

# Science Zone : An Augmented Reality based Mobile Application for Science

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**Abstract**—In recent years, technology has rapidly developed, and it has provided many technological advancements for the field of education with an attempt to improve and overcome its limitations. Augmented Reality is among these latest technologies which support to improve learning environment around the world. It can bring education to a new level which can help students in many significant ways. In Sri Lanka, augmented reality is rarely been used for the purpose of educational enhancements. Therefore, it was decided to develop an augmented reality embedded mobile application for the G.C.E Ordinary Level Students in order to make it easy for them to learn Science with more enthusiasm and interest. This research has been used marker-based approach to transmit images or objects in the text book into the real-world scenes in order to create a more productive learning environment for the students. The first version of the application covers four main areas in the Science curriculum, such as; Preparation of Acids, Human Anatomy, Organization of Plants and Biosphere Cycles. Feedback for the application was taken from randomly selected ten science teachers and twenty grade eleven students and accordingly the application was further developed. Their feedback proves that the application would satisfy the common requirements of students, and it would be an immense support in scoring good results for science.

**Keywords**—Augmented Reality, Science, Education, Technology

## I. INTRODUCTION

According to the statistics of national examinations department pass rate of the science subject at the G.C.E ordinary level examination is comparatively lower than the other compulsory subjects [1].

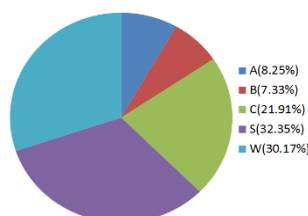


Fig. 1. O/L Science Results of 2018 [1]

According to the Fig. 1 even among the passed students of Science subject, most of the students have scored average grades. Only few have scored good grades such as A and B for Science subject. This is because the science content has become more advance with the introduction of the new syllabus. The deep concepts of science have become the reason for getting lower grades. Moreover, Science is a practical subject and lack of proper practical experience will make it hard to understand the subject. Also, schools in rural areas are not having proper lab facilities and even some urban schools are lacking good lab facilities. In such situations it will be a huge disadvantage for students in scoring higher marks for Science.

Basically, traditional classroom was carried out through face-to-face instructions where the learning activities were conducted by the teacher. Rapid advancements in information technology have created well organized learning environments, going beyond the traditional classroom. During the COVID 19 outbreak students were unable to attend schools for a long period of time and they had to do their studies by themselves. In such an instance this application would be a great help for students rather than just referring their text books. According to the statistics of national examinations department the Science passed rate at the G.C.E ordinary level examination is comparatively lower than the other compulsory subjects [1]. With the newly introduced concepts the science content has become more advance [2]. Hence, embedding new technologies such as augmented reality with science will be more useful for students. Nowadays, augmented reality has become a growing field of information technology. Augmented reality based mobile apps are an

effective mode of E-learning as it is having the ability to demonstrate even deeper concepts in an attractive and interactive way. Science Zone is a mobile app developed targeting Ordinary Level Science subject which uses marker based Augmented Reality, where the user points the device's camera on a specific content of the textbook to learn the contents in the syllabus. It is possible to visualize an object through smartphone camera pointing towards a marker (image target) and then the app will display 3D models, videos and audios explaining the targeted content [3]. Since Science subject mostly goes with practical sessions, applying AR in an educational context equals to using "technology to add virtual objects to real scenes, by adding missing information to real life" [4].

## II. BACKGROUND STUDY

Today, technology has become an important part in everyone's life, making it nearly impossible to survive in any field without it. Education is one of those fields which use technology for its development and enhancement in order to obtain the desirable outcome. Combining technology and education has opened new opportunities for immersive learning environments, and it has brought education to a level which makes it more beneficial and effective for the students. Among different kinds of technologies which are been used for the educational advancements, Augmented Reality (AR) has become one of the most popular technologies these days. It is being used as a new medium to combine aspects from ubiquitous computing, tangible computing, and social computing. Moreover, it has its own characteristics and benefits that are promising to support learning and make students more interested in learning. Since AR brings lots of benefits to the field of education, many research studies have been carried out to emphasize its true usage in this field.

Rita Layonaa, Budi Yuliantob, and Yovita Tunardi together have carried out a research to develop an AR application for human body anatomy learning to make it easier for students to understand the content clearly. For collecting data for the research, a questionnaire has been distributed among 48 junior and senior high school students of a higher education institution in Jakarta, Indonesia. As mentioned in the research, this application enables students to learn human body anatomy with 3D object interaction, and previously it was taught using textbook and mannequin, and therefore, students have faced a difficulty in understanding its content. As a solution, this

application has provided the three-dimensional practice form for the students to visualize the anatomy of a two-dimensional body shape [5].

Similarly, another research has been carried out to develop an AR mobile application to learn railway transportation. As mentioned in this research, this AR application has been tested among 18 users, and as per the results gained from the testing process, using the AR application has made its users to learn boring and difficult subjects in a more interesting way [6].

Another research has been carried out about applying augmented reality technology using a marker-based approach in E-learning system for transmitting virtual objects into the real-world scenes. According to this research, there are two approaches for transmitting virtual objects into the real-world scene: Marker-based and Monitor-based registration approach. Finally, the research has indicated that a subject which is explained using several pages can be eliminated by replacing it with a small marker [7]. In another research carried out by Kamalika Dutta, the benefits and the detriments of AR with regard to e-learning have been emphasized. Furthermore, this research has explained some relevant aspects which are need to be considered in order to identify the true benefits of the AR technology in order to improve the learning processes [8]. Similarly, V. Camilleri and M. Montebello have emphasized in their research that the industrial-age approach has added barriers between the "classroom" setting and the real world, and AR is one of those powerful technologies which can break these barriers. Moreover, the following advantages of AR have been mentioned in the research [9].

- Flow in balancing inactivity and challenge.
- Repetition allowing learners to repeat their experimentation until they are satisfied with the outcomes.
- Experimentation in encouraging learners to try and learn in the process.
- Experience which is more engaging than other digitally mediated technologies.
- Doing through practice.
- Observing through an essential communication platform.
- Motivation stimulated by the people's own active part.

Apart from the above-mentioned researches, another research has presented four applications developed using augmented reality for e-learning; two has focused on collaborative work of students

and the other two on biology and geography. As mentioned in the paper, the use of images, 3D models, sounds and animations are the important factors in AR which get the attraction from the students, and it is effective more than the classical teaching methods. The paper has explained further that these augmented elements allow students to retain new information more easily, and tests designed as games contribute to reduce their stress. This paper has mainly focus on indicating the use of augmented reality in order to improve the communication and collaboration skills between children, especially autistic children, and the game-based evaluation of pupils in various teaching areas, allowing for a stress free testing environment [4].

According to the above-mentioned facts, it is clear that AR is one of the most effective and powerful technologies which can be used to improve the field of education. Also, it is evident that, in Sri Lanka, this technology is still not being used for the purpose of enhancing the education of our children. Therefore, implementing an AR application can be highly important for Sri Lankan students, and it can surely be useful to obtain the educational advancements, and encourage the students for learning.

### III. METHODOLOGY

This application facilitates both Sinhala and English languages and consists of four main components such as Human Anatomy, Plant Organization, Acids, and Biosphere Cycles. Following Fig 2 shows the overview of the implemented system.

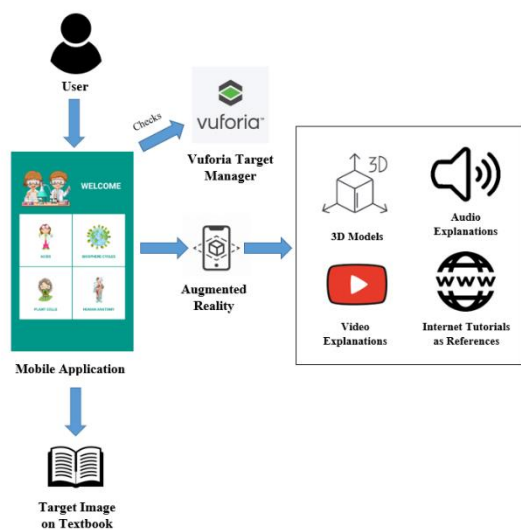


Fig. 2. System Diagram of “Science Zone” Application

Unity was used to develop the application and Vuforia was used as the database while Sketch Up and Blender 2.8 3D were used to create the 3D models. C# scripts were written to rotate 3d models (Fig. 3), to provide access to URLs, to navigate through button clicks (Fig. 4), to enable back button to load the previous scene.

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

public class NewBehaviourScript : MonoBehaviour
{
    //speed of rotation
    float speed = 50.0f;

    // Start is called before the first frame update
    void Start()
    {
    }

    // Update is called once per frame
    void Update()
    {
        transform.Rotate(Vector3.right * speed * Time.deltaTime);
    }
}
```

Fig. 3. C# Script to Rotate the 3D Model

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine.SceneManagement;
using UnityEngine;

public class buttonClick : MonoBehaviour
{
    public void changemenuscene(int index) {
        SceneManager.LoadScene(index);
    }
}
```

Fig. 4. C# Script to Navigate through Button Clicks

#### A. Human Anatomy

Human anatomy has three main categories. Those are Animal Cell, Digestive system and Urinary system. Under Animal Cell section it demonstrates cell overview and generates text-based descriptions. When student points the camera on animal cell image in text book, Application Displays the 3d model of the animal cell and describe the Animal cell organization with audio explanation to be played on the background and generate text-based descriptions. Animal cell and the Urinary System will be displayed using augmented reality as shown in Fig. 5 and Fig. 6 respectively.

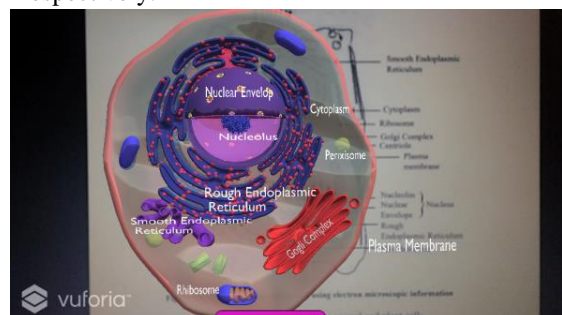


Fig. 5. 3D Model of Animal Cell

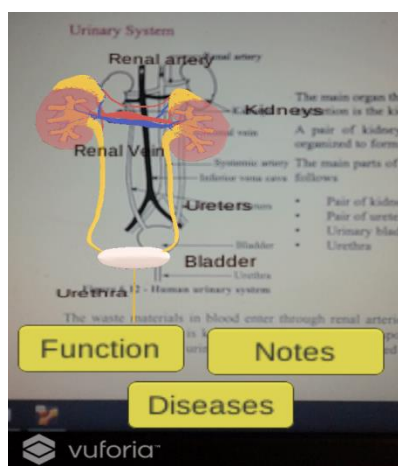


Fig. 6. 3D Model of Urinary System

Under Urinary and Digestive Systems System Overview, Function of the system (Digestion and Urine Formation), Additional Notes and Diseases related to Both Systems are being demonstrated using augmented reality. When student points the camera to the structure of the digestive system or the Urinary system images in the text book, System overview displays the 3d model of the respective system and describe the structure of each system with audio explanations to be played on the background. Also functions describe Digestion or Urine Formation processes using video explanations, Additional Notes option generates text based descriptions related to the systems and describe common diseases of the systems with the text based explanations and access to online tutorials.

### B. Plant Organization

This component focuses mainly on three categories Plant Cell Structure, Process of Photosynthesis and the experiments related to the process of Photosynthesis. This component covers the organization of the plant cell, Photosynthesis Process and experiment related to production of Oxygen during Photosynthesis. Once the student points the device's camera on plant cell image in the text book the application displays a labeled 3D model of a plant cell including special notes and the functionalities of each cell organelles with audio explanations to be played on the background. This mobile application facilitates the students to learn either in Sinhala or English according to their preference. Images from the Ordinary Level text book have been taken as the image targets to detect these 3D models. Once the student points the device's camera on the image of Photosynthesis process in the text book, the application displays

video explanations on Photosynthesis process with audio. When the student points the device's camera on the experiments related to production of Oxygen during Photosynthesis process in the text book, the application displays video explanations on the experiment with audio.

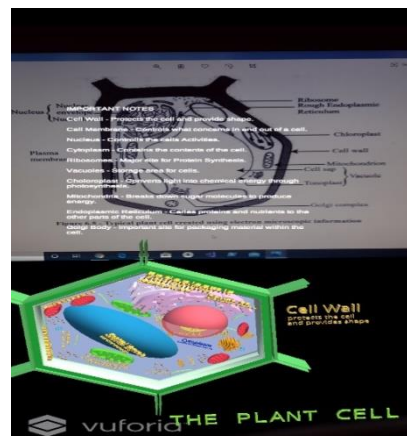


Fig. 7. 3D model of Plant Cell including Special Notes and the functionalities of each Cell Organelles

### C. Acids

The main aim of this component is to teach students acids in the O/L syllabus using an interactive manner. In order to do this, we have used augmented reality to cover the areas specific to acids. Content related to acids are demonstrated using AR in this component. Formulas and equations in the grade 11 science text book are used as image targets in this component. Once a student captures an image of a chemical formula of an acid which is available in the text book our application will identify it and will be matched with a suitable 3D model stored in the Vuforia database. The 3D model of the molecular formation of the acid will be displayed over the captured image using augmented reality. Additionally, an audio will be played with an explanation to the acid. If a student captures an equation of a reaction of an acid with an element in the above manner a video of an experiment will be played using augmented reality to explain the reaction.

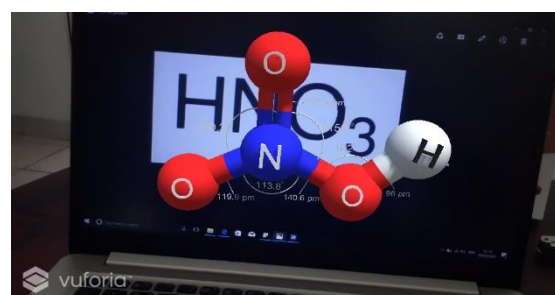


Fig. 8. 3D Model of Nitric Acid



#### D. Biosphere Cycles

Under “Biosphere Cycles” mainly two cycles have been discussed: Carbon cycle and Nitrogen cycle. Using this part of the application, students can view 3D models for the above cycles while listening to an audio explanation playing in the background. In order to do that, phone camera should be pointed to the relevant cycle image in the textbook. The application facilitates students to learn these cycles in Sinhala and English languages, and they can choose it according to their preference. This application also provides a set of questions related to the two cycles which will help students to measure their knowledge. They can attempt these questions before or after learning the cycles, and the application allows students to view their results after completing the quiz. It will be a massive support for them to identify their knowledge about these cycles. Following Fig. 9 shows how the application will display the 3D model of the Carbon cycle.

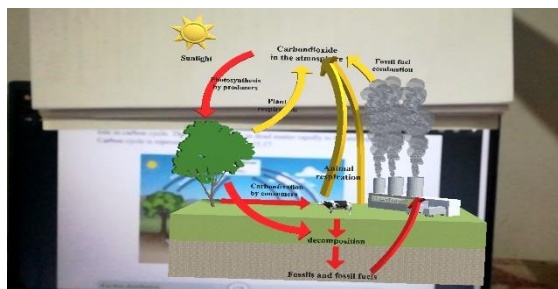


Fig. 9. 3D Model of Carbon Cycle

#### IV. DISCUSSION

The main expected outcome of this research is to provide an interactive method for G.C.E O/L students to learn science and score higher grades at their examination

"Science Zone" mobile application was given to randomly selected ten science teachers and twenty grade 11 students along with a questionnaire in order to obtain their feedback for the application. The table 1 and 2 show the results of the survey done with both students and teachers.

TABLE I.  
SUMMERISED RESPONSES OF STUDENTS

Comment	Accepted Percentage
Easy to use	83%
More interesting than reading	81%
Using AR was effective	75%
Attractive user interfaces	92%

TABLE II.  
SUMMERISED RESPONSES OF TEACHERS

Comment	Accepted Percentage
Appropriate for students	85%
Align with the subject content	82%
User friendly	90%

According to the collected responses of the survey, most of the students stated that this application was easy for them to work with. Moreover, 90% of the teachers who participated for the survey were also satisfied with the app and stated that it was user friendly. 81% of the student participants have felt more interested in learning science with the app rather than reading the textbook. General idea of most of the teachers who participated in the survey was that the application is properly aligned with the syllabus and appropriate for students to use.

While considering the overall survey results, it indicates that "Science Zone" would be an application which can satisfy the common requirements of the students, and it would help them in gaining interest in science and in obtaining higher grades in future.

#### V. CONCLUSION

The main intension of this research was to develop a mobile application to overcome the drawbacks of teaching science for G.C.E O/L students in Sri Lanka using traditional methods. The application is basically based on an augmented reality-based approach to teach science for O/L students. The key concepts of the grade eleven science syllabus are being focused on this research. The final product which is a mobile application consists of four major components as animal systems using augmented reality, Plant systems using augmented reality, acids using augmented

reality and bio spherical cycles using augmented reality.

We have evaluated the performance of the application and the results show that the final product would be more effective for O/L students to grab even more advanced concepts of science rather than learning using traditional methods. Also, this application would be a tremendous support for students with low laboratory facilities to get an understanding of their practical.

## VI. FUTURE WORK

Current application is focusing only on the key concepts of the G.C.E O/L syllabus. This can be improved to cover the entire O/L science syllabus and even further developments can be done to expand the application for all the grades and all the subjects.

Another recommendation is to add virtual reality with an addition to augmented reality in this application. So, students will get the ability to get a real-world experience while using this product. It would be more realistic in demonstrating the practical concepts using virtual reality.

## VII. ACKNOWLEDGMENT

Several people played a major role in making our research a success. First, we would like to thank Sri Lanka Institute of Information Technology for giving us the opportunity to carry a real research which helped us a lot to refresh all the concepts which we learnt throughout our degree. Also, we would like to thank the students and teachers who helped us by spending their valuable time in participating in our survey. The support we received from all parties is highly appreciated.

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