing objects/situations	"watch Einstein performing experiments in real," "how the earth was made"	
Bringing out the dynamism	"visualizing combining of particles and molecules," "see parallel and meridian lines"	
Dimension of learning: incentive (*sensitivity*)		
Exploring mediums for AR	"see the contents on display board in 3D," "scan globe to see the cultures"	*Developing Interest:* Finding it engaging while the content is explained *Cognitive Sustenance*: Sense of efficiently understanding in one go *Creative Instances:* Feeling of experimenting with innovative mediums *Playfulness:* Feeling of excitement while interacting with elements of AR
3D Depiction of 2D graphics	"country or world map can be visualized for memorizing easily"	
Expressive diagrammatic examples	"while studying gravitational force, one is able to see the occurrence of the event with an example"	
Dimension of learning: interaction (*Integration*)		
Visualizing real-time information	"content taught in class should pop in front of students to help backbenchers"	*Immersive:* Feeling of being engrossed in the interaction of elements and learning *Tangible*: Sense of interactivity with the elements of AR *Familiarity:* Relating with prior knowledge of the associated content *Exploratory:* Sense of experimenting with the AR elements
Linking with familiar day-to-day events	"exploration of teeth in 3D," "watch famous places to visit in 3D"	
Extremities in size	"visualize the constellation right in front of me," "watch microbes in actual"	

applications. Most of the students were dependent on their parents to use their smartphones or any other gadget. Very few students tried to explore materials beyond the textbooks and smartclass modules by using some additional educational applications. However, they mostly used the smartphones of their parents to play games. Many students knew about the popular AR-based game—PokemonGo [19]. However, only four students knew the technology it used, i.e., Augmented Reality (AR), and could describe it a bit.

The teachers were asked about their comfort in using the smartboard technology. The online stored modules helped the teachers to reuse the taught content any time. They believed that it helped students in improving their visualizing skills but yet lacked interaction from students' end. The parents in the study were interviewed after they had experienced the working of an AR display with their children in the mall. After the introductory interview with the three user groups, they were explained about the AR technology and were given the demo using some existing AR-based educational applications. On asking about their perception of introducing AR in classrooms, certain insightful comments were obtained from the three user groups. Most of the participants gave responses by linking the possible features of AR applications with the features of existing technologies. Thus, their expectations were pretty much based on their prior experiences. At times, some of the students went off-topic by being too futuristic with their responses. But they were encouraged to do so in order to get further inferences.

The themes obtained from these user stories were classified under the three dimensions of learning given by Knud Illeris [20]. Based on the themes categorized under the three dimensions of learning, 12 characteristics of expectations were obtained. The suggested characteristics of expectations under "Content" dimension focus on designing the functionality of the AR applications to help the students understand clearly what is taught to them. The suggested characteristics of expectations under "Incentive" dimension focus on designing the AR interactions targeting the emotional intelligence quotient to help the students to bring in the sensitivity of cognition and keep them motivated in the learning process. The suggested characteristics of expectations under "Interaction" dimension focus on designing the AR applications with factors that integrate the functionality of AR interactions with the related incentive.

While designing the AR-based learning applications, designers can use the combination of these characteristic expectations from each of the learning dimensions to help the students in understanding the abstract concepts using features of AR. For example, in order to introduce the different forms of 3D shapes in Geometry to 7th-grade students, the designers can make sure that the interactions using AR provide the "informative" "visual cues" for their "cognitive sustenance" and "developing interest" in "exploring" the 3D shapes. Similar such combinations by using at least one characteristic from each learning dimension from Table 63.1 can be used to evaluate if the AR applications are effectively designed to enhance the learning experiences of the students of different grades in different subjects. This would ultimately help the students to initiate the process of learning with the AR

interactions. Thus, in order to provide the students with a satisfactory experience in terms of learning using the AR interactions, these characteristics of expectations must be kept in mind while designing an AR application for schools.

63.6 Conclusion

In this paper, we have focused on understanding the viewpoint of students, teachers and parents with the use of current technologies introduced in Indian schools and the potential introduction of Augmented Reality technology in future. We have thus addressed two research questions. The results of RQ1 focused on understanding the outlook of students in using technology for learning purposes. Students are still dependent on elders to use the accessible technologies. The results of RQ2 focused on arriving at characteristic expectations of AR experience in schools. These characteristics were developed on the basis of the three dimensions of learning given by Knud Illeris [20] to enhance the learning of students using the AR interactions. We posit that while designing an AR application, these characteristic expectations may help in providing satisfactory user and learning experiences to students.

The study has been conducted in a single school. In future work, participants from different demographics having exposure to different types of technologies can be studied to have a better understanding of their expectations and to identify a pattern or commonality among them. This can help in generalizing the characteristics of expectation across the schools in the country. Following this, an AR application built upon these characteristics can be tested to evaluate the validity of the stated characteristics.

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