# SCIENCE APP FOR O/L STUDENTS USING AUGMENTED REALITY

2020 - 160

BSc (Hons) in Information Technology

Specialising in Software Engineering

Department of Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

September 2020

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Dissertation submitted in partial fulfilment of the requirements for the B.Sc. Degree in Information Technology Specialising in Software Engineering

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## DECLARATION

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## ABSTRACT

After investigating the G.C.E ordinary level results of Sri Lankan students for past few years we were able to identify that the pass rate of science is comparatively low than other compulsory subjects and even among the passed students most of the students have scored average grades. An unsatisfactory amount of students had been able to score higher grades. This is because science is a hard subject due to its abstract and complex nature. The main intention of this research is to uplift science results by providing an attractive way for studying science. So the research is targeting to attract students towards the subject by using visualisation techniques. The research is involved in developing a series of lessons related to the O/L syllabus using different techniques relevant to augmented reality. The survey conducted on behalf of the research proved that most of the O/L students would like to learn science using 3D technology instead of traditional approaches. The availability of 3D models, animations and conversion of detailed descriptions into augmented videos by the application will enhance the science knowledge of students.



*Key words : Augmented reality , visualisation techniques , G.C.E ordinary level.*

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# 1. INTRODUCTION

## 1.1 Background Literature

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 have been used for 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 study 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 [1].

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 [2].

Another research has been carried out about applying augmented reality technology using a marker-based approach in the 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 [3].

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 need to be considered in order to identify the true benefits of the AR technology in order to improve the learning processes [4]. 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 [5].

- Flow in balancing inactivity and challenge.
- Repetition allows 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 studies, 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 more effective 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 focused 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 [6].

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.

### 1.2 Research Gap

In different countries, different researches have been carried out to enhance the educational level of their students using AR, but in Sri Lanka, it has not been used. Therefore, a huge gap can be seen between the existing applications and the new application. The following table is a summarized comparison that shows the gap in order to emphasize the importance of the newly implemented application.

Table 1: Comparison between the New Product and the Existing Applications

| Existing Research and Applications | Ability to visualize the textbook objects using 3D models | Audio Support | Provides both Sinhala and English Audios | Relevant to the O/L Syllabus |
|---|---|---|---|---|
| Augmented Reality Mobile Application to Enhance Sinhala Learning Experience for Children | ✓ | ✓ | Sinhala Only | ✗ |
| Anatomiar | ✓ | ✗ | ✗ | ✗ |
| GeoAR | ✓ | ✗ | ✗ | ✗ |
| Digital Anatomy | ✓ | ✗ | ✗ | ✗ |
| Spellbound | ✓ | ✗ | ✗ | ✗ |
| ARBio | ✓ | ✓ | English Only | ✗ |
| New Product | ✓ | ✓ | ✓ | ✓ |

### 1.3 Research Problem

National Examinations department statistics of the previous two years [9] show that the amount of students who have passed science is comparatively lower than other main subjects.

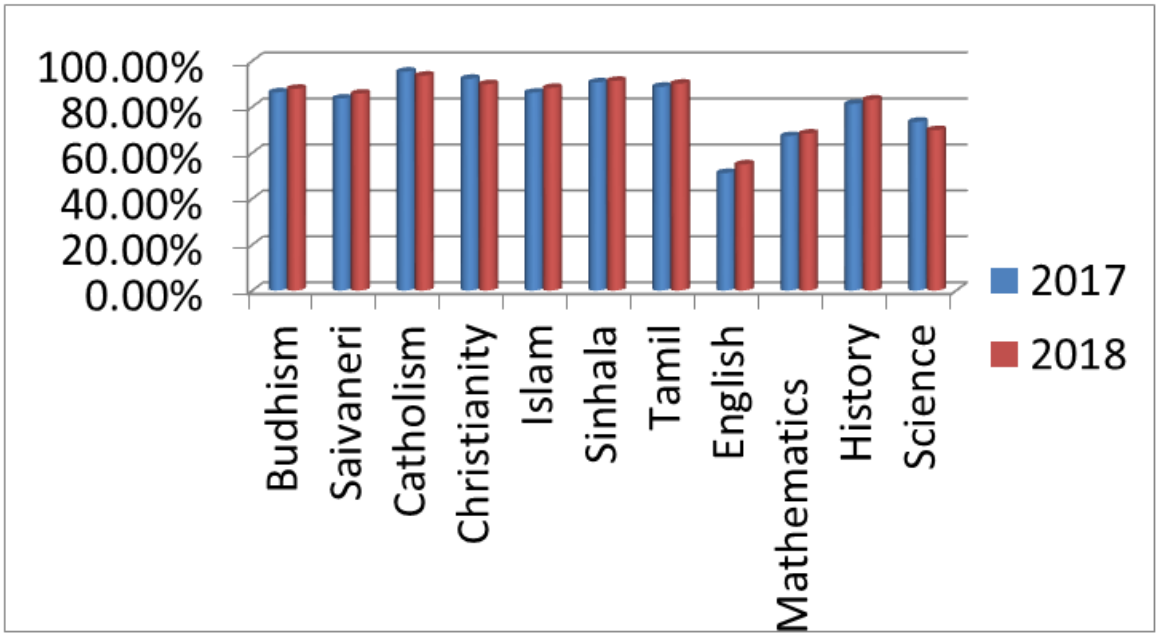


Figure 1: Passed percentage of compulsory subjects during previous two years [9].

Figure 1 depicts that the amount of students who have passed science is somewhat low than other major subjects and Figure 1 depicts that the amount of students who have scored higher grades at the ordinary level examination is low. Most of the students have scored average grades (c and s).

There are several reasons for the inability of most of the students to score higher grades in science.

- The concepts of science are complicated and hard to understand.
- Some students are not much interested in studying science.
- Lack of proper practical experience as some schools are not having proper lab facilities.

The survey we conducted in order to gather requirements for our research shows the value of using 3D technology in learning science.


Figure 2: Difficulties in studying Science

Figure 2 shows that about 71% of the students who took part in the survey are having difficulties in studying science.

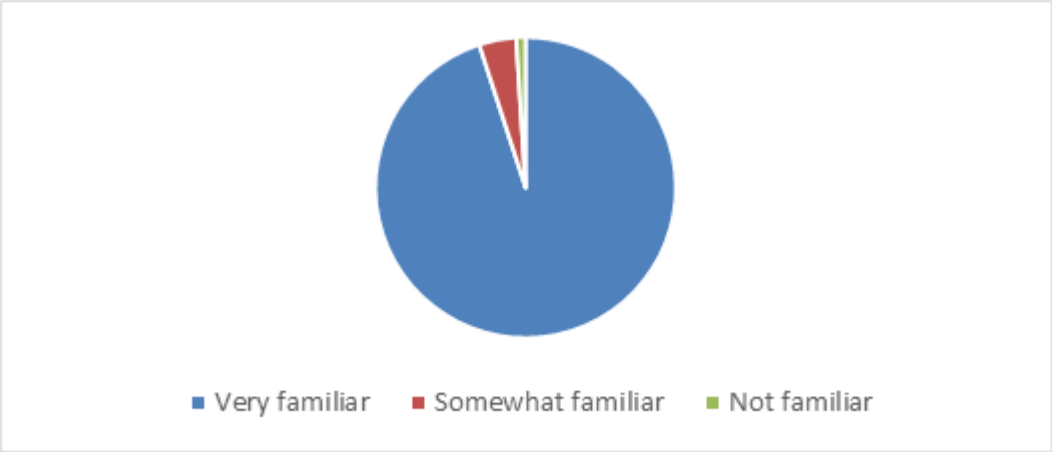


Figure 3: Usage of Mobile phones among O/L students

Figure 3 shows that mobile phone usage is not a new thing for O/L students.So using a mobile application will not be a hard task for students.

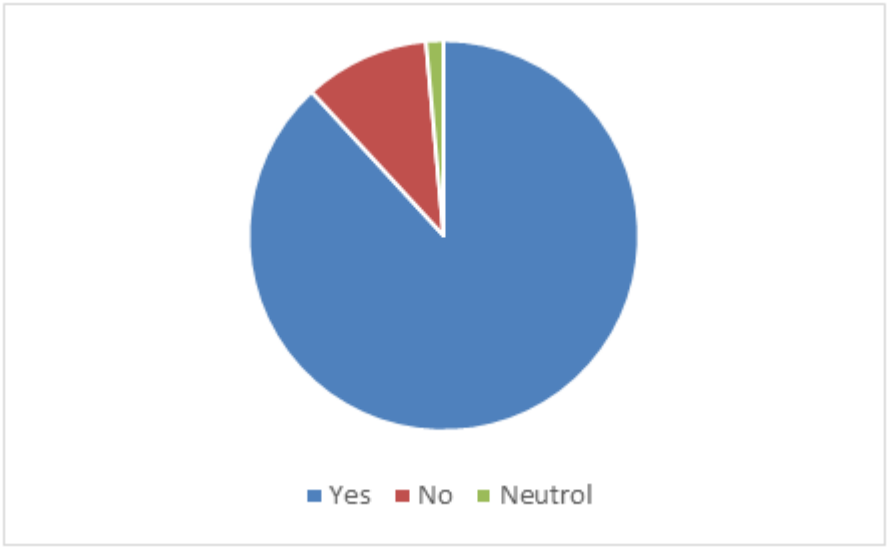


Figure 4: Students desire to use 3D technology to learn science.

Figure 4 shows that most of the students would like to learn science using 3D technology.

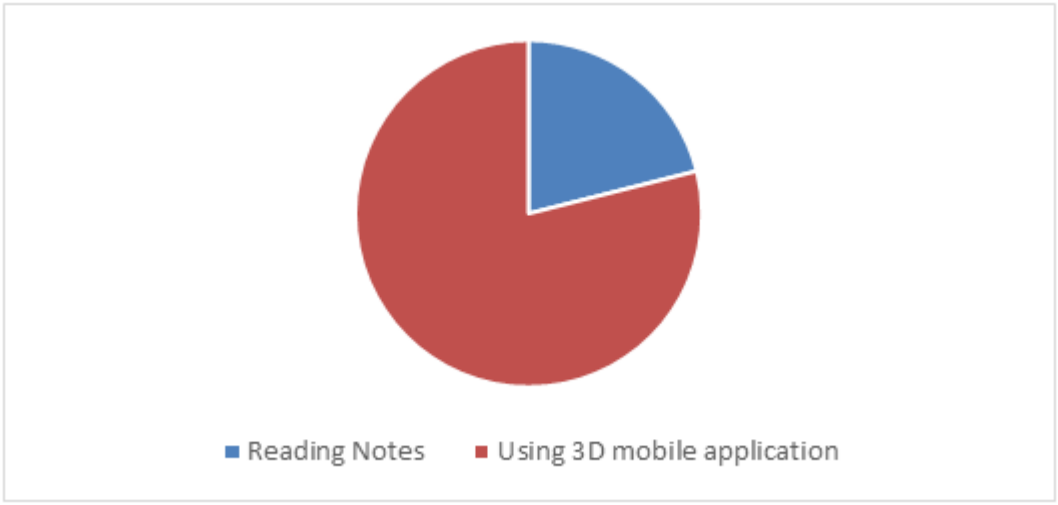


Figure 5: Convenient way of Studying science

Figure 5 show that most of the students are interested in using a 3D application to study instead of reading long notes. According to our survey results mentioned above we can ensure that our proposed application will definitely be a great support to uplift O/L results in Sri Lanka.

## 1.4 Research Objectives

### 1.4.1 Main Objective

Main Objective of this research is to improve G.C.E ordinary level science results by introducing an augmented reality based self-learning mobile application.

### 1.4.2 Specific Objectives

- Language support on both Sinhala and English
- AR support on Plant bodies

  Students can learn about organization of the plant cell, Photosynthesis Process and experiment related to production of Oxygen during Photosynthesis by generating 3d models, while playing audio in the background and some special notes need.

- AR support on Human anatomy

  Students can learn about organization of the animal cell, structure of the digestive system , structure of urinary system, digestion process, urine formation and important notes regarding animal cell , digestive system and urinary systems by generating 3d models while playing audio in the background, videos and text - based descriptions using augmented reality.

- AR support on acids

  Students can learn about Nitric acid, Sulphuric acid and hydrogen are mainly discussed in the component related to acids. 3d model of the molecular structure of that particular acid. And this application demonstrates reactions of the above mentioned acids with elements, using augmented videos.

- AR support on biosphere cycles

  Students can learn about carbon cycle and nitrogen cycle.students can view 3D models for the above cycles while listening to an audio explanation playing in the background.

# 2. METHODOLOGY

## 2.1 Methodology

The developed solution for the problem discussed above is a mobile application which uses augmented reality to support ordinary level students in Sri Lanka in their science subject. Augmented reality is the technology used in the app to teach even hard concepts in an interactive way. A survey was carried among several O/L students in Sri Lanka to investigate the areas which most of the students need support in their Science subject. The analysed results of the survey were considered in developing the application. The developed mobile application was implemented as a combination of four major components. Those are,

- AR support on the study of the human body
- AR support on the study of plant bodies
- AR support on studying about acids
- AR support on the study of the biosphere.

All these four components are providing AR support for students in studying the relevant areas of the O/L Science syllabus. Augmented reality is a growing field of technology and using it in elearning purposes provides the ability to demonstrate even complicated concepts using an attractive manner. So this application would be helpful to provide an effective method for O/L students to easily grab even harder concepts of their Science syllabus easily. This will also create an interest among O/L students to study Science due its attractive nature of teaching.

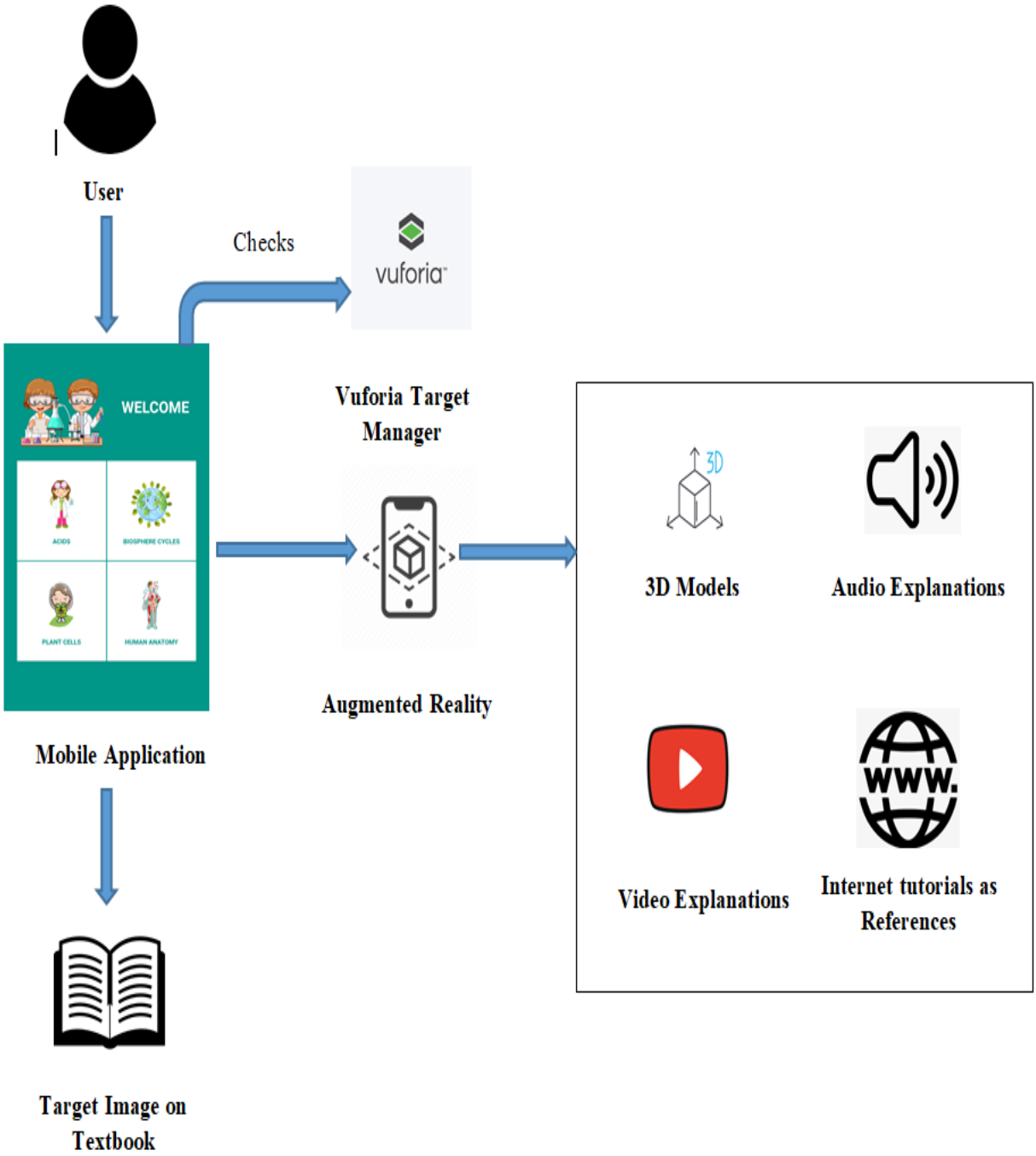


Figure 6: High Level Architecture

Figure 6 depicts the system architecture of the entire application. The four components of the application are further discussed below.

### 2.1.1 Human Anatomy

Human anatomy has three main categories. There are Animal Cell, Digestive system and Urinary system. The Animal Cell section describes cell overview and generates text based descriptions. When a student points the camera on animal cell image in a text book, application Displays the 3d model of animal cell and describes the Animal cell organization with audio and generates text based descriptions according to Fig.7 and Fig.8.

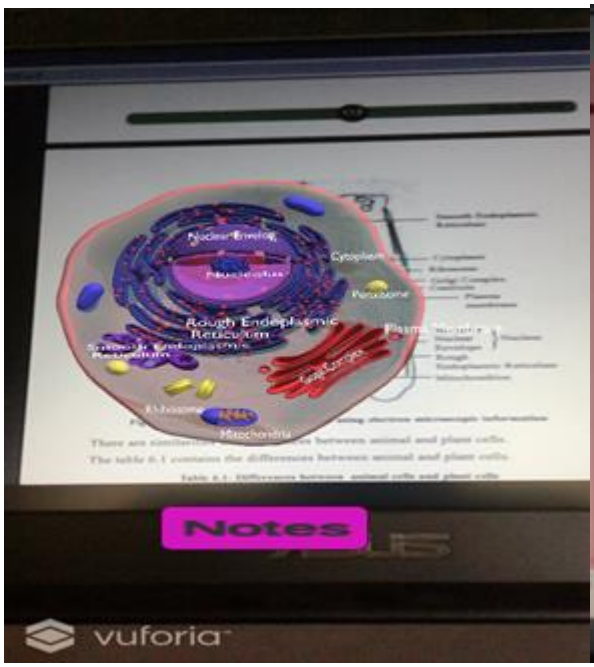


Figure.7: 3D model of Animal Cell

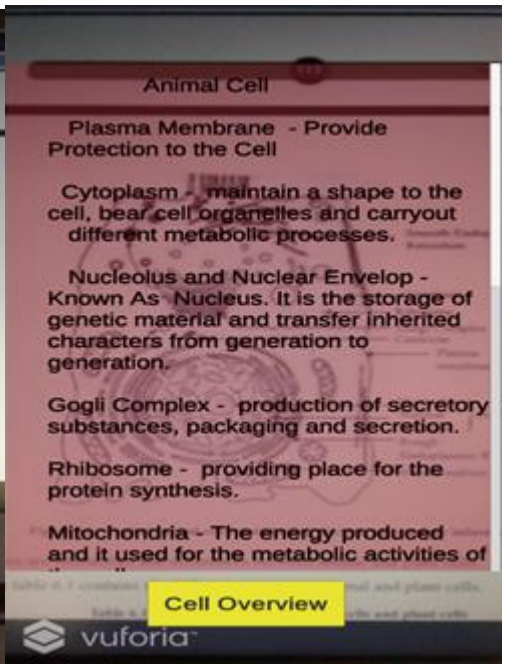


Figure.8: Notes in Animal cell

Urinary system and Digestive Systems describes System Overview, Function of the system (Digestion and Urine Formation), Additional Notes and Diseases related to Both Systems. When student points the camera to structure of digestive system or Urinary system images in text book, System overview displays the 3d model of

digestive system or Urinary system and describe the structure of the each system with audio explanations, Functions describes Digestion or Urine Formation processes using video explanations, Additional Notes option generate text based descriptions related to systems and describe diseases related to systems with the text based explanations and access to online tutorials..

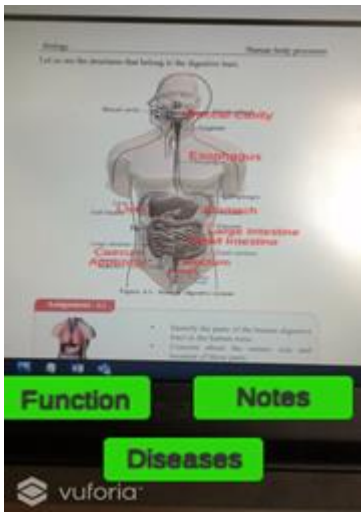


Figure 9: 3D model of digestive system

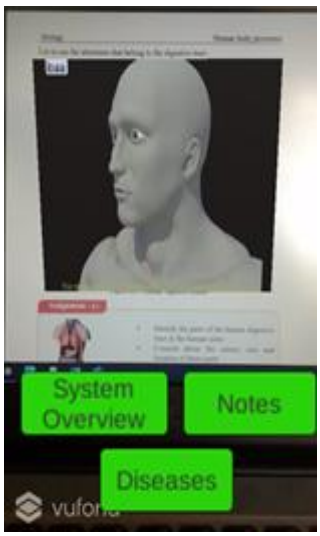


Figure 10: video explanation of digestion process


Figure 11: Description about diseases related to Digestive System

### 2.1.2 Plant Cell Structure

This component covers mainly three categories as 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 a plant cell image in the textbook the application displays a labelled 3D model of a plant cell including special notes and the functionalities of each cell organelles while listening to audio explanations playing in the background. This mobile application facilitates the students to learn either in Sinhala or English according to their preference.

#### A. 3D model demonstration of plant cell using augmented reality

Once the user captures the image of the plant cell on the textbook. It displays the labelled 3D model of Plant Cell with audio explanations playing on the background. Similarly the zoom feature is enabled to view the 3D model by scaling the 3D model on the image target including special notes which are important to the users that need to be noted.

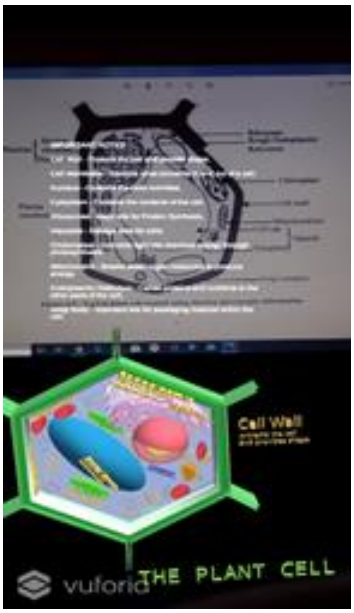


Figure12: 3D model of the plant cell

**B. Playing video on an image target**

Once the user captures the image of Photosynthesis process and image of oxygen production during photosynthesis, on the textbook. It displays the videos related to Photosynthesis using augmented reality, which explains the Photosynthesis process in an attractive and interactive way. Accordingly, audio played in the background gives a brief understanding about the concept more clearly.

### 2.1.3 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. When the camera detects the 2D image of the Carbon cycle it will display a 3D Carbon cycle model. Also, when the camera detects the 2D image of the Nitrogen cycle it will display a 3D Nitrogen cycle model. The 2D images of the two cycles are stored in the Vuforia database as the markers, and the 3D models will be displayed when the camera identifies the exact marker in the textbook. Moreover, the application facilitates students to learn these cycles in Sinhala and English languages, and they can choose it according to their preference. Also, it provides the notes related for the two cycles. The following Fig.13 shows how the application will display the 3D model of the Carbon cycle.

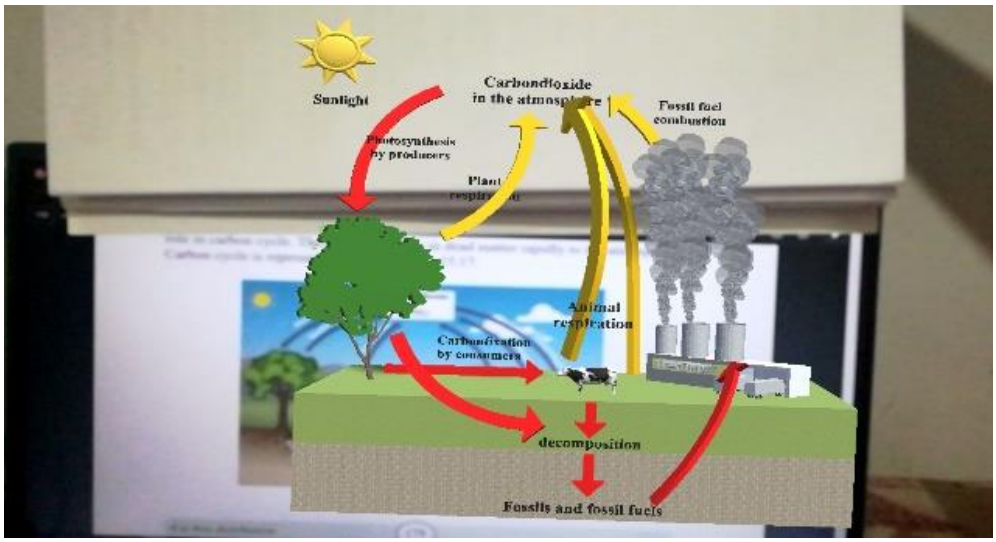


Figure 13. 3D Model of Carbon Cycle

### 2.1.4 Acids

The Acids component is a solution to provide support for students in studying the lessons relevant to acids in the Science syllabus. The component is using augmented reality to cover the content relevant to acids. The component is developed in a manner which can provide students an engaging experience on the content and also students will be able to get a practical experience even without using any lab equipment.

According to the task performed the component is subdivided into three sub components.

- Visualisation of acidic bonds using augmented reality.
- Demonstrating experiments for the reactions between acids and elements.
- Converting descriptions on productions done by acids, into image slideshows using augmented reality.

This component will demonstrate the molecular structure of acids, productions done by acids and the reactions between acids and elements using 3D models, animations,

videos and audios. The underlying technology which was used to fulfil these tasks was augmented reality.

### A. Demonstrating 3D models using augmented reality

This feature was used to demonstrate the molecular structure of acids. Once the user captures a formula of an acid the application will identify the captured formula and a suitable 3D model will be retrieved from the Vuforia database and it will be displayed on top of the captured formula.

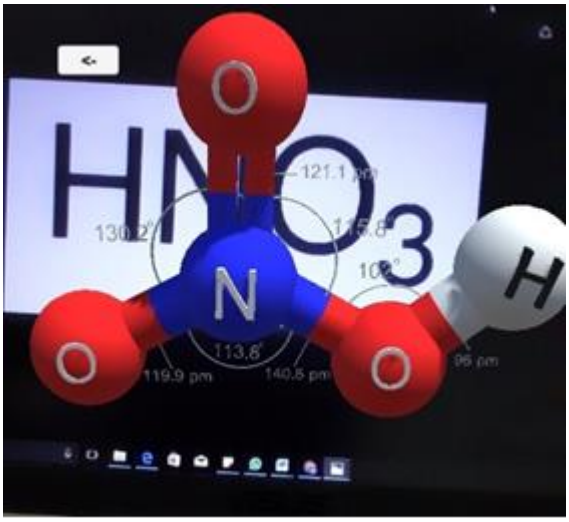


Figure 14: 3D model of an acid

Figure 2.3 shows how the 3D model of the HNO3 acid is displayed using augmented reality once the application identifies the formula of HNO3 using the mobile camera.

The application will play animations when displaying 3D models with the intent to make the demonstrations more attractive. C# scripts were written to enable animations to 3D models.

```
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);

    }
}
```

Figure 15: C# scripts to enable rotations

Figure 2.4 shows the C# script which was used to rotate 3D models which will be displayed using augmented reality.

**B. Playing videos/ audios on an image target using augmented reality**

Once the user captures an equation of a reaction between an acid and an element an experiment will be demonstrated using augmented reality. This will be useful for students with less laboratory facilities. Even without any materials they can get an experience on the experiments related to acids in the O/L syllabus.

Audios are also played along with the AR content in order to give students the ability to understand the concepts more clearly. The content in the textbook relevant to acids will be presented in a more attractive and simplified way by combining audios to the AR demonstrations.

### C. Image slideshows using augmented reality

This feature was used to convert detailed text based descriptions into attractive image slideshows using augmented reality. Once the user captures a detailed text based description about the production of a particular acid an attractive image slideshow will be played using augmented reality. This would be more effective than reading detailed descriptions.

## 2.2 Commercialisation aspects of the product

This application is a Science Augmented Reality mobile application for Ordinary Level students. Augmented Reality is a technology which is capable of creating an attractive and interactive learning environment to the students to learn even deeper concepts in an effective and productive way. Main objective of the proposed application is to apply advancement of technology to educational context in order to create an interactive learning environment going beyond the traditional learning environment. By referring to existing apps for E-learning it is clear that Audio visualization has become the most effective method of learning than learning through printed materials such as papers, books, and short notes. So the proposed application will guide the user with audio instructions and visualize contents using technology. So this application focuses mainly to bridge the gap between learning through online content and learning through printed material.

The existing apps for E-learning use only English as the language. Therefore in order to bridge the gap between languages the application has been implemented in both Sinhala which is the native language of Sri Lanka and English. So that the user will be able to learn science using a preferred language either Sinhala or English. During a pandemic situation as present this application will guide the students to cover up the contents in the syllabus through self-learning. Although Science is a practical

subject this application has been recommended for schools in remote areas to overcome the limitations occurring during the practical sessions.

### 2.3 Testing and Implementation

The application was implemented using Unity 3D which is a powerful IDE used in AR development. Vuforia was used as the database to store image targets and Blender was used to develop 3D models. C # scripts were developed to perform various AR features. Microsoft planner was used to plan the task of the research and a Git lab repository was used to maintain the code of the developed application. The GitLab repository was partitioned into four branches separately for the four components of the application. Once the implementation was completed we were able to successfully integrate the application without any merge conflicts.

Parallel to the implementation process testing was also carried out in different methods. Unit testing was carried out to ensure that the application might not have severe errors at latter stages. Each component underwent component testing after the completion of implementation and finally after all the four components were completed integration testing was carried out. Following are some test cases designed for each component.

#### 2.3.1 Human anatomy

Table 2: Checks the language support

| | |
|---|---|
| Test Case ID | 01 |
| Description | Language support on both Sinhala and English languages |

| | |
|---|---|
| Pre - condition | User should navigate to the Human Anatomy Home page and clicks “START” button |
| Steps | 1. User chooses a language<br>2. User selects a preferred option from “Select an option” page<br>3. User chooses preferred sub option provided in selected option |
| Expected Output | Audio explanations, video explanations and text based descriptions should given from the language which was selected by the use. |
| Actual Output | Audio explanations, video explanations and text based descriptions demonstrated from the language which was selected by the use |

Table3 : Accessibility of mobile device’s camera

| | |
|---|---|
| Test Case ID | 02 |
| Description | Accessibility to device’s camera |

| | |
|---|---|
| Pre - condition | User should navigate to the Human Anatomy Home page and clicks “START” button |
| Steps | 1. User chooses a language<br>2. User selects to preferred option from “Select an option” page<br>3. User chooses proffered sub option provided in selected option<br>4. Opens the device camera<br>5. Capture the image target |
| Expected Output | The mobile device’s camera should open successfully. |
| Actual Output | The mobile device’s camera opened successfully. |

Table 4: 3D models generated while audio explanation

| | |
|---|---|
| Test Case ID | 03 |
| Description | 3D model display while audio explanation |
| Pre - condition | User should navigate to the Human Anatomy Home page and clicks “START” button |

| | |
|---|---|
| Steps | 1. User chooses a language<br>2. User selects preferred option from “Select an option” page<br>3. User chooses “Cell overview” or “System Overview” in according to the selected sub option provided in selected option<br>4. Opens the device camera<br>5. Capture the image target |
| Expected Output | 3D model of animal cell, digestive system or urinary system and audio explanation should generate. |
| Actual Output | 3D model of animal cell, digestive system or urinary system and audio explanation generated. |

Table 5: Video displaying on process related to digestive and urinary systems

| | |
|---|---|
| Test Case ID | 04 |
| Description | Process regarding to digestive and urinary system explained using video |
| Pre - Condition | User should navigate to the Human Anatomy Home page and clicks “START” button and choose language |

| | |
|---|---|
| Steps | 1. User selects an option either digestive system or urinary System<br>2. User selects “Digestion Process” or “Urine Formation” option in relevant pages<br>3. Opens the device camera<br>4. Capture the image target |
| Expected Output | Video should displayed using augmented reality. |
| Actual Output | Video displayed using augmented reality. |

Table 6: Notes displaying related to animal cell, digestive and urinary systems

| | |
|---|---|
| Test Case ID | 05 |
| Description | Notes display regarding each section. |
| Pre - Condition | User should navigate to the Human Anatomy Home page and clicks “START” button and choose language |

| | |
|---|---|
| Steps | 1. User selects an option either animal cell, digestive system or urinary System<br>2. User selects “Notes” or “Additional Notes” option in relevant pages<br>3. Opens the device camera<br>4. Capture the image target |
| Expected Output | Notes should generated using augmented reality. |
| Actual Output | Notes generated using augmented reality. |

Table 7: Note generation of Diseases

| | |
|---|---|
| Test Case ID | 06 |
| Description | Diseases display as notes regarding to digestive system or urinary system. |
| Pre - Condition | User should navigate to the Human Anatomy Home page and clicks “START” button and choose language |

| | |
|---|---|
| Steps | 1. User selects an option either digestive system or urinary System<br>2. User selects “Gastritis” or “Kidney Stones” option in relevant pages<br>3. Opens the device camera<br>4. Capture the image target |
| Expected Output | Notes regarding gastritis or kidney stones should be generated using augmented reality. |
| Actual Output | Notes regarding gastritis or kidney stones generated using augmented reality. |

Table 8: Accessing online video tutorials

| | |
|---|---|
| Test Case ID | 07 |
| Description | Online video tutorial access to learn about diseases display regarding the digestive system or urinary system. |
| Pre - Condition | 1) User should enable Internet on the device<br>2) User should navigate to the Human Anatomy Home page and clicks “START” button and choose language |

| | |
|---|---|
| Steps | 1. User selects an option either digestive system or urinary System<br>2. User selects “Gastritis” or “Kidney Stones” option in relevant pages<br>3. Opens the device camera<br>4. Capture the image target<br>5. User select further references button |
| Expected Output | Online video tutorials regarding gastritis or kidney stones should be generated using augmented reality. |
| Actual Output | Online video tutorial regarding gastritis or kidney stones generated using augmented reality. |

### 2.3.2 Plant organisation

Table 9: Display 3D model of plant cell

| | |
|---|---|
| Test case ID | 01 |
| Description | Detecting Plant cell image target |
| Pre -condition | · The system should be properly installed and connected to internet |

| | |
|---|---|
| | · The device camera should pointed towards the marker |
| Steps | 1. User selects the preferred language to learn<br>2. The application opens device camera<br>3. Point the device camera towards the marker |
| Input | Device camera captures plant cell image |
| Expected Output | Display 3D model of plant cell on the image target |
| Actual Output | Plant cell model displayed on the image target successfully. |

Table 10: Display background audio on plant cell marker

| | |
|---|---|
| Test case ID | 02 |
| Description | Testing whether the background audio displays correctly on each image target/marker |

| | |
|---|---|
| Pre -condition | · The system should be properly installed and connected to internet<br>· The device camera should pointed towards the marker |
| Steps | 1. User clicks Learn button<br>2. The application opens device camera<br>3. User points the device camera towards the marker |
| Input | Device camera captures plant cell image |
| Expected Output | Playing background audio when marker is detected |
| Actual Output | Playing background audio successfully when marker is detected |

Table 11: stop 3d model demonstration when marker lost

| | |
|---|---|
| Test case ID | 03 |
| Description | Testing whether the 3D model display stops when the image target/marker is lost. |
| Pre -condition | · The system should be properly installed and connected to internet<br>· The device camera should be away from the marker |
| Steps | 1. User clicks Learn button<br>2. The application opens device camera<br>3. User points the device camera towards the marker<br>4. User points the devices camera away from the marker |
| Input | Device camera removes from plant cell image |
| Expected Output | 3D model display stops when image target/marker is lost. |

| | |
|---|---|
| Actual Output | 3D model display stopped when image target/marker is lost. |

Table 12: stop background audio when marker lost

| | |
|---|---|
| Test case ID | 04 |
| Description | Testing whether the background audio explanations stops when image target/marker is lost. |
| Pre -condition | · The system should be properly installed and connected to internet<br>· The device camera should be away from the marker |
| Steps | 1. User selects Learn button<br>2. The application opens device camera<br>3. User points the device camera towards the marker<br>1. User points the devices camera away from the marker |
| Input | Device camera removes from plant cell image |

| | |
|---|---|
| Expected Output | Background audio explanations stops when the image target/marker is lost. |
| Actual Output | Background audio explanations stopped when the image target/marker is lost. |

Table 13: Sinhala and English language support

| | |
|---|---|
| Test case ID | 05 |
| Description | Checking language support |
| Pre -condition | User should navigate to Plant component |
| Steps | 1. User selects preferred language to learn<br>2. User navigates to the home page of the plant organization component.<br>3. User clicks Learn in English button |
| Input | 1. Image target<br>2. Preferred Language |

| | |
|---|---|
| Expected Output | Delivers learning sessions with user selected language |
| Actual Output | Delivers learning sessions with user selected language |

### 2.3.3 Acids

Table 14: Accessibility of mobile camera

| | |
|---|---|
| Test Case ID | 01 |
| Description | Checking accessibility to the mobile camera |
| Pre-condition | User should start the Acids component |
| Steps | 1. User chooses a language.<br>2. User selects a section.<br>3. Click the button to open the mobile camera. |
| Expected Output | The mobile camera gets opened successfully. |
| Actual Output | The mobile camera gets opened successfully. |

Table 15: 3D molecular structure of acids

| | |
|---|---|
| Test Case ID | 02 |

| | |
|---|---|
| Description | Identifying a formula of an acid |
| Pre-condition | User should start the Acids component. |
| Steps | 1. User selects a language.<br>2. User selects the molecular structures section.<br>3. Open mobile camera.<br>4. Captures a formula of an acid. |
| Input | Camera capture of an acidic formula. |
| Expected Output | 3D molecular structure of the acid using augmented reality. |
| Actual Output | 3D molecular structure of the acid using augmented reality. |

Table 16: Experiments using augmented reality

| | |
|---|---|
| Test Case ID | 03 |
| Description | Demonstrating experiments using augmented reality. |
| Pre-condition | User should start the Acids component. |
| Steps | 1. User selects a language.<br>2. User selects the molecular reactions section.<br>3. Open mobile camera.<br>4. Captures an equation of a reaction between an acid and an element. |

| | |
|---|---|
| | |
| Input | Camera capture of an equation. |
| Expected Output | The experiment relevant to the captured reaction using augmented reality. |
| Actual Output | The experiment relevant to the captured reaction using augmented reality. |

Table 17: Productions done by acids using augmented reality

| | |
|---|---|
| Test Case ID | 04 |
| Description | Converting detailed descriptions of productions of acids into attractive image slideshows using augmented reality. |
| Pre-condition | User should start the Acids component. |
| Steps | 1. User selects a language.<br>2. User selects the production section.<br>3. Open mobile camera.<br>4. Captures a detailed description about productions done by acids from the textbook. |

| | |
|---|---|
| Input | Camera capture of a description about productions by acids.. |
| Expected Output | Image slideshow based on productions done by acids using augmented reality. |
| Actual Output | Image slideshow based on productions done by acids using augmented reality. |

Table 18: Sinhala and English language support

| | |
|---|---|
| Test Case ID | 05 |
| Description | Ability to give instructions in any language either English or Sinhala. |
| Pre-condition | User should start the Acids component. |
| Steps | 1. User selects a language.<br>2. User selects a preferred section.<br>3. Open mobile camera.<br>4. Captures a suitable image target |
| Input | 1. Image target.<br>2. Language preference. |
| Expected Output | Instructions should be given from the language which was selected by the user. |
| Actual Output | Instructions should be given from the language which was selected by the user. |

### 2.3.4 Biosphere Cycles

Table 19: Test Case Table 01

| | |
|---|---|
| Test Case ID | 01 |
| Test Description | Checking whether the Carbon cycle interface is displayed when the Carbon cycle button is clicked |
| Pre-condition | User should select the Biosphere Cycle tab |
| Steps | 1. User clicks the *Carbon Cycle* button from the Biosphere cycle interface |
| Expected Output | Displaying the Carbon cycle interface |
| Actual Output | Displaying the Carbon cycle interface |

Table 20: Test Case Table 02

| | |
|---|---|
| Test Case ID | 02 |
| Test Description | Checking whether the camera gets opened automatically when a preferred language is selected. |
| Pre-condition | User should select the Biosphere Cycle tab |
| Steps | 1. The user clicks on the *Carbon Cycle* button.<br>2. The user clicks on the *Learn* button.<br>3. The user selects a language. |
| Expected Output | The camera gets opened automatically |

| | |
|---|---|
| Actual Output | The camera gets opened automatically |

Table 21: Test Case Table 03

| | |
|---|---|
| Test Case ID | 03 |
| Test Description | Checking whether the Carbon cycle 3D model is displaying when the marker is detected. |
| Pre-condition | User should select the Biosphere Cycle tab |
| Steps | 1. The user clicks on the *Carbon Cycle* button.<br>2. The user clicks on the *Learn* button.<br>3. The user selects a language.<br>4. The camera gets opened and the user points the camera to the 2D carbon cycle image in the textbook. |
| Expected Output | The 3D model of the Carbon cycle is displayed properly. |
| Actual Output | The 3D model of the Carbon cycle is displayed properly. |

Table 22: Test Case Table 04

| | |
|---|---|
| Test Case ID | 04 |
| Test Description | Checking whether the Nitrogen cycle 3D model is displaying when the marker is detected. |
| Pre-condition | User should select the Biosphere Cycle tab |
| Steps | 1. The user clicks on the |

| | |
|---|---|
| | *Nitrogen Cycle* button.<br>2. The user clicks on the *Learn* button.<br>3. The user selects a language.<br>4. The camera gets opened and the user points the camera to the Nitrogen cycle image in the textbook. |
| Expected Output | The 3D model of the Nitrogen cycle is displayed properly. |
| Actual Output | The 3D model of the Nitrogen cycle is displayed properly. |

Table 23: Test Case Table 05

| | |
|---|---|
| Test Case ID | 05 |
| Test Description | Checking whether the Sinhala audio explanation is played when the Sinhala language is chosen. |
| Pre-condition | User should select the Biosphere Cycle tab |
| Steps | 1. The user selects a cycle to learn.<br>2. The user clicks on the *Learn* button.<br>3. The user clicks on the *Sinhala* button.<br>4. The camera gets opened and the user points the camera to the relevant cycle image in the textbook. |
| Expected Output | Sinhala audio is playing properly |

| | |
|---|---|
| | along with the 3D model. |
| Actual Output | Sinhala audio is playing properly along with the 3D model. |

# 3. RESULTS AND DISCUSSION

## 3.1 Results

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.

Table 24: Summarized responses of students

| **Comment** | **Accepted Percentage** |
|---|---|
| Easy to use | 83% |
| Attractive user interfaces | 92% |
| More interesting than reading the textbook | 81% |
| Using AR was more effective | 75% |

Table 25:Summarized responses of teachers

| Comment | Accepted Percentage |
|---|---|
| User friendly | 90% |
| Appropriate for students | 85% |
| Properly aligned with the subject content | 82% |

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.

### 3.2 Research Findings

The research was carried out in order to provide support for O/L students in Sri Lanka in improving their Science results. As a result of the background study done at the beginning of the research we were able to find out that the Science results at the G.C.E O/L exam is somewhat low compared to other main subjects. A survey was done to find out the difficulties which O/L students are facing in getting good grades for Science. Some reasons were lack of proper lab facilities in rural areas and even some urban schools are also not having proper lab equipment to cover all the experiments in the O/L Science syllabus. Without getting a good practical experience it is hard to understand the concepts of the Science syllabus. Also for most of the students Science is a complicated subject to understand and they are not that much interested in studying Science. In order to solve this issue the research team decided to introduce a mobile application which uses Augmented Reality to teach Science.

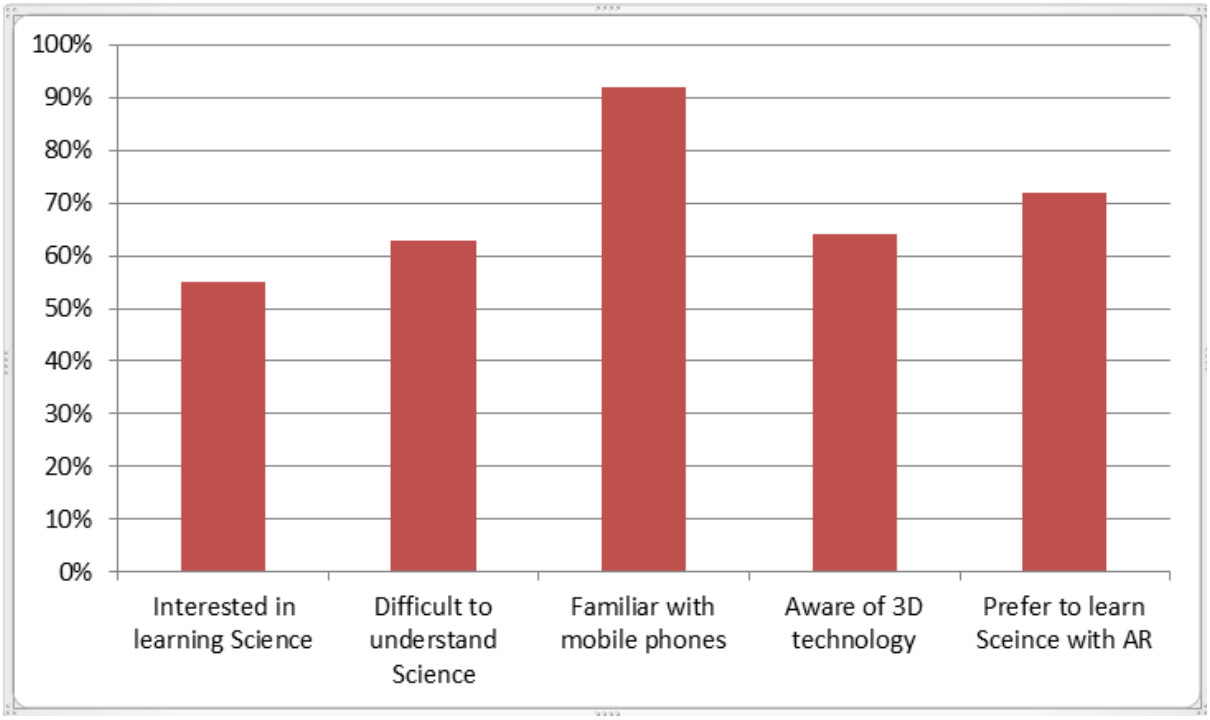


Figure 16: Initial survey findings

According to the survey results, only 55% of the students are interested in learning science. Among the students who are interested in learning science, some stated that

even though they are interested in the subject, it is difficult for them to score good grades. This is because science is a subject of high cognitive demand and it requires more practical experience in order to understand the concepts clearly. In Sri Lanka, most students are struggling to understand the subject due to a lack of facilities in schools to conduct lab sessions, and resources to gain advanced thinking. Therefore, it would be beneficial if there is a way for them to learn the concepts in science more simply in an interactive way.

Among the participants of the survey, 92% are familiar with mobile phones and 72% of the respondents prefer to use augmented reality to learn science. This is because nowadays the younger generation is very familiar with using new technologies and mobile phones. Therefore, this application would be easy for them to use. Also, it could provide the necessary knowledge about the science experiments in the textbook by using only a mobile phone, and it would be a solution for the lack of proper lab facilities in schools.

The application was developed considering the findings of the initial survey.

### 3.3 Discussion

This section discusses the challenges the research team had to face during various stages of the project and the steps taken to overcome those challenges. Additionally, this section discusses future improvements that can be applied to this application. The research was started at the beginning of November 2019 and the main intention of this research was to produce a solution for O/L students to improve their Science results. The research team did a thorough study on this area and finally decided to develop a mobile application that uses Augmented Reality to teach the important sections of the O/L Science syllabus. This decision was taken because Augmented reality is a technology which is having the ability to demonstrate even harder concepts in an attractive manner. Initially, a survey was carried among several Science teachers and grade 11 students from different schools to gather requirements needed to implement the solution. A literature survey was also carried to find out whether similar applications were already developed and the limitations of such existing applications.

After gathering requirements the solution was implemented consisting of four sub components as discussed above in the methodology. The plan was to hand over the application to several grade 11 students as well as Science teachers and get it tested and improve the application according to their feedback. But due to the sudden COVID 19 pandemic situation we were unable to meet teachers and students. But as a solution online demonstrations were done for several randomly selected teachers and students and their comments were collected to improve the application.

This application can be improved by providing virtual reality support in addition to AR support. So students can get a real world experience in their lessons through the application. Also this application can be developed to cover all the subjects of the O/L syllabus.

# 4. SUMMARY OF EACH STUDENT'S CONTRIBUTION

Table 26: Description of personnel and facilities

| Member | Component | Task |
|---|---|---|
| IT17107624<br>De Silva K.V.P.W | AR support on studying about acids | • 3D structures of the formation of acids in an acidic compound.<br>• Animated Demonstrations of the productions done by acids.<br>• Demonstrating the experiments based on the reactions between acids and other elements using AR |
| IT17106252<br>U.S Hettihewa | AR support on the study of plant bodies | • 3D demonstration of plant cell structure<br>• Photosynthesis process<br>• Production of oxygen during photosynthesis |
| IT17157988<br>Liyanage P.M | AR support on the study of the human body | • Demonstration of the animal cell<br>• Human body systems using AR |

| | | |
|---|---|---|
| IT17098588<br><br>N.M.W.K.P.C Naranpanawa | AR support on the study of the biosphere | • Demonstration of Carbon cycle and the Nitrogen cycle in the topic Biosphere using AR |

# 5. CONCLUSION

The solution is a mobile application developed 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 ten and eleven science syllabus are being focused on this research. And it mainly covers selected areas in biology and chemistry. The final product which is a mobile application consists of four major components as animal cell overview and human anatomy 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 an immense support for students with low laboratory facilities to get an understanding of their practical.

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