SCIENCE APP FOR O/L STUDENTS USING AUGMENTED REALITY – PLANT ORGANIZATION

Project Id: 2020-160

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B.Sc. (Hons) Degree in Information Technology

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DECLARATION

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Ms Uthpala Samarakoon Date

ABSTRACT

Over the last years, many information technologies have been applied to learning environments in an attempt to overcome limitations in traditional teaching environments. Augmented Reality is one of the latest technologies that offer virtual learning environment. In recent years, Augmented Reality has been used in various domains, from medical, entertainment, E-Learning, facial recognition, virtual friends, Internet of things. One of the important aspects of E-learning systems is user interaction. A user is forced to learn without any form of interaction when learning, has become a major drawback in traditional learning environment. As a result, they are likely to lose interest quickly, and the produced content may be forgotten after being learnt. Therefore advancement in wireless technology have raised interest on researches in the development of E-learning environments to enhance learner motivation and learning performance. As augmented reality is rarely been used for the field of education in Sri Lanka. In order to make it easier for students to study Science with greater passion and interest, it has been decided to develop an augmented reality based mobile application for Ordinary Level students. This study reports the use of augmented reality (AR) technology to generate virtual objects for use in mobile devices to create AR enabled application as a support for Ordinary Level students to study about plant bodies in an efficient and interactive way. The goal is to provide learners a friendly, interactive engaging media to enhance learning performance.

Keywords – Augmented Reality, Mobile Application, Marker based, E-Learning.

ACKNOWLEDGEMENT

Several people played a major role in making our research a success. First, we would like to thank Sri Lanka Institute of Information Technology and specially the CDAP team 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 our special thanks should go to our supervisor Mrs Uthpala Samarakoon and our co supervisor Mr Chathura Amarasena for their immense support and guidance given to us throughout our research. Their valuable ideas helped us a lot in making our research a success. Also we would like to thank the students who helped us by spending their valuable time in participating in our survey. The support we received from all parties are highly appreciated.

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LIST OF ABBREVIATIONS

AR – Augmented Reality

apk – Android Application Package

IDE – Integrated Development Environment

3D – Three Dimensional

2D – Two Dimensional

1. INTRODUCTION

1.1 Background Literature

Basically traditional classroom was carried out through face-to-face instructions where the learning activities were conducted by the teacher. Rapid advancement in Information Technology have created organized learning environment, going beyond the traditional classroom. According to the statistics of national examinations department [1] the science passed rate at the G.C.E ordinary level examination is comparatively lower than other compulsory subjects. Although the science content has become more advanced than the previous syllabus with new concepts to learn, it has been a major reason for the students for getting lower grades. One of the important aspects of E-learning systems is user interaction. A user is forced to learn without any form of interaction when learning, has become a major drawback in traditional learning environment. As a result, they are likely to lose interest quickly, and the produced content may be forgotten after being learnt. Nowadays Augmented reality has become growing field of Information Technology.

Augmented reality based mobile apps are an effective mode in E-learning as it is having the ability to demonstrate even deeper concepts in an attractive and interactive way. The proposed application is a mobile app for Ordinary Level Science subject which uses marker based Augmented Reality, where the user point the device's camera on a specific content of the textbook to learn the contents in the syllabus. This report mainly focuses on the support for the student's on the study of plant organization. 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 [2].

Since Science subject mostly goes with practical sessions, it will be easy to build an attractive learning environment. Moreover, it has its unique characteristics and benefits that are beneficial to support learning and make students more interested in learning. Since AR brings lots of benefits to the field of education, many researches have been carried out to emphasize its true usage in this field.

Athanasios S. Drigas and Pantelis Angelidakis together have carried out a research on the effects of usage of electronic devices in the field of education. As discussed in the research they have used selected mobile applications measure how effective is to use mobile devices in learning environment. A predefined measurements have been used to measure user satisfaction on using electronic devices in education. Whole research discussion was based on a questionnaire,

1) Can technology assist student learning?

2) How can an app be of use within education? [3]

At the end of the report it is concluded that E- learning encourages an anywhere – anytime learning habit and easy access to critical data which will take hours of search to find resources.

Apart from the above mentioned researches, the research carried out by Kamalika Dutta, the benefits and the detriments of AR with regard to e-learning has been emphasized. Furthermore, this research has explained some relevant aspects which is 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 have been added barriers between the "classroom" setting and the real world, and AR is one of those powerful technologies which can break these barriers. The following advantages of AR have been mentioned in the research.

- Experimentation in encouraging learners to try and learn in the process.
- Experiments on which is more engaging than other digitally mediated technologies.
- Motivation stimulated by the people's own active part [7].

"Cell world", which is an available app on play store gives the user a 3D view of an interior structure of a plant cell and helps to discover the details of each cell part by navigating in game-like fashion to the Nucleus, Mitochondria, Ribosomes and more [4].

"Plant Tissue Plus", which is an available app on play store, utilizes your device's camera allowing you to capture photos to include with analysis results making grower discussions easier [5].

"Biology Photosynthesis L", which is an available app on play store, describes the user on Photosynthesis process and a plant performs these functions [6].

Rather than the above researches, the research conducted by M Sarosa was an approach to develop the Character Education through augmented reality based application using unity with Vuforia SDK. It is discussed that using Unity Engine combined with Vuforia SDK for implementation has minimum development cost though unity is cheaper (free version available) than other engines. Moreover it has been discussed about setting up Unity SDK and the Vuforia configurations. Furthermore, it has been suggested in the research about, improvement of the animations would be more interested to use it over an extended period.

According to the above mentioned facts, it is clear that AR is one of the most powerful technologies which can be used to enhance the field of education. Even if it is true, in Sri Lanka, this technology is rarely being used in the field of education. Therefore, implementing an AR application can be highly important in Sri Lanka, and it can surely be useful to obtain the educational advancements, and encouragement to the students in their academics.

1.2 Research Gap

Although, many mobile applications were developed using augmented reality. It was a great support for us to do further enhancement in the application by comparing with the existing apps from the Google Play Store. The below table is a comparison of the "Science Zone" application with the existing apps.

Table 1.2.1: Comparison with existing

	3D animations on plant cell structure	Videos on Photosynthesis	Lecture delivery in native language(Sinhala)	Specific to local syllabus
Cell World[4]	✓	***x***	Only English	***x***
Plant Tissue Plus[5]	***x***	✓	Only English	***x***
Biology Photosynthesis L[6]	***x***	✓	Only English	***x***
"Science Zone" mobile application	✓	✓	✓	✓

The above table highlights that though there are many augmented reality applications developed for e-Learning systems, they have lot of drawbacks such as,

- **Comprehensive learning environment.**
  This application is capable of creating a single interface to users to learn all the difficult concepts than browsing each of those concepts separately.

- **Concepts included does not specific to the local syllabus.**
  Most of the existing applications in the Google Play Store were developed by foreign natives where the contents of those applications are specific to foreign syllabus. Therefore it will be an issue for Sri Lankan students to learn Science.

- **Language inconsistency.**
  As most of the applications available in the Google play store was implemented in English, it will be a problem for the students in rural areas to learn Science who are least proficient in English.

- **Poor guidance for the user to keep the session more interactive.**
  It is clear that the traditional classroom is under the supervision of the class teacher and it is her responsibility to hold the student attention throughout the session without getting bored. When it comes to online learning it is a self-learning approach which is not supervised by the teacher. So as the developer of the application it should be more tactful to keep the online learning session more attractive and interactive to the user.

According to the comparison it is clear that most of the applications have the above mentioned drawbacks and it is decided to develop an application by producing solutions to overcome the above mentioned drawbacks.

Finally, it has been decided to develop an android application. It covers the difficult concepts for students being specific to the local syllabus and overcoming the language inconsistency by delivering the content in both Sinhala and English languages. Accordingly, it is clear that the proposed function will be an assistance to the learner to go for a higher grade through online learning approach.

1.3 Research problem

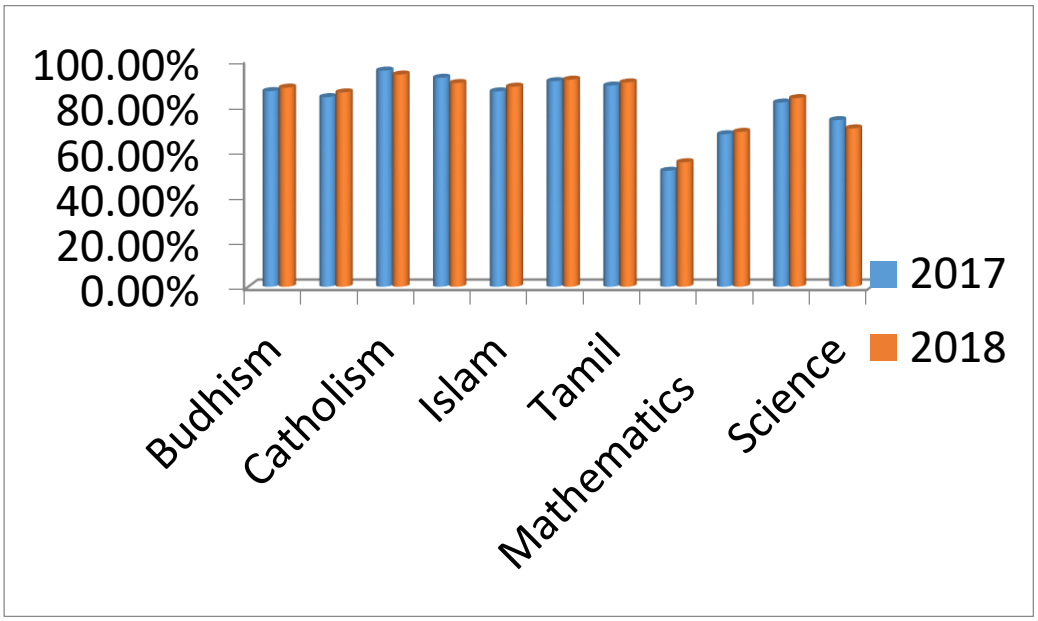


Figure 1.3.1: Passed percentage of compulsory subjects during previous two years [1].

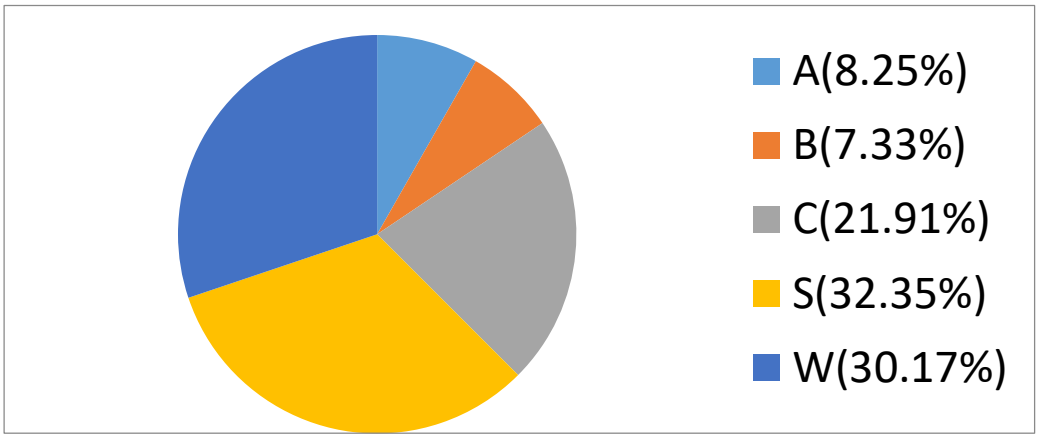


Figure 1.3.2: Science results of 2018 by grades [1].

Figure 1.1 depicts that the amount of students who have passed science is somewhat low than other major subjects and Figure 1.2 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).

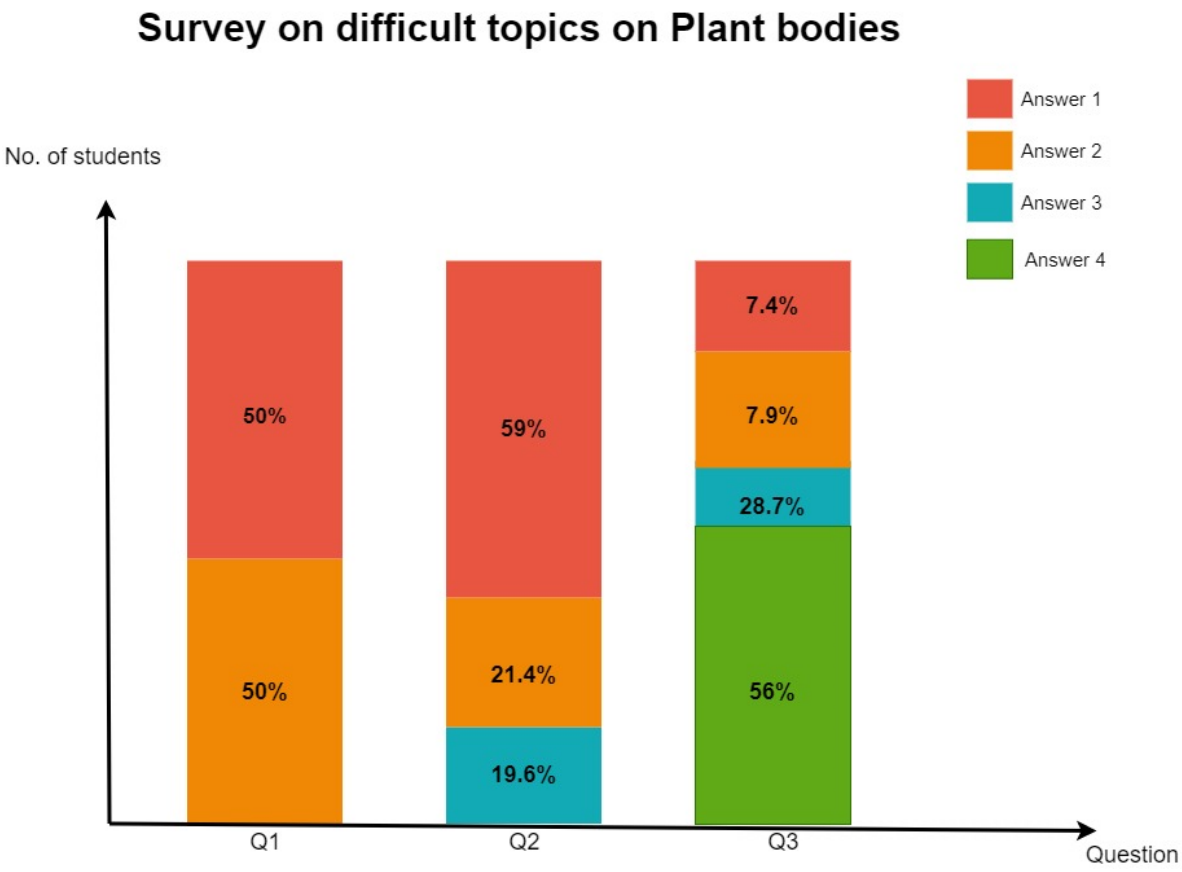


Figure 1.3.3: Survey on ordinary level students on weak topics about Plant structure.

Figure 1.3 depicts the opinion of ordinary level students on the difficult topics about plant structure out of 40 students. The survey proved that students are more interested to learn about Structure of plant cell, process of Photosynthesis and production of Oxygen during Photosynthesis under Plant Organization. Therefore it is decided to include those concepts to cover up those weaker topics which supports students scoring higher grades.

1.4 Research Objective

1.4.1 Main Objective

The main objective of this research is to enhance the G.C.E ordinary level Science results of students by providing an interest in the subject. The main objective of this component is to support the above mentioned objective by providing interest in the Plant Cell Organization section of the grade 11 Science syllabus and provide practical experience for the experiments relevant to this component using technology.

1.4.2 Specific Objective

- Language support on a preferred language both in Sinhala and English
- 3D demonstration of virtual objects related to organization of Plant Cell structure.
- Video demonstration on the process of Photosynthesis.
- Video demonstration to understand the production of Oxygen during Photosynthesis.
- Aims to improve communication and collaboration skills to ease Science learning.
- Generating 3d models on 2d images to make studying more effective.

2. METHODOLOGY

2.1 Methodology

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 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.

Figure 2.1.1: Home page

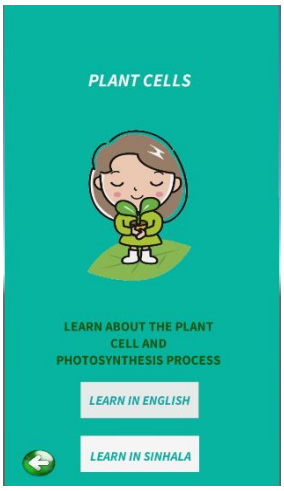


Figure 2.1.2: Learn Plant component

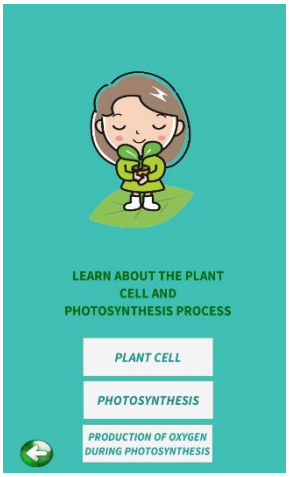


Figure 2.1.3: Plant organization component home page

Once the user prefers to learn Science in Sinhala, user interfaces has been prompted as given below.

Figure 2.1.4: Plant organization component home page in Sinhala

This component also allows the user to attempt a quiz, so that the student will be able to self-evaluate their knowledge before and after having learning sessions. So that it will be a massive support for them to evaluate about these concepts by themselves. Images from the Ordinary Level textbook has been taken as the image targets to detect these 3D models.

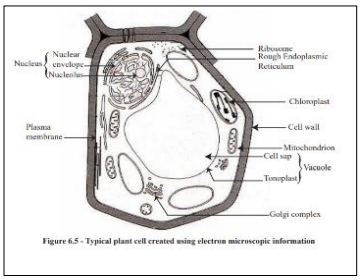


Figure 2.1.5: Plant cell

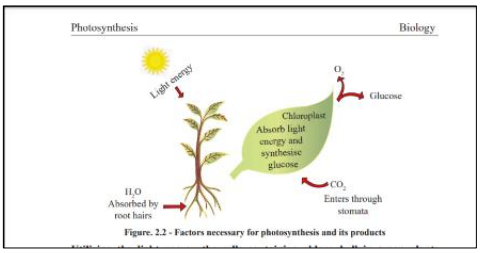


Figure 2.1.6: Photosynthesis image

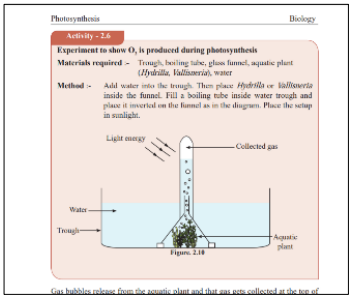


Figure 2.1.7: Oxygen Production experiment image

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 explanation playing in the background. 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

about the experiment with audio explanation playing in the background. When camera is away from the marker, the AR animation also stopped, this is intended that augmented reality only runs when camera is pointed towards the marker because AR system usually triggered to a particular object.

- 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 is important to the users that is need to be noted.

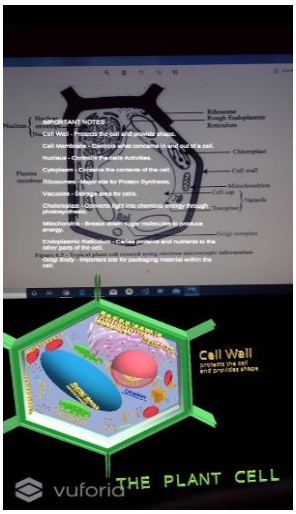


Figure 2.1.8: 3D Model demonstration of Plant Cell

- Playing video on an image target

Once the user captures the image of Photosynthesis process and image of oxygen production during photosynthesis, on the text book. 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.

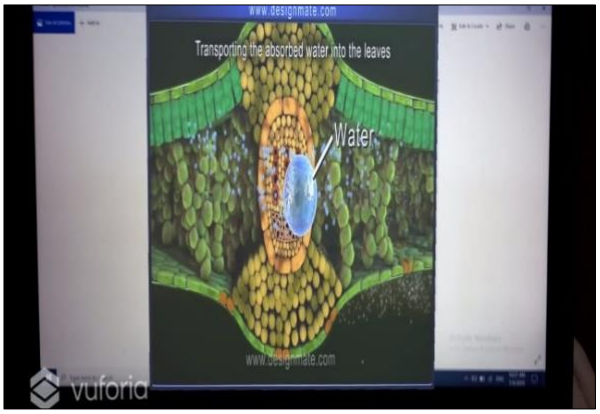


Figure 2.1.9: Video Explanation about Photosynthesis in English

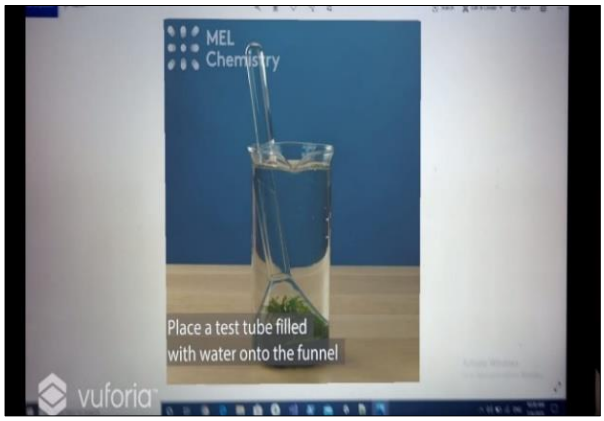


Figure 2.1.10: Production of Oxygen during Photosynthesis using Video in English

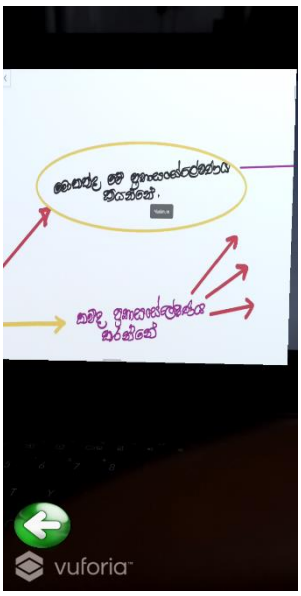


Figure 2.1.11: Video Explanation about Photosynthesis in Sinhala

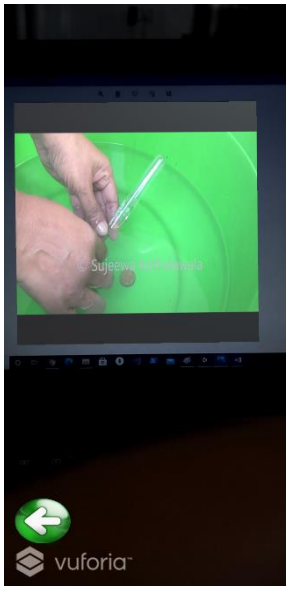


Figure 2.1.12: Production of Oxygen during Photosynthesis using Video in Sinhala

In order to view the functionalities of the application user needs to points the device camera to the target images/marker in the science text book, the marker which is stored in the database is detected and produces the output accordingly. First of all, it is necessary to create a database in Vuforia engine to store target images. Vuforia target manager is a web tool which is responsible for create and manage target databases on Vuforia's developer portal. When user points device camera to the target image, Vuforia target manager checks the captured image with the stored images targets in the database.

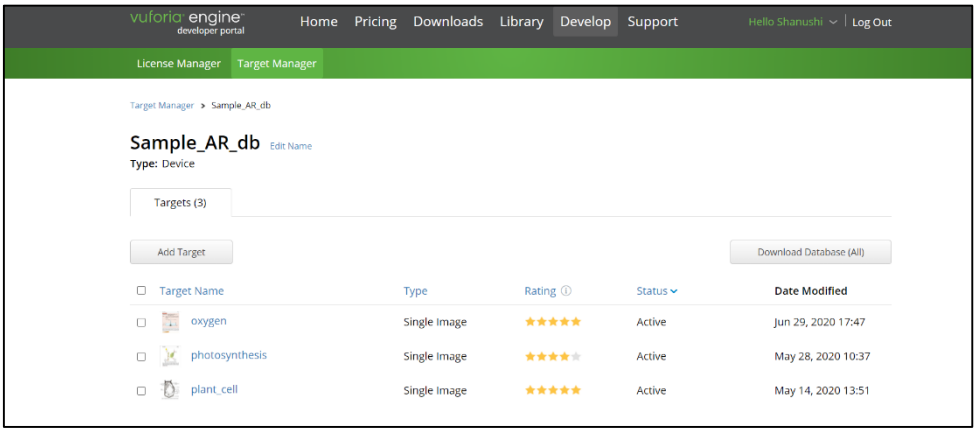


Figure 2.1.13: Vuforia Target Manager

Once the application recognize the captured image it will display 3D models with background audio explanations, video explanations according to the language preference of the user.

This application has been implemented using several technologies. Augmented reality part of this mobile application was developed using Unity IDE and Vuforia engine. Vuforia is an augmented reality Software Development Kit (SDK). It recognizes the images and 3D objects real time. Vuforia target manger allows to create and manage databases by storing images in any allowed types. Unity IDE is a powerful cross platform gaming engine which allows building two dimensional (2D), three dimensional (3D), Virtual Reality Augmented Reality Scenes unity supports to iOS, android, windows MacOS desktop platforms. The Sketch Up and Blender 2.8 3D modelling software were used to do modifications to the 3D models.

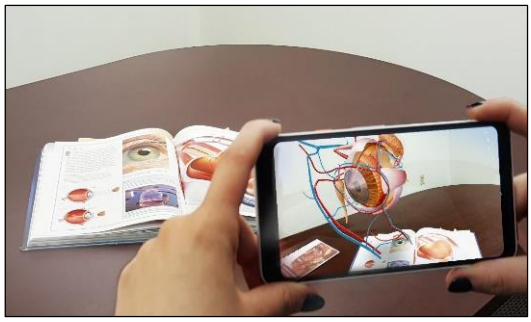


Figure 2.1.14: Marker based augmented reality

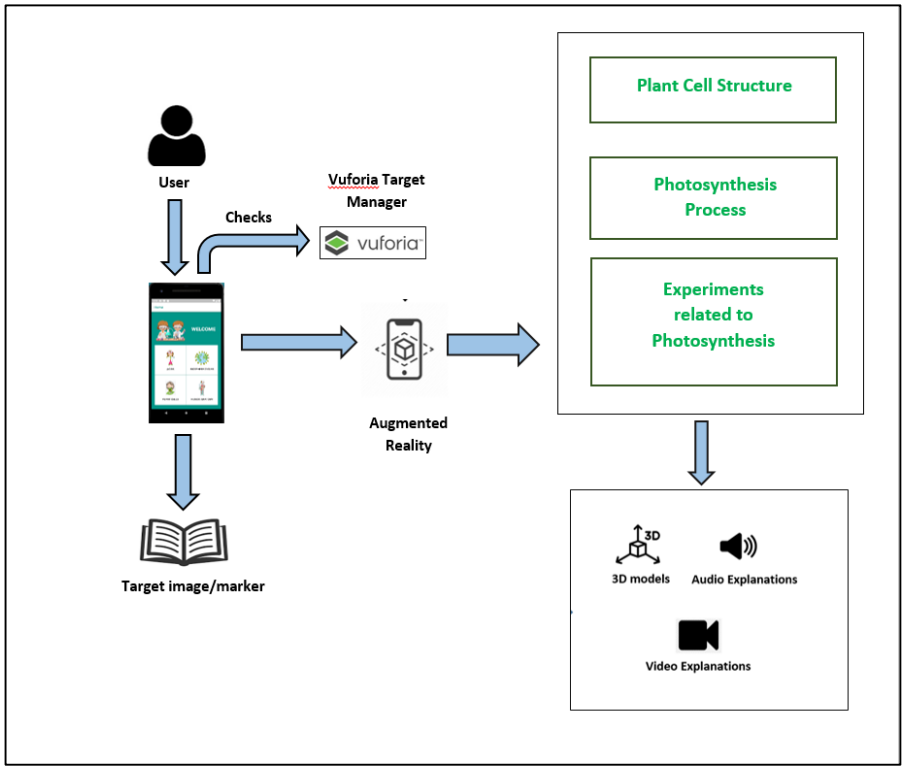
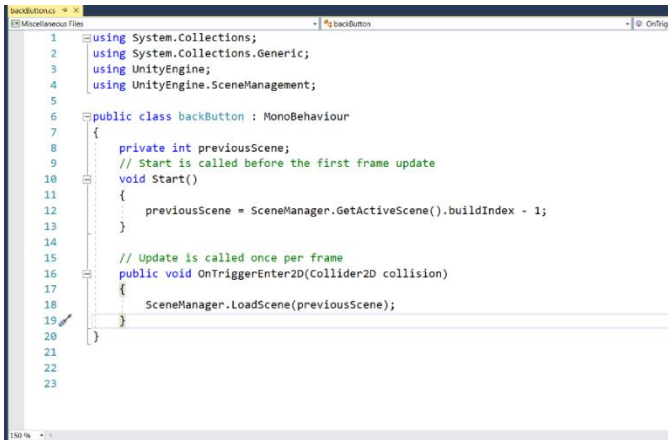


Figure 2.1.15: System Diagram for the plant Organization component

In order to enable mobile gestures such as zoom in/out to scale and rotate 3D animations, back button navigations, navigations through button clicks were implemented using .NET Framework. Audio and video explanation feature were enabled using the Unity IDE. To enable mobile gestures it has to import Unity Lean Touch package from Unity Asset Store which is offered free of charge. This package has sample c# scripts that can be used to enable touch controls to augmented reality animations.

✓ **Script to enable back button navigations**

The script given here is implemented to enable back button navigations. Though mobile applications implemented using Unity do not enable back button navigations by default. It has been implemented using the script given below. So that user can switch to the previous scene.



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

public class backButton : MonoBehaviour
{
    private int previousScene;
    // Start is called before the first frame update
    void Start()
    {
        previousScene = SceneManager.GetActiveScene().buildIndex - 1;
    }

    // Update is called once per frame
    public void OnTriggerEnter2D(Collider2D collision)
    {
        SceneManager.LoadScene(previousScene);
    }
}
```

Figure 2.1.16: Back button script

✓ **Script to change scenes**

The script given here is implemented to navigate within scenes. Each of the scenes have an index. Therefore by passing the index value as the parameter navigations within scenes can be implemented.

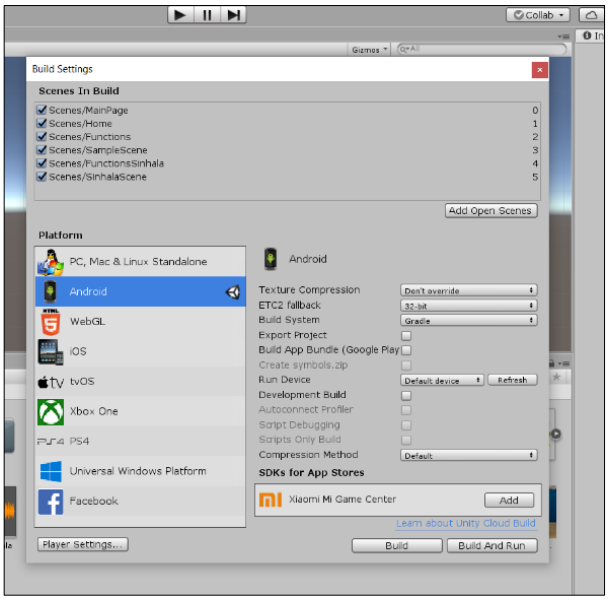
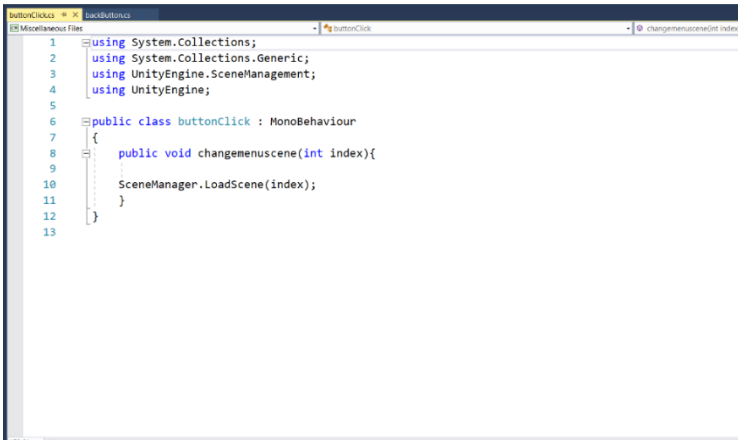


Figure 2.1.17: Build indexes for scenes

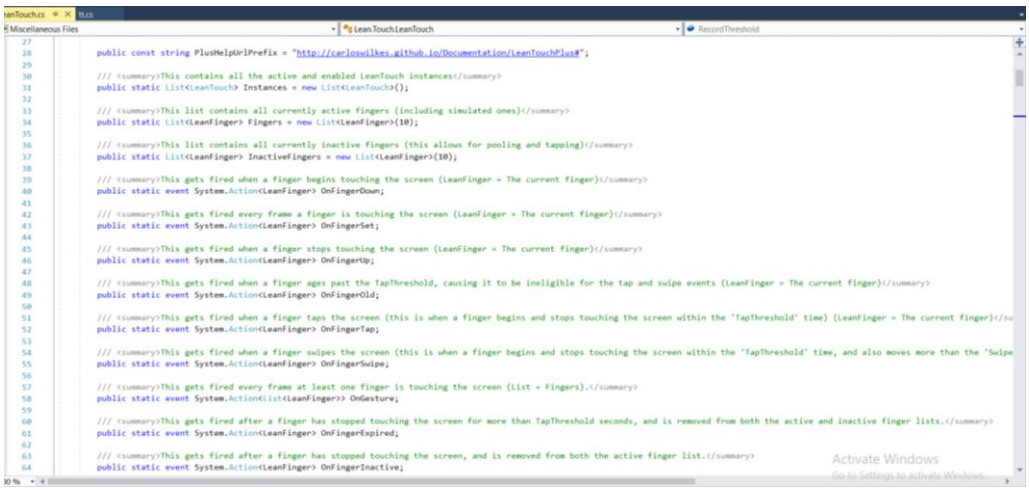


```
using System.Collections;
using System.Collections.Generic;
using UnityEngine.SceneManagement;
using UnityEngine;

public class buttonClick : MonoBehaviour
{
    public void changemenuscene(int index){

    SceneManager.LoadScene(index);
    }
}
```

Figure 2.1.18: Button Click script

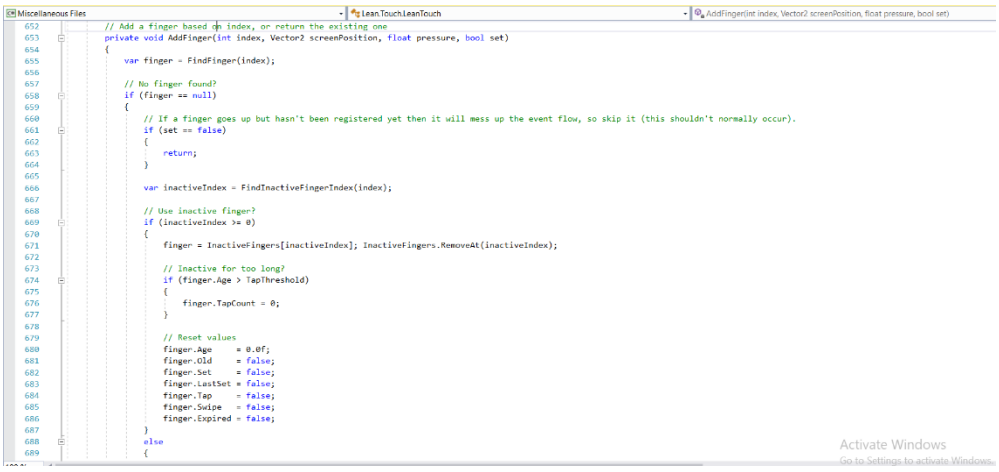
✓ **Script to enable zoom feature to scale 3D model on image target**

To enable mobile gestures it has to import Unity Lean Touch package from Unity Asset Store which is offered free of charge. This package has sample c# scripts that can be used to enable touch controls to augmented reality animations.



```
public const string PlusHelpUrlPrefix = "http://carloswilkes.github.io/Documentation/LeanTouchPlus#";

/// <summary>This contains all the active and enabled LeanTouch instances</summary>
public static List<LeanTouch> Instances = new List<LeanTouch>();

/// <summary>This list contains all currently active fingers (including simulated ones)</summary>
public static List<LeanFinger> Fingers = new List<LeanFinger>(10);

/// <summary>This list contains all currently inactive fingers (this allows for pooling and tapping)</summary>
public static List<LeanFinger> InactiveFingers = new List<LeanFinger>(10);

/// <summary>This gets fired when a finger begins touching the screen (LeanFinger = The current finger)</summary>
public static event System.Action<LeanFinger> OnFingerDown;

/// <summary>This gets fired every frame a finger is touching the screen (LeanFinger = The current finger)</summary>
public static event System.Action<LeanFinger> OnFingerSet;

/// <summary>This gets fired when a finger stops touching the screen (LeanFinger = The current finger)</summary>
public static event System.Action<LeanFinger> OnFingerUp;

/// <summary>This gets fired when a finger ages past the TapThreshold, causing it to be ineligible for the tap and swipe events (LeanFinger = The current finger)</summary>
public static event System.Action<LeanFinger> OnFingerOld;

/// <summary>This gets fired when a finger taps the screen (this is when a finger begins and stops touching the screen within the 'TapThreshold' time) (LeanFinger = The current finger)</
public static event System.Action<LeanFinger> OnFingerTap;

/// <summary>This gets fired when a finger swipes the screen (this is when a finger begins and stops touching the screen within the 'TapThreshold' time, and also moves more than the 'Swipe
public static event System.Action<LeanFinger> OnFingerSwipe;

/// <summary>This gets fired every frame at least one finger is touching the screen (List = Fingers).</summary>
public static event System.Action<List<LeanFinger>> OnGesture;

/// <summary>This gets fired after a finger has stopped touching the screen for more than TapThreshold seconds, and is removed from both the active and inactive finger lists.</summary>
public static event System.Action<LeanFinger> OnFingerExpired;

/// <summary>This gets fired after a finger has stopped touching the screen, and is removed from both the active finger list.</summary>
public static event System.Action<LeanFinger> OnFingerInactive;
```

Figure 2.1.19: Script to enable touch controls



```
// Add a finger based on index, or return the existing one
private void AddFinger(int index, Vector2 screenPosition, float pressure, bool set)
{
    var finger = FindFinger(index);

    // No finger found?
    if (finger == null)
    {
        // If a finger goes up but hasn't been registered yet then it will mess up the event flow, so skip it (this shouldn't normally occur).
        if (set == false)
        {
            return;
        }

        var inactiveIndex = FindInactiveFingerIndex(index);

        // Use inactive finger?
        if (inactiveIndex >= 0)
        {
            finger = InactiveFingers[inactiveIndex]; InactiveFingers.RemoveAt(inactiveIndex);

            // Inactive for too long?
            if (finger.Age > TapThreshold)
            {
                finger.TapCount = 0;
            }

            // Reset values
            finger.Age     = 0.0f;
            finger.Old     = false;
            finger.Set     = false;
            finger.LastSet = false;
            finger.Tap     = false;
            finger.Swipe   = false;
            finger.Expired = false;
        }
        else
        {
```

Figure 2.1.20: Script to enable touch controls

2.2 Commercialization aspects of the product

This application is a Science Augmented Reality mobile application for Ordinary Level students. The 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 approach.

With reference to existing apps for E-learning it 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 augmented reality 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. In order to bridge the gap between languages the application facilitates students to learn using both English and Sinhala which is the native language of Sri Lanka. 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 approach. Although Science is a practical subject, this application has been recommended for schools in remote areas to overcome the limitations occur during the practical sessions.

2.3 Testing and Implementation

After the implementation of the plant Organization component each of the functionalities has been tested through Unit Testing. The final output of this component which is the .apk file (Android application package) has been installed in a smartphone for testing. Next the functionalities of the whole component has been tested through Component testing. Below given are test cases used to test the Plant Organization component.

Table 2.3.1: 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 2. The application opens device camera 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 2.3.2: 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 • The device camera should pointed towards the marker
Steps	1. User clicks Learn button 2. The application opens device camera 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 2.3.3: 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 • The device camera should be away from the marker
Steps	1. User clicks Learn button 2. The application opens device camera 3. User points the device camera towards the marker 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 2.3.4: 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 • The device camera should be away from the marker
Steps	4. User selects Learn button 5. The application opens device camera 6. User points the device camera towards the marker 5. 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 2.3.5: 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 2. User navigates to the home page of the plant organization component. 3. User clicks Learn in English button
Input	1. Image target 2. Preferred Language
Expected Output	Delivers learning sessions with user selected language
Actual Output	Delivers learning sessions with user selected language

3. RESULTS AND DISCUSSION

3.1 Results and Discussion

The main expected outcome of this component is to provide an interactive method for G.C.E O/L students to learn Plant Organization and score higher grades at their examination. The final output of this component is the .apk file (Android application package). The .apk file is an installer file that created for devices to be run on Android devices. The .apk files needed to be installed initially to the smartphone. "Science Zone" mobile application were distributed among randomly selected sample including ten science teachers and twenty grade 11 students along with a questionnaire to obtain their feedback about the application.

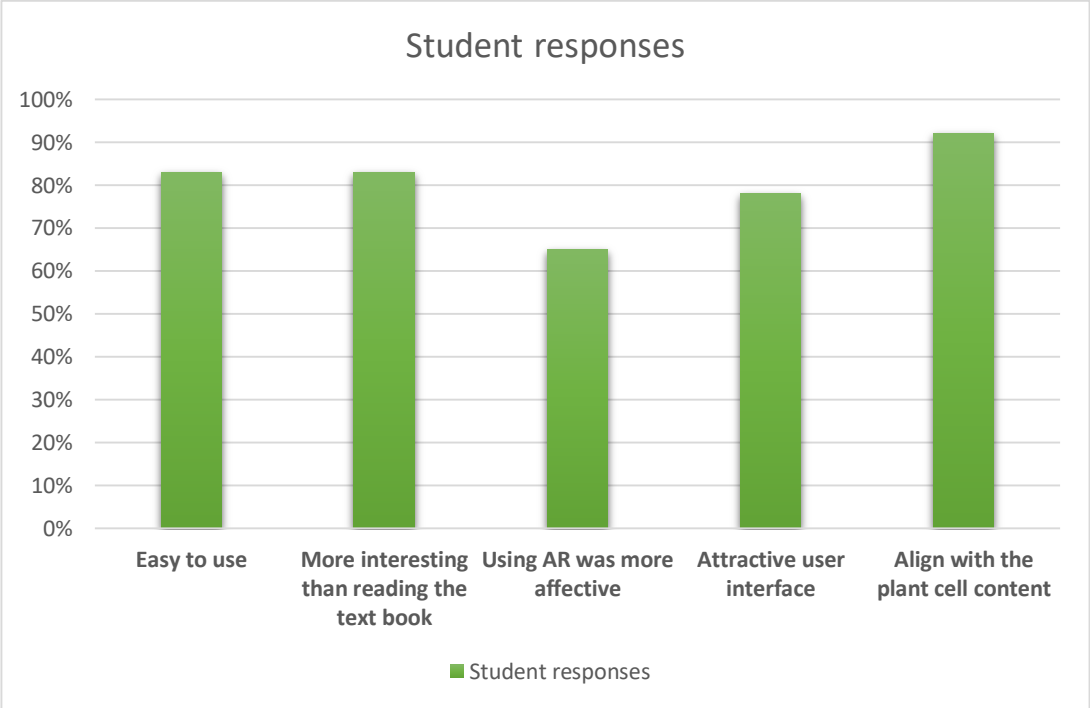


Figure 3.1.1: Summarized responses of students

According to the collected responses of the survey, most of the students stated that this application was easy for them to work with. Moreover, 91% of the teachers who participated for the survey were also satisfied with the app and stated that it was user friendly. 83% of the student participants have felt more interested in learning science using the app rather than referring textbooks or any printed materials.

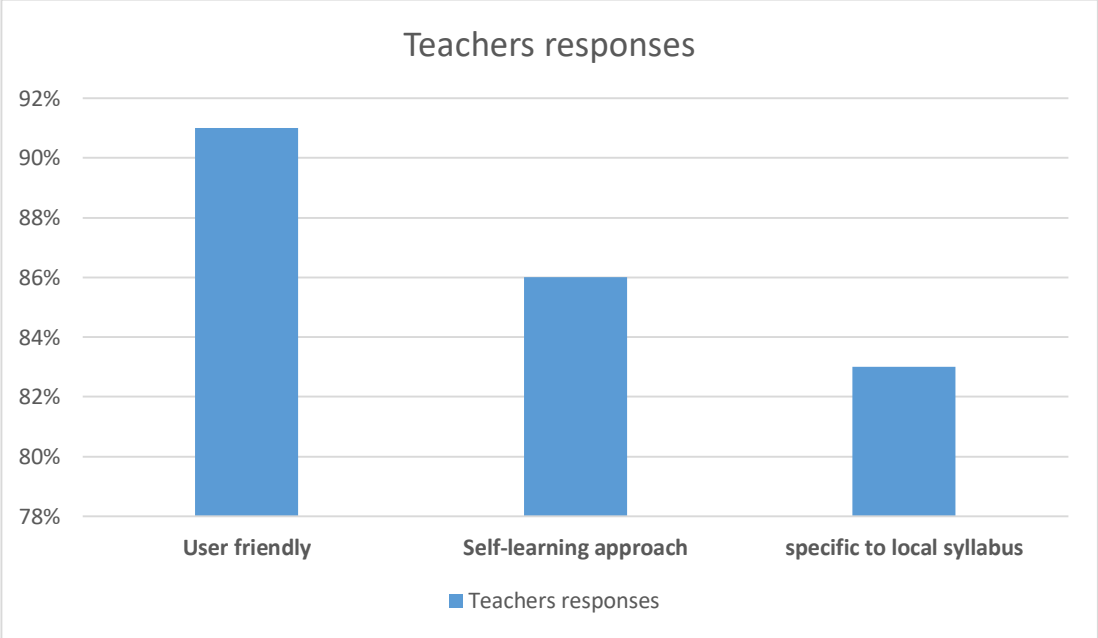


Figure 3.1.2: Summarized responses of teachers

General idea of most of the teachers who participated in the survey was that the application is properly aligned with the local syllabus and appropriate for students to use. Moreover, conducting the learning sessions in both Sinhala and English is a plus point. Similarly 86% of the teachers has admired the application as it is gone through self-learning approach.

While considering the overall survey results, it is clear 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 Plant Organization and in obtaining higher grades.

The research was started during 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 detailed study on this area which is decided to develop a mobile application which 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 capable of demonstrating even harder concepts in an attractive manner. Initially a survey was conducted among several Science teachers and grade 11 students from different schools to collect 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 using four sub components. The plan was to hand over the plant organization component 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 sample of teachers and students and their comments were collected to improve the content of the plant component.

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.

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. The research team decided to introduce a mobile application utilizing Augmented Reality to teach Science in order to solve this issue.

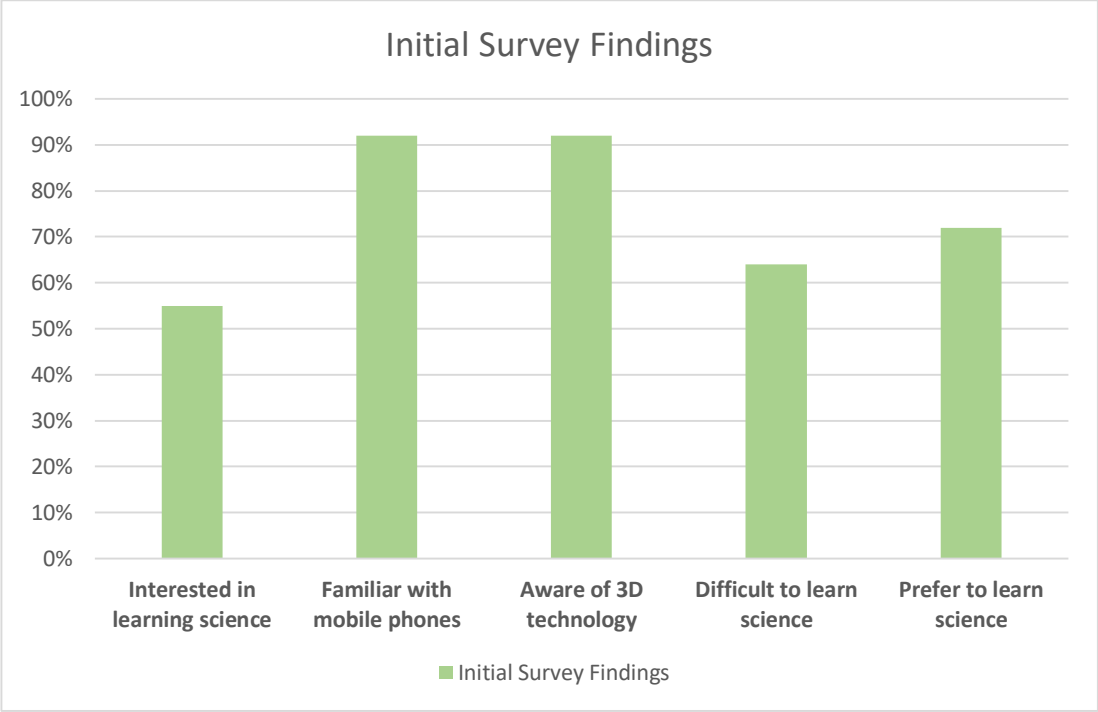


Figure 3.2.1: Initial Survey Findings

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 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.

Therefore the initial survey findings has been given a great support to decide the problems student face which impacts the results of Ordinary level exams.

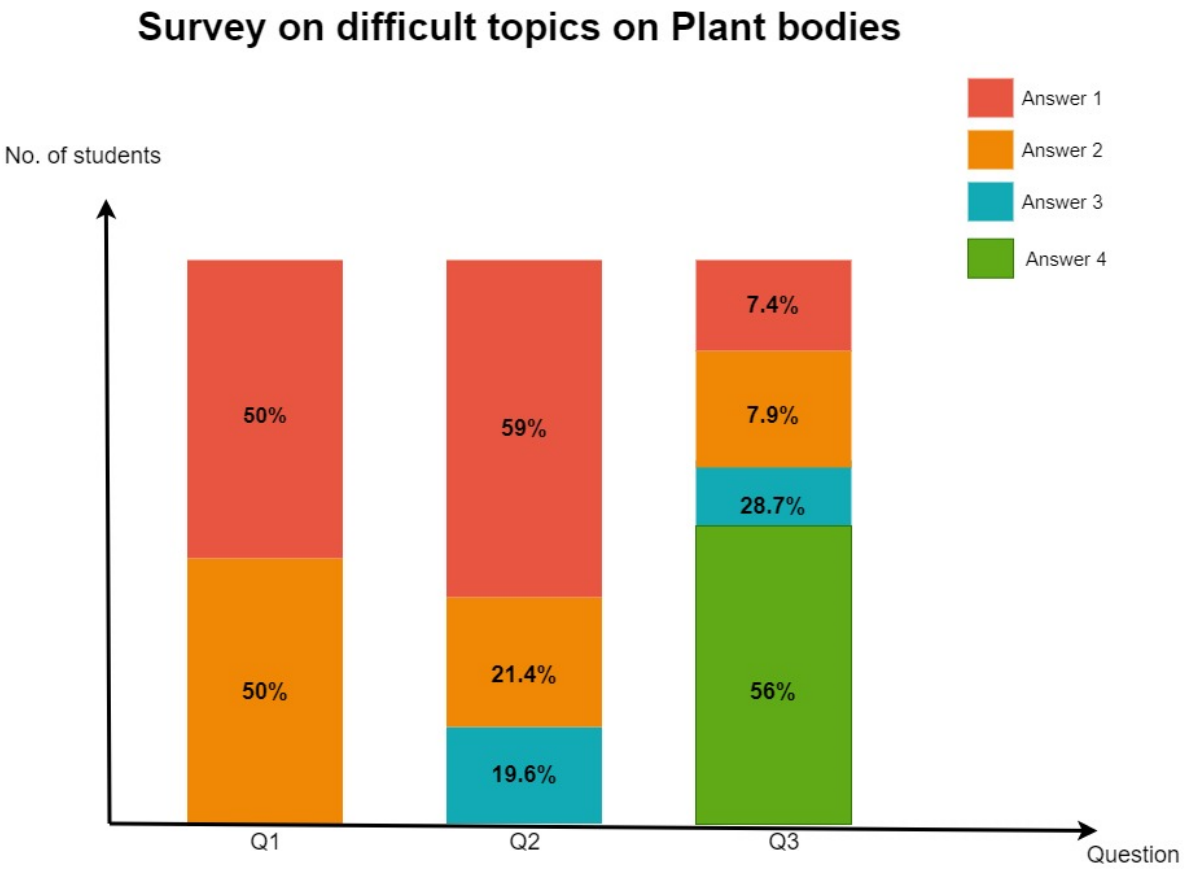


Figure 3.2.2: Survey on ordinary level students on weak topics about Plant structure.

Figure 3.2.1 depicts the results of the survey conducted for the Ordinary level students in order to find out the weaker topics, under Plant Organization component. Figure 1.3 depicts the opinion of ordinary level students on the difficult topics about plant structure out of 40 students. The survey proved that students are more interested to learn about Structure of plant cell, process of Photosynthesis and production of Oxygen during Photosynthesis under Plant Organization. Therefore it is decided to include those concepts under Plant organization component with the intention to cover up those weaker topics.

The test results show that the system works fine for most cases; however, some improvements are still necessary in working towards a reliable system.

4. 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 eleven science syllabus are being focused in this research. 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 learning approach. Also, this application would be a tremendous support for students with low laboratory facilities to get a real time experience on the practical sessions.

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APPENDIX A

Sample Questionnaire

Question 1) Which of the below topics on plant processes, you feel difficult in your studies? Number according to your preference. (1-most difficult, 3-least difficult)

Answer 1) Photosynthesis

Answer 2) Plant respiration

Answer 3) Reproduction

Question 2) Number the following according to the order which is hard for you to study (1- most , 4 - least)?

Answer 1) Plant cell structure

Answer 2) Plant tissue organization

Question 3) Which of the following experiments do you feel difficult from your science syllabus? (1-most, 5-least)

Answer 1) Identify Starch is produced during Photosynthesis.

Answer 2) Carbon dioxide is required for Photosynthesis.

Answer 3) Chlorophyll is required for Photosynthesis.

Answer 4) Oxygen is produced during Photosynthesis.