Augmented Reality Education System

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Declaration

We, hereby declare that this thesis is based on results we have found ourselves. Materials of work from researchers conducted by others are mentioned in references.

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ABSTRACT

Technology in education can influence students to learn with enthusiasm and can motivate them, leading to an effective process of learning. Researchers have identified the problem that technology will create a passive learning process if the technology used does not promote critical thinking, meaning-making or metacognition. Since its introduction, augmented reality (AR) has been shown to have good potential in making the learning process more active, effective and meaningful. This is because its advanced technology enables users to interact with virtual and real-time applications and brings the natural experiences to the user. In addition, the merging of AR with education has recently attracted research attention because of its ability to allow students to be immersed in realistic experiences. Therefore, this thesis paper is based on the research that has been conducted on AR. The review describes the application of AR on primary education using individual "topic cards" for different topics of primary school syllabus. The review of the results of the research shows that, overall, AR technologies have a positive result and potentiality that can be adapted in education. The review also indicates the advantages and limitations of AR which could be addressed in future research.

KEYWORDS: Augmented Reality, Education, Mobile, Android, 3D, Animation

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INTRODUCTION

1.1 Motivation

While our world has seen extraordinary strides in Technology, but there hasn't been that much change in application of technology into our Education. Our studies still mostly rely on traditional ink and paper. And in case of Multimedia usage, we are mostly limited to PowerPoint Slides. How to make education more fun and updated then? More often than not, schools do not have enough money to buy all the supplementary learning materials they would like. Further, these learning materials get worn down, lose their relevance, and get misplaced over time [1]. Teachers are continuously trying to better the process of education to enhance students' comprehension, and there is a very active body of research in finding better teaching methods using tools that can reach their students at multiple levels [2]. The learning experience is a key point in education, and it has been shown that it can become more meaningful when more senses are involved (Sandor and Klinker, 2005). From the children's perspective, a very exciting way of using their senses is through visuals, which is an important way to improve and develop children's capability to understand things. Visuals can be used effectively to make use of all of children's senses to solve problems and to understand their environment in a natural way. Above mentioned reasons motivated us to build a new learning system. We make an emphasis in understanding the particularities of working with children and how they deal with this kind of technology that presumably can improve the way they learn.

1.2 Objective

In the Commercial Sector, Survey shows consumers favor Augmented Reality products 33% more than non-AR products. AR has been mostly incorporated in Higher Studies but Elementary and Childhood Learnings is a major field to concentrate and develop in AR. Shelton (2002) estimated that AR has not been much adopted into academic settings due to little financial support from the government and lack of the awareness of needs for AR in academic settings [3]. Our aim is to build an app-based education system based on AR that will help elementary students and kids to learn basics of science, math and various difficult subjects through 3d visual in their android phone. The most general objective of the research presented in this document is to explore the possibilities of AR in a learning environment and the implications in interaction. To achieve this long-term objective, we have established a series of goals for the realization of this thesis:

- Development of a playful system that engages and motivates children.
- Explore the use mobile AR interaction with the children.
- Study the introduction of AR in learning environments.
- Study the use of tactile and tangible user interfaces with children.
- Use a multimodal interface providing several ways of interaction.
- Test the systems with a minimum number of children.
- Measure the educational outcomes, satisfaction and interaction issues in our experiments.
- Provide a thorough statistical analysis of the results.

1.3 Background study

The origin of the word *augmented* is ***augment***, which means ***to add or enhance something***. In the case of Augmented Reality (also called **AR**), graphics, sounds, and touch feedback are added into our natural world to create an enhanced user experience [4]. While our world has seen extraordinary strides in Technology, but there hasn't been that much change in application of technology into our Education. Our studies still

mostly rely on traditional ink and paper. And in case of Multimedia usage, we are mostly limited to PowerPoint Slides. How to make education more fun and updated then? More often than not, schools do not have enough money to buy all the supplementary learning materials they would like. Further, these learning materials get worn down, lose their relevance, and get misplaced over time [5]. With Augment, we do not have to invest in physical materials. Students can access virtual models from any device at any time but which teaches real education subjects. Whether they are at home or in the classroom, students can study and interact with the course materials. As we know some basics are very important to grasp in Elementary Science or Math. So we narrowed down the important basics from our curriculums study materials to transform texts to AR interactivity. It has been proven that Color, Sound and Images help in understanding or remembering easier than mere texts. Also, most households with school-going children has smartphones at their home now. So, based on these findings our proposed app-based AR system will bring change as to how students learn and Spread knowledge in this modern era.

1.4 Thesis orientation

This thesis is organized as follow:

Chapter 2 Introduction of the existing education system of Bangladesh and about the feasibility of our system if it can be possible with our economic situation

Chapter 3 Description of development of the AR education application along with character animation, Coding, and implementation

Chapter 4 Information about results and outcomes from User based surveys

Chapter 5 Conclusion

CHAPTER 2
FUNDAMENTALS OF AR AND AR BASED EDUCATION SYSTEM

2.1 Existing traditional education system

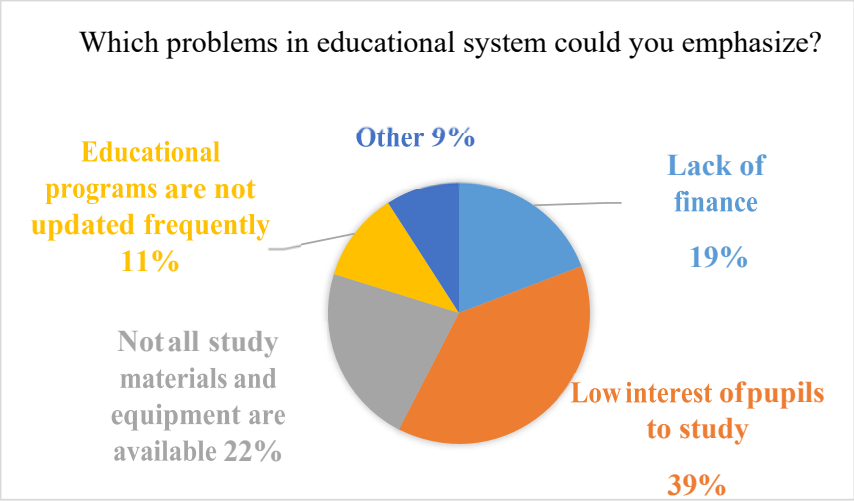

Figure 1.1 Survey for teachers: Which problems in educational system could you emphasize?

The Bangladeshi education system is unusually complex in that primary, middle, senior and tertiary education are oriented towards general, madrasha (religious) or technical / vocational preferences Even private schools and universities are heavily subsidized – in fact the constitution decrees that children between ages 6 and 10 shall pay nothing. To complicate things further, local education is controlled by a hierarchy of school boards [6]. The first phase, fully free primary school lasts for 5 years, typically between ages 6 and 10. Textbooks are given free till primary classes which follow the national curriculum and are same all over Bangladesh. These text books were written in ancient

time and still is used a learning booklet with some minor changes every year. But the text book writings are becoming harder and harder every year which makes the topics less understandable by students. In an article written by Abu Afsarul Haider is stated that the minimum international standard for teacher- student ratio is 30: 1, but in Bangladesh there is one teacher for every 53 students [7]. Lack of qualified teachers and poor school facilities in terms of the number of schools, classrooms, libraries and playgrounds are responsible for poor quality education at primary schools. A recent DPE internal report shows that around 70 percent of children are unable to read or write properly, or perform basic mathematical calculations even after five years at primary school. It also observed that the most common teaching method at secondary classes in the country is lecturing and reading textbooks and when it comes to interaction, teachers only ask closed 'yes' or 'no' questions to check whether the students have memorized the textbook information or not. Most teachers feel uncomfortable in adopting innovative educational approaches as they fear that using other approaches may result in poor performances in examinations. As a result, a huge number of students are failing to master the desired competencies due to a flawed teaching system.

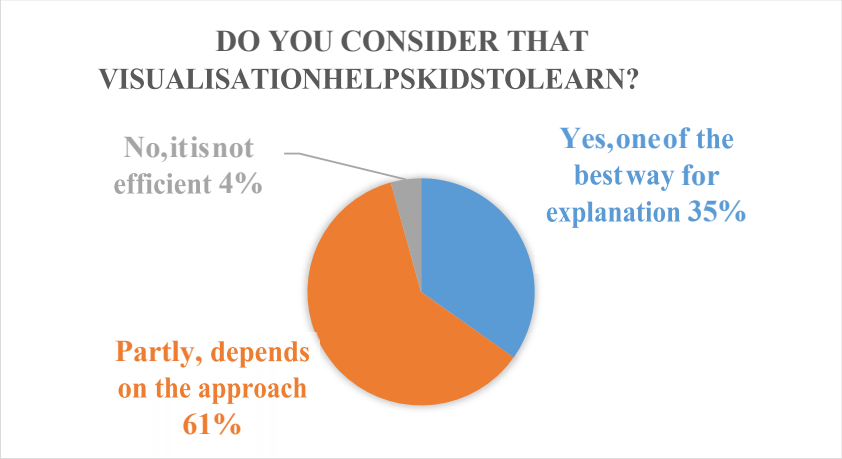

Figure 1.2 Survey for teachers: Do you consider that visualization helps kids to learn?

2.2 Feasibility study

Today, with the advancement of technology and reduction in costs for study in the AR is beginning to emerge as an alternative in various business segments. Lanzetta (2010) says that AR besides increasing the quality of communication with the consumer, emerging as a new solution relationship. The use of AR as a form of innovation in the way of communicating with the customer is fact. All it takes is creativity to implement the AR intelligently in order to delight users with a service useful and interesting. For an action happening with the AR is needed:

- A real object with some kind of benchmark that enables the interpretation and creation of the virtual object.
- Camera or device capable of transmitting the image of the real object
- Software able to interpret the signal transmitted by the camera or device
- Virtual model, preferably in 3D.

Bangladesh spends less than 3 percent of its GDP on the education sector. In our national budget for the year 2013, the education sector got the third largest allocation amounting to Tk.25, 114 crore of which Tk. 11,935.37 crore was set for the primary and mass education, and Tk.13, 179.23 crore for the education ministry [7]. But research shows that there are around 79.21 %(year 2017) users of android devices. With the advancement of technology, the price of AR supported android devices are decreasing. That means AR can be easily used by primary school students with the help of government. That way, the shortage of teachers in the primary schools can be made up by virtual teachers using a mere handheld phone. Above information show that the requirements for our system is cost effective enough and subject wise topic animations can be developed which can be visualized through regular android devices. So, the technical and economical assessment of our system can be confirmed through the information collected.

2.3 Augmented reality

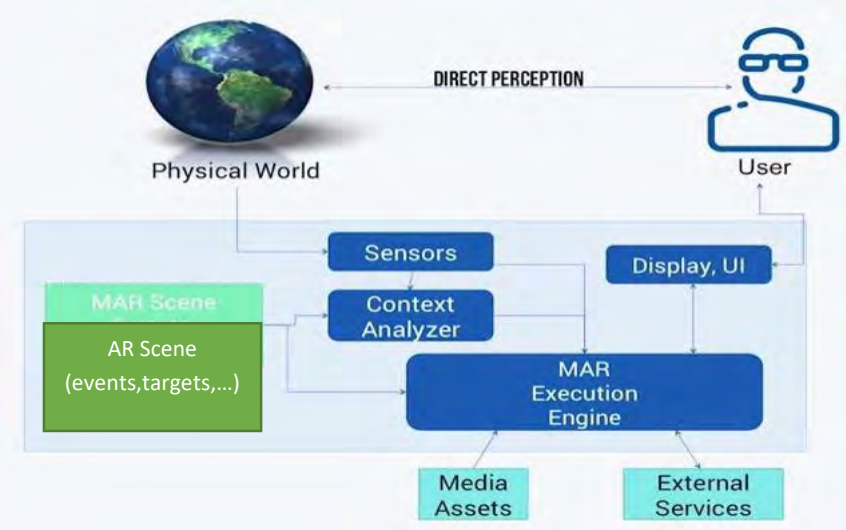

Figure 1.3 Mixed and Augmented Reality Reference Model

Augmented Reality (AR) is a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. Unlike virtual reality, which requires you to inhabit an entirely virtual environment, augmented reality uses your existing natural environment and simply overlays virtual information on top of it [8]. As both virtual and real worlds harmoniously coexist, users of augmented reality experience a new and improved natural world where virtual information is used as a tool to provide assistance in everyday activities. And in this era of Smartphones, AR technology has reached out to millions of Users. Augmented reality is not a toy, it's a powerful tool that will help solve some of the world's biggest problems. If it can be done right, it can be the next great platform for education, human connection and productivity. By integrating augmented reality into our study lectures, we can capture the attention of the audience. We propose to build an app-based Augmented Reality Education System, where students will get to learn and interact in a more fun way through smartphones. By viewing augmented models, the students can gain a better understanding of the concepts they are studying. The app will respond to touch as well as voice commands by the users. This is a fun way to engage students and reinforce concepts they've seen during class lectures.

CHAPTER 3
PROPOSED AR BASED EDUCATION SYSTEM

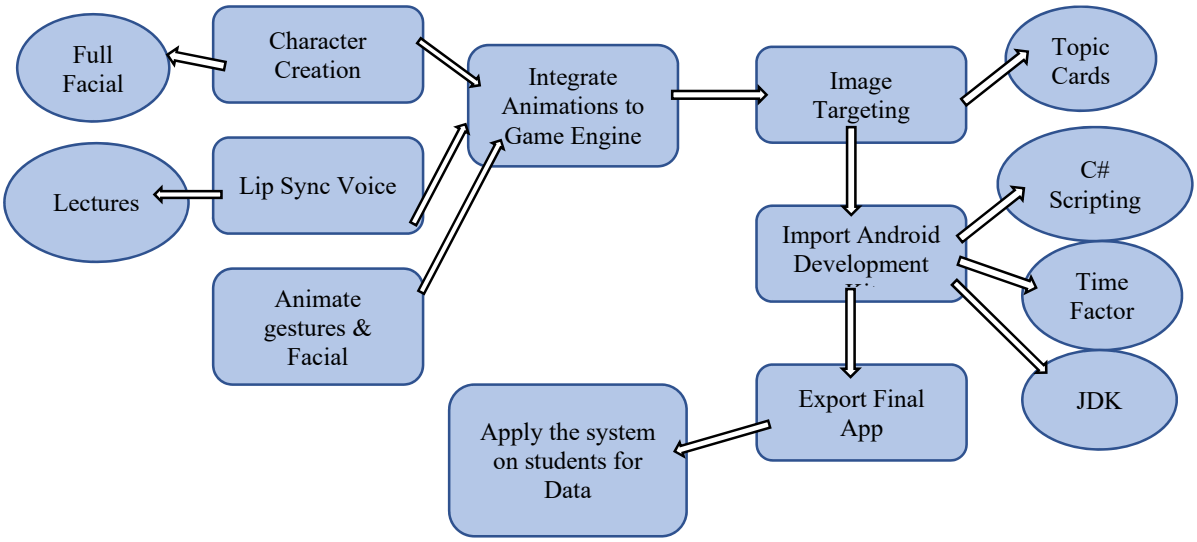

Figure 2.1 System Architecture

3.1 System workflow

- Research on the study materials and narrow down the crucial basics in learning materials for each subject.
- Character Creation
- Record and Animate Virtual materials for learning according to our findings.
- Integrate the animations into Game Engines for AR app.
- Augment and Place 3D using Target detection
- Simple and User-friendly UI
- For our initial build, we are concentrating on quality over quantity. So we will release limited study contents with as much interactivity as possible.
- Package of Education Cards will cost lesser than single Topic Cards.
- Encourage Sharing or Exchange of Topic Cards amongst students to maximize social fun and learning.
- Boost popularity and usage through Social Medias.

- Add more study contents over time and include more Academic contributors.
- Partner and Collaborate with other digital Learning platforms like 10minuteschool, Khan's Academy etc.

3.2 Character Creation

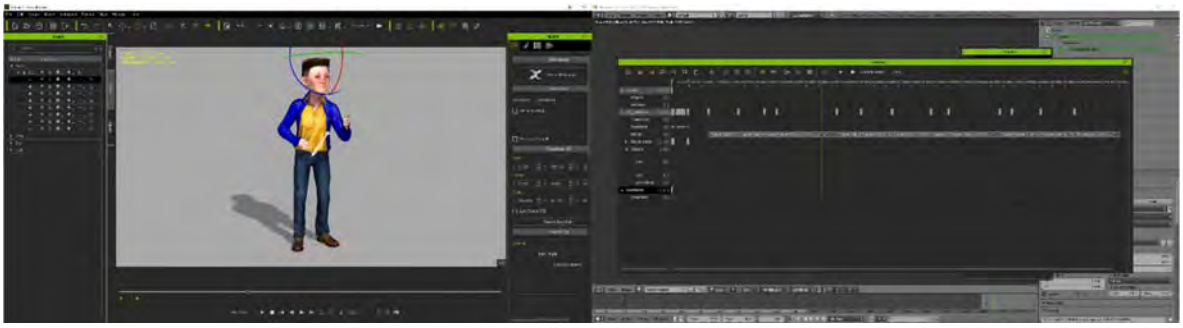

Figure 2.2 3D character development and animation in iClone

We created the 3D character to be the main actor of the system using Reallusion Character Creator and lip sync/ animation using iClone. iClone is a real-time 3D animation and rendering software program that enables users to make 3D animated films [9]. By using a 3D videogame engine for instant on-screen rendering Real-time playback is enabled. Other functionality includes: full facial and skeletal animation of human and animal figures; lip-syncing, import of standard 3D file types including FBX, a timeline for editing and merging motions, a scripting language (Lua) for character interaction; application of standard motion-capture files, the ability to control an animated scene in the same manner as playing a videogame, and the import of models from Google 3D Warehouse, among many other features. Character Creator 2.0 is an add-on tool for iClone. It can create realistic looking, animation-ready 3D human characters for use with iClone and other 3D tools. Unique character designs are created through the use of shape morphs, customizable high-resolution skin textures, and outfits with clothing containing your own fabric designs [9].

First, we had to identify what kind of character we can use to connect with children. We decided that to connect with kids, we need to design a kid aging 9-10 years old. So, we created 'Raju', a 10-year-old boy. Students of primary schools can easily be fond

of someone at their age explaining tough topics to them as their friend. Then we animated the character movements using iClone 7. We recorded our lecture on a particular topic from National Curriculum class 5 science book and used that mp3 to lip sync with 'Raju's character. Then we exported the 3D character file in (.fbx) format. **FBX** (**F**ilm**b**o**x**) is a proprietary file format (.fbx) developed by Kaydara and owned by Autodesk. It is used to provide interoperability between digital content creation applications. This format allows us to import the character into Unity with all textures and animations from any third-party software.

3.3 Augmented 3d using Target Detection

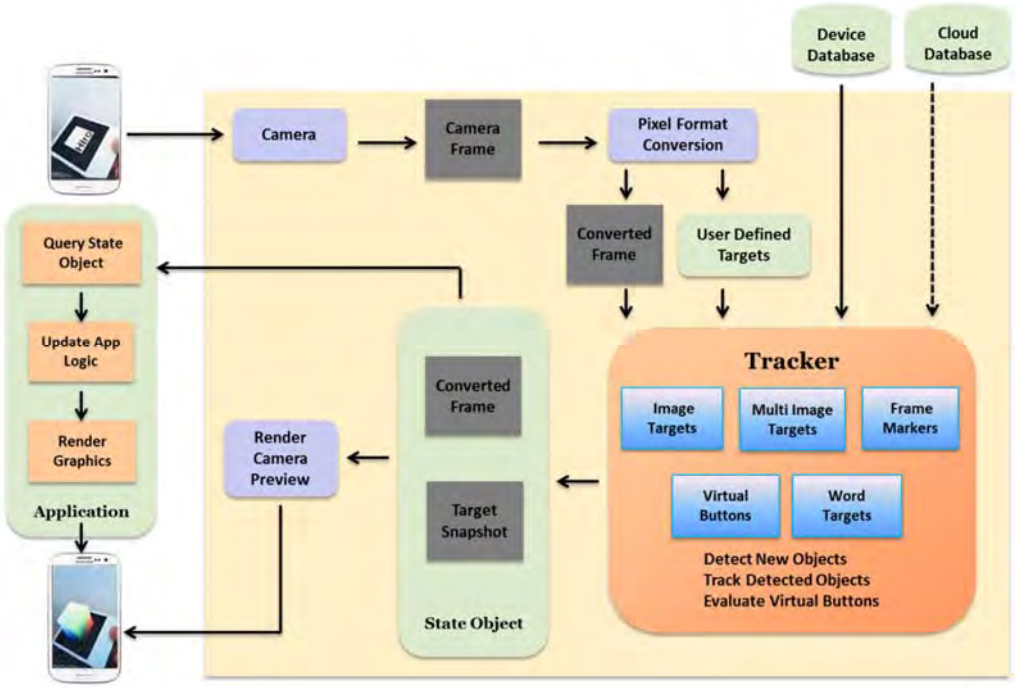

Figure 2.3 Flowchart for Target Detection

Vuforia is a software platform for creating augmented reality apps. Developers can easily add advanced computer vision functionality to any applications, allowing it to recognize images and objects, and interact with spaces in the real world. The vuforia platform supports augmented reality app development for Android, iOS, and UWP devices. In 2017 unity integrated the vuforia engine, making it even easier to create cutting edge augmented reality experiences for both handheld and head-worn devices. Vuforia is world's most widely used platform for AR development, with support for all

the latest devices [10]. Some of the ground-breaking features of vuforia are model targets, ground plane, image targets, vuforia fusion etc. The vuforia engine is natively integrated with unity, and delivered with the unity editor which can be installed using the unity download assistant or editor's XR settings panel.

Image targets represents images that can be tracked and detected by the vuforia SDK. Unlike traditional markers, data matrix codes and QR codes, image targets do not need special black and white regions or codes to be recognized. The vuforia SDK detects and tracks the features that are naturally found in the image itself by comparing these against a known target resource database. After the detection of image target, the SDK will keep tracking the image as long as it is at least partially visible in the camera. Image targets are commonly used for recognizing and augmenting printed media and product packaging for gaming, visualizing products and marketing campaigns where the products are to be used. Image targets can be created using vuforia target manager using JPG or PNG images in RGB or grayscale. The input image size must be within 2 MB. Features extracted from these images are stored in database, which can be downloaded and packaged together with the application [10]. Then the database can be used by vuforia for comparisons. The viewing environment of the image targets should be under moderate bright and diffuse lighting. The surface of the image should be evenly lit. There are two phases of working with image targets. First design our target images is needed and then upload them into vuforia target manager for processing and evaluation. Image targets can be any plane image that gives away sufficient information to be detected by vuforia SDK. It can be incorporated into our apps using either embedded device database or a cloud database online.

Object recognition allows to detect and track intricate 3D objects. This object recognition feature can be used to build rich and interactive experience with 3D objects. These experiences could mean augmenting a toy with 3D content to bring it to life. Object targets are a digital representation of the features and geometry of a physical object.

Vuforia ground plane as part of smart terrain enables digital content to be placed on horizontal surface in our regular environment. It supports tracking and detection of horizontal surface and also allows us to place content in mid-air using anchor points.

Ground plane provides an opportunity for developers to create AR experiences in developed apps. Some features of ground plane are detecting and tracking horizontal surface, anchor creation and tracking, scale approximation, 6 degree of freedom positional tracking, surface hit-testing to precisely place content on surface, integration of all other vuforia trackers and track-able types. Ground plane analyzes images from the device camera to understand the basic geometry of our environment. Therefore it is necessary to stage ground plane experience in settings that enable the camera to accurately capture the details of the surroundings. To get precise result stable lighting condition, moderate lighting, avoiding glare and dark shadows, surface details for improved accuracy and performance is necessary. Ground plane can work in both indoors and outdoors in variety of conditions given the environmental recommendations are followed.

Following is the C# code to play the audio lecture in our AR app:

```
using Vuforia;
using UnityEngine;
using System.Collections;

public class ImageTargetPlayAudio : MonoBehaviour,
ITrackableEventHandler
{
    private TrackableBehaviour mTrackableBehaviour;

    void Start()
    {
        mTrackableBehaviour = GetComponent<TrackableBehaviour>
();
        if (mTrackableBehaviour)
        {
            mTrackableBehaviour.RegisterTrackableEventHandler(
this);
        }
    }

    public void OnTrackableStateChanged(
        TrackableBehaviour.Status previousStatus,
        TrackableBehaviour.Status newStatus)
    {
```

```
        if (newStatus == TrackableBehaviour.Status.DETECTED ||
            newStatus == TrackableBehaviour.Status.TRACKED ||
            newStatus == TrackableBehaviour.Status.EXTENDED_TR
ACKED)
        {
            // Play audio when target is found
            GetComponent<AudioSource>().Play();
        }
        else
        {
            // Stop audio when target is lost
            GetComponent<AudioSource>().Stop();
        }
    }
}
```

Following is the C# code used to track a surface in real world (ie. Topic Card) and play our 3D character ‘Raju’ as the teacher.

```
/*==============================================================================
Copyright (c) 2010-2014 Qualcomm Connected Experiences, Inc.
All Rights Reserved.
Confidential and Proprietary - Protected under copyright and other laws.
==============================================================================*/


using UnityEngine;
using System.Collections;
using System.Collections.Generic;


namespace Vuforia
{
    /// <summary>
    /// A custom handler that implements the ITrackableEventHandler interface.
    /// </summary>
    public class DefaultTrackableEventHandler : MonoBehaviour,
    ITrackableEventHandler
    {

        #region PRIVATE_MEMBER_VARIABLES

        private TrackableBehaviour mTrackableBehaviour;
        float timeS = 0;
        public GameObject canvasObject;
        bool didFunction = false ;

        #endregion // PRIVATE_MEMBER_VARIABLES
```

```
#region UNTIY_MONOBEHAVIOUR_METHODS

void Start()
{
    mTrackableBehaviour = GetComponent<TrackableBehaviour>();
    if (mTrackableBehaviour)
    {
        mTrackableBehaviour.RegisterTrackableEventHandler(this);
    }
    canvasObject.gameObject.SetActive (false);

}
void Update(){
    if(didFunction) {
        timeS +=1;
        seconds = timeS / 60;
    }
    if (seconds >= 6) {
        canvasObject.gameObject.SetActive (true);
    }

}

#endregion // UNTIY_MONOBEHAVIOUR_METHODS



#region PUBLIC_METHODS

public float seconds = 0;
/// <summary>
/// Implementation of the ITrackableEventHandler function called when the
/// tracking state changes.
/// </summary>
public void OnTrackableStateChanged(
    TrackableBehaviour.Status previousStatus,
    TrackableBehaviour.Status newStatus)
{
    if (newStatus == TrackableBehaviour.Status.DETECTED ||
        newStatus == TrackableBehaviour.Status.TRACKED ||
        newStatus == TrackableBehaviour.Status.EXTENDED_TRACKED)
    {

        didFunction = true ;
        OnTrackingFound();

    }
    else
    {
        didFunction = false ;
        OnTrackingLost();

    }
}

#endregion // PUBLIC_METHODS



#region PRIVATE_METHODS
```

```
        private void OnTrackingFound()
        {
            Renderer[] rendererComponents = GetComponentsInChildren<Renderer>(true)
;
            Collider[] colliderComponents = GetComponentsInChildren<Collider>(true)
;

            // Enable rendering:
            foreach (Renderer component in rendererComponents)
            {
                component.enabled = true;
            }

            // Enable colliders:
            foreach (Collider component in colliderComponents)
            {
                component.enabled = true;
            }

            // *** Additional animation code
            Animation[] animationComponents = GetComponentsInChildren<Animation>();

            foreach (Animation animation in animationComponents)
            {
                foreach (AnimationState animState in animation)
                {
                    animState.speed = 1f;
                    animation.Play();
                }
            }
            // *** end of animation code

            // Enable rendering:
            foreach (Renderer component in rendererComponents)
            {
                component.enabled = true;
            }
            // *** Code für Audiostart
            AudioSource[] audioComponents = GetComponentsInChildren<AudioSource>();
            foreach (AudioSource component in audioComponents) {
                component.GetComponent<AudioSource>().Play();
            }
            // *** end of audio code


            Debug.Log("Trackable " + mTrackableBehaviour.TrackableName + " found");
        }

        private void displayQuestion(){

        }

        private void OnTrackingLost()
        {
            Renderer[] rendererComponents = GetComponentsInChildren<Renderer>(true)
;
            Collider[] colliderComponents = GetComponentsInChildren<Collider>(true)
;

            // Disable rendering:
            foreach (Renderer component in rendererComponents)
            {
```

```
            component.enabled = false;
        }

        // Disable colliders:
        foreach (Collider component in colliderComponents)
        {
            component.enabled = false;
        }

        Animation[] animationComponents = GetComponentsInChildren<Animation>();

        foreach (Animation animation in animationComponents)
        {
            foreach (AnimationState animState in animation)
            {
                animState.speed = 0;
            }
        }

        AudioSource[] audioComponents = GetComponentsInChildren<AudioSource>();
        foreach (AudioSource component in audioComponents) {
            component.GetComponent<AudioSource>().Pause();
        }
        // *** end of audio code


        Debug.Log("Trackable " + mTrackableBehaviour.TrackableName + " lost");
    }

    #endregion // PRIVATE_METHODS
}
}
```

3.4 Building the final app

Figure 2.4 Unity Development platform

Unity is a cross-platform engine developed by Unity Technologies. Unity gives users the ability to create games/app in both 2D and 3D. The engine provides a primary scripting API in C# language. Unity allows to build apps which need to interact with 2D or 3D space. It lets making interaction not only through code but also with visual components. This platform also allows to experiment apps in almost every major mobile platforms. The Unity interface is fully scriptable and it allows many third party plug-ins to integrate into the Unity GUI. Unity is totally feature packed which makes it a lot more interesting to the developers. Unity 3D integrates Animation mechanics, character mechanics, player mechanics, environment mechanics and programming developer together. One of the most useful features of unity is that it supports online assets shop for designers. The designers are able to find and buy abundant game assets. Designers can also design their own assets themselves.

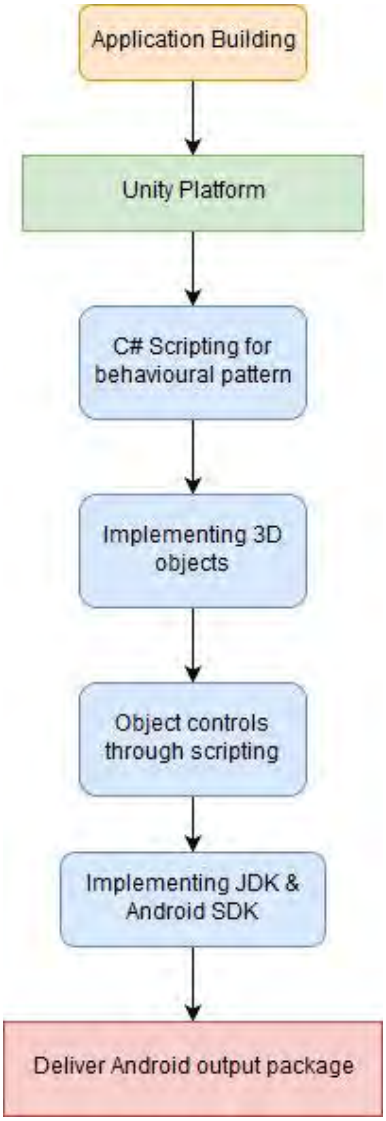

Figure 2.5 Workflow of final app development and packaging using Unity

We have used C# scripting for our app development in unity. Scripts can hold any number of information and instruction. We have organized our script such that the engine knows

how and when to use the information. Another challenge in scripting is deciding where to put the script, for example some script may not be just dependent on player's interaction it also can be depended on other factors like time. The script makes the app objects to work. In the creation section of the unity platform we can make any objects of our choice, such as 3D models, lights, camera etc.

To deploy our developed app into android devices Java development kit and Android SDK is needed. First, we need to download and install the latest version of JDK. Then we need to add our Android SDK to unity's build properties. We then need to connect our android device with the computer turning on the debug mode. For IL2CPP scripting backend for android we need the Android Native Development Kit (NDK). It contains the tool chains needed to build the necessary libraries, and finally to produce the android output package (APK). For building first time we need to locate the folder in which we have installed the Android JDK and NDK.

3.5 Testing of AR based application in education

As mentioned in the previous chapter, quantitative data has a supportive role for this master thesis. User testing and feedback is always richer with qualitative data. However, to support the methodology of the research and identify its direction, the author participated in a user testing and a follow-up questionnaire with the pupils.

Additionally, surveys were conducted with the number of teachers about the aspects of teaching sciences and the usage of educational games without demonstration of the app.

The algorithm of steps during the demonstration followed these steps:

1. Scanning Topic cards using app in Android phone.
2. Watch the 3D cartoon character and learn from his lecture
3. Answer simple multiple choice on screen to win the game

The demo- 3D lecture can also be viewed by scanning the Image target below.

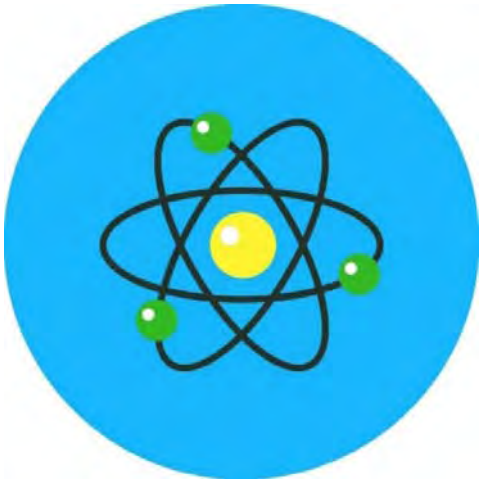

Figure 2.6 Short demo-3D lecture with AR app.

Due to the limitations in equipment, testers used only 2 phones for demonstration. Therefore, various medium of kids and parents were interviewed in small numbers. This allowed to show the application only briefly but the general feedback was positive. Several of the pupils stated that it explained the process more efficiently than previously in the classroom.

Table 1. List of the interviewed participants in Dhaka

Residence	Name of the kid	Name of the parent
Shantinagar	Faariz	Farhin
Savar	Nafi	Belayet
Shamibagh	Priyonto	Wahid
Shamibagh	Araf	Liza
Shantinagar	Farhan	Shorna

At the beginning of each interview, the demo of the app was shown to the kids and parents. Kids had direct interaction with the app – they could observe and explore augmented reality using moleql application. Meanwhile a parent was observing the kid and his/her behavior. Parents were asked not to help the kid with the usage of the app and to emphasize their own opinion for the clear and transparent outcome of the research. Furthermore, parents had time to try the app by themselves after the interview with the kid. Afterwards, the interview was handled with the parent.

Moreover, in addition to the interview participants were asked to rate five main progressive learning components in the scale from the most important to the least important. The results give us a clear picture what major and minor priority in the learning process is. The consolidated results of the answers are shown in Table 2.

After analyzing the data collected during the interview we could summarize the general attitude of parents and kids towards augmented reality experience as a part of the learning process. The results are shown in Table 3.

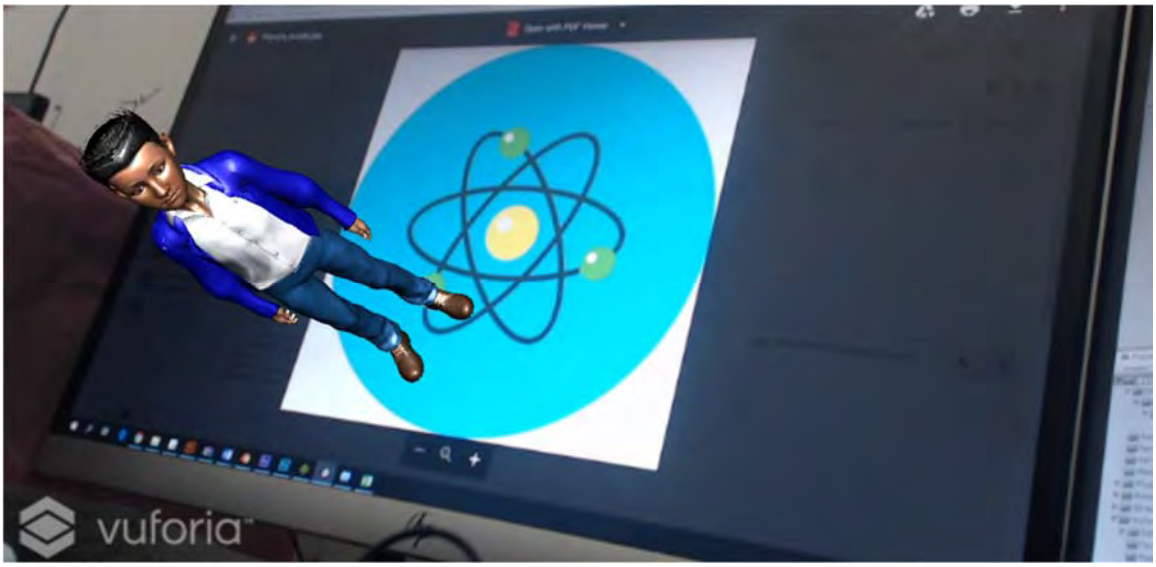

Figure 2.7 In-App UI of character standing on Real world surface

Table 2. Rating of the five main components of progressive learning

1 – Insignificant; 2 – Unimportant; 3 – Neutral; 4 – Important; 5 - Highly Important

Residence	**Name of the Interviewed**	**High-quality content**	**Visualization of objects**	**Gamification**	**Game-based learning**	**Real-time performance and interaction**
Shantinagar	Faariz (kid)	2	4	5	3	1
Shantinagar	Farhin (parent)	5	3	2	1	4
Shantinagar	Farhan (kid)	1	2	5	4	3
Shantinagar	Shorna (parent)	5	1	3	2	4
Shamibagh	Priyonto (kid)	1	2	4	5	3
Shamibagh	Wahid (parent)	4	5	3	1	2
Shamibagh	Araf (kid)	1	2	4	3	5
Shamibagh	Liza (parent)	4	5	1	2	3
Savar	Nafi (kid)	2	1	3	5	4
Savar	Belayet (parent)	5	2	1	3	4
Sum of kids evaluation		7	11	21	20	16
Sum of parents evaluation		23	16	10	9	17
Total		30	27	31	29	33

Table 3. Attitude towards augmented reality application as a part of the study process

Country	Name of the Intervied	Attitude towards augmented reality
Shantinagar	Faariz (kid)	Positive
Shantinagar	Farhin (parent)	Positive
Shamibagh	Priyonto (kid)	Neutral
Shamibagh	Wahid (parent)	Neutral
Shamibagh	Araf (kid)	Positive
Shamibagh	Liza (parent)	Neutral
Savar	Nafi (kid)	Positive
Savar	Belayet (parent)	Positive
Shantinagar	Farhan (kid)	Positive
Shantinagar	Shorna (parent)	Positive

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Implementation Outcomes

We have presented a study that compares traditional mediums and handheld AR in our education system. Our study was centered in the field of education, but many conclusions can be extrapolated to other areas of HCI. To our knowledge, this is the first study that analyses interactions between human and a 3d teacher/friend standing in an augmented platform to mimic interactive learning. First, we examined current education mediums in primary schools of our country. Then studied the feasibility of our proposed augmented reality app to accompany/help in the early learning process. We then shortlisted some topics to initially teach through our AR app. Then we studied on how to connect properly with the young users and give them a fun way of learning easily. We created a friendly school going cartoon character named “Raju” to teach them in the app and made him using 3D animation. This Raju can stand on their books or any 3D space, if handheld phone was focused on the target image. This made existing books more interesting. Raju gave summarized lectures with expressions, and cheered for the user if he could give correct answers in the app. This way children were amazed to use more of the app and played this like a game while listen to lectures from Raju. The handheld device was used in a video see-through mode to visualize the augmented world, taking some of the advantages of HMDs, but resulting in a much more comfortable way to the children. This metaphor was chosen for being one of the most used in education. Our proposal is very well suited for primary schools, since nowadays handheld devices are affordable and multipurpose, so they can replace expensive desktop PCs and enhance their value contributing to create richer multimedia experiences for the students. In the experiment we evaluated, the app consisted a topic card on which the AR marker was placed. The children could rotate the handheld device to see the 3D objects from different perspectives. As for the children’s perspective, we could see a very high level of satisfaction with the game and they were very engaged. However, there was no evidence that the interface used influenced this engagement. The AR system appealed the children very much without being affected by the interaction method. In this thesis we have carried out a research about the implications

of handheld devices and AR in an educational context and the consequences in HCI. Through three studies we have fulfilled the principal and the secondary objectives. A playful activity was developed, themed in natural sciences of Class 5. The motivation of children was very high, and they learned much faster while playing. We programmed the game and evaluated it in handheld devices, making use of accelerometers, the tactile screen, and the camera, thus providing a multimodal interface that appealed to the children. The game had mini quiz to assess their learning and gave very satisfactory results compared to traditional means. The consequences of using a book or our app were studied concluding that the introduction of AR was an important step for current education mediums used in the classroom. Also, two different handheld devices were tested and compared when children played the game with them, and we saw that both of them were similarly effective. Furthermore, a study that compared tactile and tangible interaction was presented, providing data to support that it could be preferable to use tactile interfaces in some situations. All the studies presented a decent number of subjects and several measures were taken, such as learning speed, outcomes, satisfaction and interaction. Finally, we presented a statistical analysis of the data captured and provided a critical discussion. This evinces that technology itself is not enough to improve education, it needs connecting reality. We saw our hypothesis accomplished when we saw the great results in motivation. The main conclusion we can get is that AR can improve primary education, since it enhances the learning experience for the children with more appeal and attraction, but it does not imply a radical change in education. We also tested the game in the second study comparing two handheld devices with different sizes and weights. Despite our initial hypothesis, the Tablet PC would be more engaging than the smartphone, and the interaction would be easier, we found that in our experience, both devices were similarly appreciated. We perceived in children an extraordinary ability to adapt to any kind of environment. From a global perspective, we can see that handheld devices have a great potential in educational environments. Given our experience in the studies, an interesting conclusion that can be reached is that providing a multimodal interface to the children seems to be favorable for engagement.

4.2 Summary of Findings

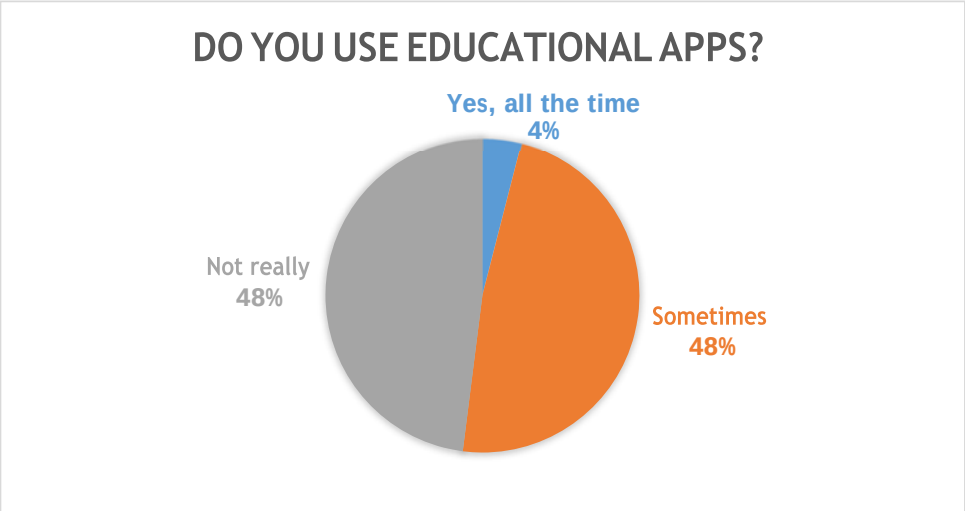

Figure 3.1 Survey for pupils: Do you use educational apps?

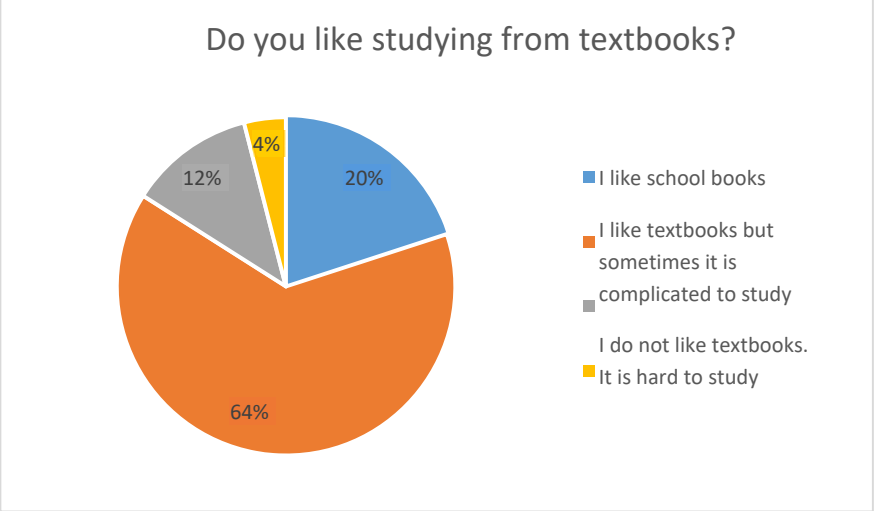

Figure 3.2 Survey for pupils: Do you like studying from textbooks?

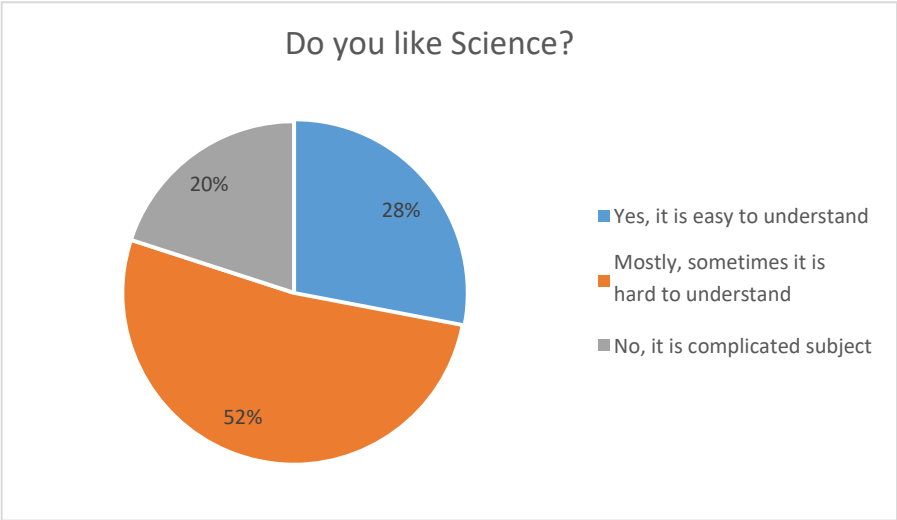

Figure 3.3 Survey for pupils: Do you like Science?

At present, the education system is undergoing significant changes. The role of Information in life of society is increasing, which leads to increase in the requirements. For the education level. Nowadays schools have an important mission to prepare kids for the new world which is rapidly changing and progressing. It is impossible to increase the efficiency of studies without the use of the latest technical training tools. Augmented reality technology in our time is very rapidly developing and can be applied in many areas. One of the most beneficial usages of the augmented reality technology is education.

The results of the analysis of qualitative data rarely contain unexpected conclusions. But even information that seems obvious requires proof. The research showed positive attitude towards AR technology. Nevertheless, there are a lot of concerns about the future use of the technology as a part of the learning process. Moreover, full digitalization of the education could have a backside which is hard to predict. In the case of any innovative technology, it is uneasy to forecast the outcome for the future, as there is general over excitement about the technology from the beginning. Generally, kids were more broad-minded and excited about the technology while parents and teachers were more tolerant and circumspect. As interview included kids from different schools so their attitude and expectations of the school and science class were different.

For example, kids from many Bengali medium dislike school educations but at the same time they like going to school because of their friends. The kid from private schools was more discreet in comments about the school, the attitude is more neutral. Meanwhile, the kid from highly expensive English medium likes school classes more than other interviewed kids, the main reason is that during classes they have a lot of teamwork and it is perfect time for communication and interaction with friends and classmates, in addition, they have a lot of outside activities (excursions, games, walks). All kids replied that more experiments and science labs would make science class more interesting for them. Moreover, kids mentioned that they do have a few science labs during the study year, and sometimes none at all for Bengali medium students.

Also all the kids interviewed stated that sometimes they do not understand the teacher and would like to have more personal approach during the classes. According to the results of the coding about augmented reality application, it is clear that user experience and interaction with the application are beneficial for the user. Moreover, we as a researcher can conclude that our AR application includes five main components of the progressive learning. Nevertheless, they all are at the early stage of development and need to be improved before the application release. As the study has shown, kids and parents have different expectations from the school and education. According to the table 5, kids and parents were asked to evaluate five components of the progressive learning. For kids, a top priority was game-based learning and gamification features while for parents - high-quality content. During interviews, kids were more interested in the gamification of the AR application and reactions while parents were searching for educational content and correctness of 3D models. According to the research observation, kids enjoyed playing with the AR app, the majority of the kids emphasized positive experience with the app, nevertheless, a few prototype bugs and UI problems were defined in the app. The main concern of the kids was that app does not have enough reactions to play with and it should have more additional content. Comments from the teacher were that it should include more information about the reaction and detailed explanation, though he found it interesting and entertaining for the kids. The testing of the Science quiz was a bit more complicated as the kids had to read and select amongst multiple choices. The real-time lecture by 3D animated schoolboy ‘Raju’ was the best past of user experience. Which will soon be translated to Bengali to connect

with more children. Augmented reality has shown the mobility and self-driven learning of kids in the class.

CHAPTER 5
CONCLUSION

Augmented reality is a technology that allows combining a layer of digital reality with physical environment. It is a powerful tool that can enrich the future of the education. It can help to see and interact with the things from a different perspective during the learning process.

However, the technology of augmented reality is rarely used at schools. But it is impossible to overestimate the potential of the technology. By using the capabilities of augmented reality in education it is possible to visually reconstruct the processes that are difficult or almost impossible to reproduce in the real world and make learning interesting and understandable.

The research helps to understand the attitude of the user towards augmented reality technology as a part of the learning process. The obtained research is beneficial for the future development of the AR technology represented in our AR application.

Furthermore, they help to keep the focus on the most important parts of the learning process. Components are taken into consideration for the further development of the AR application. Furthermore, the research has shown that application with the usage of augmented reality technology has a combination of one of several progressive components. Meanwhile, they all should be connected to one application.

The research showed that augmented reality has a unique value for the education and future development of the school programs. Nevertheless, each technology it has pros and cons. Our research recommends to use AR technology in addition to the existing school learning program but not as a replacement of the current study process. The main concern of the research is that augmented reality technology is an innovational technology which has not been used massively, it is hard to predict the effect on kids and society in general. The monumental usage of the technology should be carefully implemented into the education under constant observation of specialists. Rapid development of technologies, which took place over the past few decades, has led to

the fact that in some countries educational system has catastrophically fallen behind. Currently we can only imagine how the process of perception and memorization of learning material would improve after implementing the augmented reality technology. It is these modern interactive technologies that bring visualization, game elements, activate the interaction of participants in the learning process, and develop spatial thinking and new learning approach. Owing to augmented reality, students have unlimited possibilities for learning new things. But, the usage of the AR needs more line testing for long term prospective. In future works we would like to concentrate more on the methodology for applying AR technologies at schools. Moreover, integration of AR into the educational program is challenging task which needs to be tested more thoroughly and investigated in the future. Better understanding of the usage of augmented reality technology and its effect not only on the user but on the education in general have to be studied. We live at the age of information and rapid development of the technology. Changes in the environment affect society and future of the state. By adopting new and innovative approaches to be used in the educational system the government could increase the intelligence and conversance of the society. Augmented Reality is the most efficient way of exploring the surrounding environment and space.

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