Augmented Reality and Virtual Reality for Learning Solar System

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A project submitted in partial fulfilment of the requirements for the degree of Bachelor Science in Computer Science and Engineering

Department of Computer Science and Engineering

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Declaration

We declare that the work "**Augmented Reality and Virtual Reality for Learning Solar System**" in this thesis is a product of our work with long hours of research work and development spent throughout the allotted time for this thesis under the supervision of **Dr. Shamim Hasnat Ripon**, Professor, Department of Computer Science and Engineering, East West University. We also declare that no organization or source has any contribution to this research work other than the ones we have acknowledged, referred to, and quoted from that are all documented in the reference section as required. We also ensure that no part of this work has been submitted elsewhere for awarding any degree or diploma from another institute.

Countersigned

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Letter of Acceptance

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Abstract

The purpose of this study was to determine how well-augmented reality and virtual reality technology may improve the comprehension of the solar system among elementary school children. Twenty students were divided into two groups, one for conventional classroom instruction and the other for augmented reality and virtual reality. In contrast to the augmented reality and virtual reality group, which utilized two apps to engage in interactive solar system exploration, the traditional group got classroom instruction using textbooks. Both Unity and Unreal engine were used to create the applications. To gauge students' understanding of the solar system, pre-and post-tests were given; meanwhile, a survey was employed to gauge their interest in the subject. The outcomes revealed that when compared to the traditional group, the augmented reality and virtual reality groups had significantly higher post-test scores and indicated better levels of engagement. The study emphasizes how augmented reality and virtual reality technologies might improve students' scientific learning outcomes and motivation. These results imply that using these tools in the classroom can be a successful way to teach difficult scientific ideas, like the solar system.

Acknowledgements

First, we would like to convey our thanks and gratitude to Almighty God, Allah, the supreme authority of the universe, for His immeasurable grace and profound kindness. Today we are successful in completing our work because He gave us the ability, chance, and a cooperative supervisor.

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Chapter 1

Introduction

1.1 Introduction and Motivation

In the recent past, Bangladesh is approaching rapidly to digitalization with the developing world. But the way of teaching is still the same. Students are learning from books without even visualizing the real thing. Some of them may include images but 2D images are not enough to make students understand the real things properly. So, in this case, the emergence of the internet gives birth to new ways to educate and learn things simply; it also allows students to study whenever and wherever they choose as approximately 70% of children in our country use mobile phones [5].

AR's 3D nature encourages youngsters to collaborate in groups; it fosters true collaboration and enhances communication [6]. The blending of reality and fantasy also causes children to consider deeply how it works and where the expanded item is. It is simple to use, which empowers children and gives them the sense that they oversee their education, whether at home or at school. This self-directed learning improves focus and data retention. It arouses and connects with children of various learning abilities.

Too far, virtual reality (VR) has had a higher profile, gaining popularity through gaming, and resources must be invested in headsets and accompanying equipment. According to a Lenovo survey, 94 percent of UK instructors feel that VR would be beneficial in the classroom [6]. 42 percent believe it will be commonplace within the next five years. VR isn't only for ECE, with manufacturers of VR headsets portraying it as being appropriate for children over the age of 13 [6].

To conduct a comprehensive and formal study on this issue, we conducted surveys and tests to analyze several criteria for AR & VR applications, such as financial feasibility. The fast advancement in technical complexity, diversity, and pervasiveness of 3D virtual learning environments, as well as the profusion of research on their usefulness in educational contexts, needs periodic rigorous analytical syntheses of their effectiveness. More effort and money are being spent to planning and developing desktop-based VR training for teaching K-12 and higher education courses [7]. Deploying desktop-based VR training in schools and colleges entails not just financial costs but also efforts to train instructors to utilize them successfully.

As a result, instructional designers must make cautious judgments while designing and developing instructional materials with desktop-based VR technology [8].

As Most students nowadays have smartphones in their hands, it will be advantageous for them if they use their smartphones to discover things and learn something. So, our objective is to use smartphones to learn something new. This is why we took the initiative to develop an AR and VR app for learning using smartphones and technology. So, our idea is to incorporate the Solar System into Augmented Reality and virtually experience the planet in Virtual Reality with potentially essential information.

The advancement of information technology and telecommunications is currently accelerating. Similarly, the modern educational system has advanced at a breakneck pace [1]. This is indicated by the many ways used in the teaching and learning process for delivering material to students, with the hope that the material delivered can be easily understood by students [2]. At present learning, media combined results of printing and computer technology can be realized with the technology of Augmented Reality (AR) [3]. AR technology which can be referred to as Increased Reality is the integration of digital elements that are added to the real world in real-time (real-world data) and follow the environmental conditions that exist in the real world and are applied to mobile devices [4]. The use of AR today has spread to all aspects of life and will experience significant developments in the future.

1.2 Research Questions

The research questions of this research are given below:

- What are the requirements to establish an interactive and real-time virtual environment for educational use?
- How virtual and augmented reality will improve interest in learning?
- How much it will be effective in education?

1.3 Research Objectives

The objectives of this research are given below:

- Create an interactive, real-time virtual environment for educational use.
- To encourage interest in learning using virtual and augmented reality.
- To find out the effectiveness of using virtual and augmented reality in education.

1.4 Focus

The goal of this study is to develop two applications, one is Planet Environment in VR and other is Solar System in AR. By which it will make studying more efficient, easier, and interactive. The key challenge of this study is to find out the assets or components that were needed to show in these applications.

1.5 Contribution

- Game development tools which were used to develop the augmented reality and virtual reality apps used in the study.
- Teachers who participated in the study, facilitated the classroom instruction, and provided feedback on the use of augmented reality and virtual reality technologies in the classroom.
- Asset store from where we collected basic assets and textures.
- Our friends who have tested and gave the initial feedback of our AR and VR applications.
- Primary school students who participated in the study, provided feedback on their learning experiences with traditional classroom instruction and augmented reality and virtual reality technologies, and contributed to the data collected for the research.

1.6 Outline

The paper highlights the Introduction in Chapter 1, the Related Works in Chapter 2, the Materials and Methods in Chapter 3, the Implementation in Chapter 4, the Results and Analysis in Chapter 5, the Conclusion in Chapter 6, and then followed by the Bibliography and the Appendix.

Chapter 2

Background

2.1 Related Work

In paper [6], children are more susceptible to using smartphones nowadays. They would rather use their cellphones than a textbook. They utilize cell phones to play a variety of games as well as view cartoons, humorous videos, and movies. The use of smartphones by children is becoming increasingly addictive. Most parents now want to teach their children using their smartphones. In that situation, they look for educational apps and games. As a result, they decided to create augmented reality and virtual reality learning apps for children. AR and VR are the most powerful forms of engagement available today. According to our survey results, we designed an alphabet book for youngsters and created an android app using Unity 3D. The phone camera will open when a youngster opens the app. And if the youngster points the camera at any photo in the book, the smartphone will display a 3D visual model of the object on the mobile display, as well as the name of the alphabet and a word associated with that word.

In paper [9], Describes an innovative program that allows students to study and comprehend their schoolwork without the assistance of a professional tutor. The system employs Augmented Reality (AR) to provide students with hands-on experience. Virtual Reality (VR) is also supported by the presented system, which improves the process and acquaints users with a pleasant and effective learning experience. Furthermore, the system includes an industry-first Artificial Intelligence (AI)-based study guide that guides students to important topics and provides feedback on areas where they may improve. All the system's basic functionalities have been implemented and are available via two different mediums. The first step is to create a standalone mobile phone application. The second step is to create a specialized web portal.

In paper [10], Technology in education can stimulate pupils to learn with excitement, resulting in a more effective learning process. Researchers have discovered that if the technology employed does not foster critical thinking, meaning making, or metacognition, it will result in a passive learning process. Since its inception, augmented reality (AR) has demonstrated a strong potential for making learning more dynamic, productive, and meaningful. This is owing to its superior technology, which allows users to interact with virtual and real-time apps while still providing natural experiences. Furthermore, the combination of AR and education has

lately received academic attention due to its capacity to engage pupils in genuine situations. As a result, the study that has been done on AR has been used to write this thesis paper. The application of AR in primary education is described in the review, which uses separate "subject cards" for various topics in the primary school curriculum. The evaluation of the research findings reveals that, overall, AR technologies have a favorable outcome and potential for use in education. The analysis also points out the benefits and drawbacks of AR, which could be addressed in the future.

In paper [11], Presented VREX (Virtual Reality-based Education eXpansion), an innovative education platform that combines online and offline components to improve curriculum development and teaching experience. The authors tried to convert slides into virtual reality scenarios so that students may learn in a somewhat real but completely virtual environment. VREX created an open and immersive virtual O2O classroom using the internet and VR equipment, with the goal of repurposing real classrooms in the future. VREX allows students to participate in an interactive learning process at anytime, anywhere, and at any frequency. VREX may be used to enhance teaching in a variety of fields, from Primary and secondary education to universities, and they have offered several examples, such as 'Marine Life,' which uses an immersive experience to make students feel like they're in the deep sea. They also proved the feasibility and advantage of VREX through statistical data.

2.2 Identification of the problem

Considering the significance of science education and the solar system's status as a fundamental scientific idea, many students find it difficult to grasp the material completely. Conventional classroom instruction, which mainly relies on textbooks, lectures, and demonstrations, frequently falls short of engaging students or assisting them in gaining a deep and comprehensive understanding of the solar system. The need for more student-centered and inquiry-based teaching strategies that promote critical thinking and problem-solving abilities has also been recognized by scientific education studies. Technologies like augmented reality and virtual reality have shown promise as aids for science teaching because they provide students with engaging, interactive learning experiences that can help them understand difficult scientific subjects. The effectiveness of these technologies in improving student's learning outcomes in science education, particularly regarding the solar system, is not, however, supported by empirical research. The purpose of this study is to find out how well secondary school pupils' comprehension of the solar system and their interest in it are improved by augmented reality and virtual reality technologies.

The following papers show the required literature review related to the identified problem and a detailed analysis of the current working process as well as the dataset and technologies used.

TABLE 2.1: Literature Review

Ref. No.	Title	Method	Results
[6]	AR & VR Based Child Education in Context of Bangladesh.	· Integrate the animations into Game Engine for AR apps. · React360, Place 3D using, alphabet VR Game Design	Alphabet AR Book Design. Alphabet VR Game Design.
[9]	Education System for Bangladesh Using Augmented Reality, Virtual Reality, and Artificial Intelligence.	· Augment and Place 3D and artificial intelligence for earth view. · For video lesion and quizzing system using in build API and java language.	- Student places phone over textbook with diagram of the solar system. - AR view of the Earth. - Visualization of the quizzing system.
[10]	Augmented Reality Education System.	· Integrate the animations into Game Engine for AR apps. · Augment and Place 3D objects	-Character Creation. -Target Detection using Augmented 3D.
[11]	VREX: Virtual reality education expansion could help to improve the class experience	Implementation of VR in practical uses like Marine Life. VR based training system on Safety, Operating cost,	- Comparison of the traditional methods and VR methods in educational field. - Actual statistical statistics from the third season of 2017 demonstrate the practicability and advantage of VREX.

	(VREX platform and community for VR based education).	Guidance, Training effect etc.	

Chapter 3

Materials and Methods

3.1 Techniques

Our goal of this project is to create an interactive, real-time virtual environment for educational use to encourage learning using virtual reality and augmented reality. For this, we've developed two different applications. We collected our necessary data from multiple online platforms and implemented those into our applications. Some of the VR app Terrains (Surfaces) were collected from Unity Asset Collection website. AR app's planet textures were collected from Solar System Scope website. These were the external sources from where we have collected our necessary data.

3.2 Skills

To complete the overall implementation, it was required to have skills in Blueprint Scripting, C# for developing backend and Digital Sculpting for designing. It was also required to know the concepts of basic Science and Mathematics.

3.3 System Design

Designing of VR: We have used unity and XR rig plugin to develop this application for google VR as google VR is cheap and widely available. We have used C# to write code for the application.

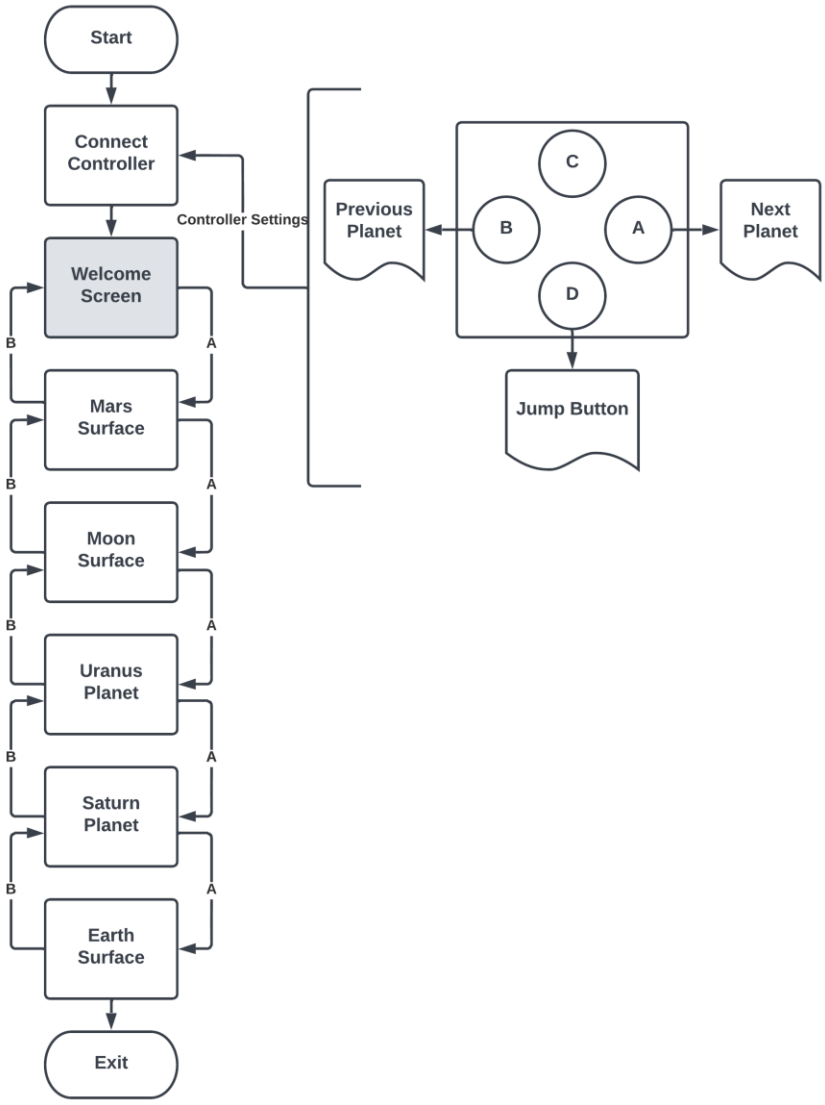

Fig. 3.1: Workflow Process of VR Application.

Designing of AR: To develop the Augmented reality application, we have used unreal engine 4 as it has a wide range of support for AR application development. We have used the Unreal AR template to start developing our AR application. We have used blueprint visual scripting to write code for the app.

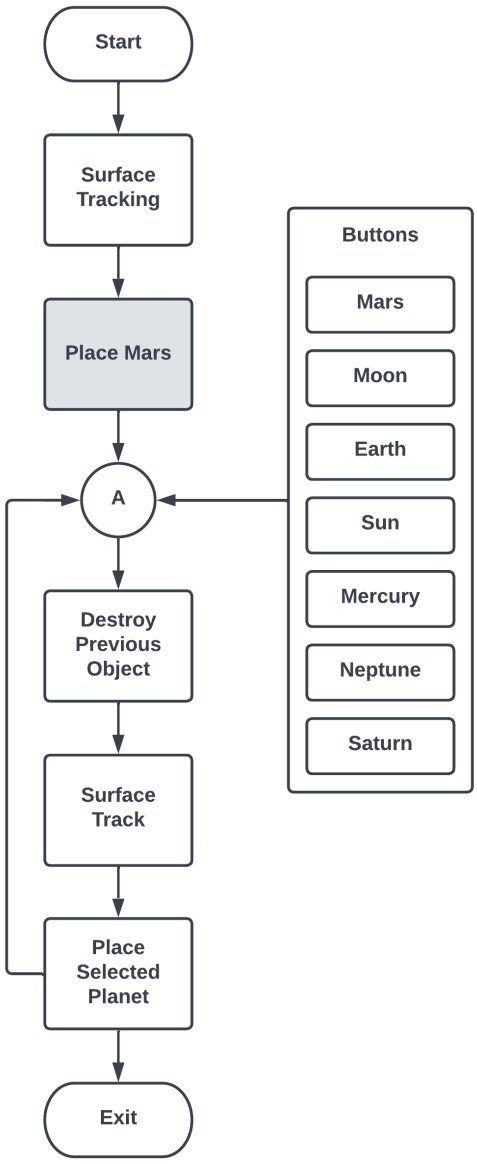

Fig. 3.2: Workflow Process of AR Application.

Chapter 4

Implementation

The implemented models from this study have been applied in a mobile-based application using the game engines of Unity and Unreal Engine 4.

Implementation of AR: This app is made in Unreal Engine 4. First, we have modified the "placeable" blueprint to place and simulate the planets of our solar system (Screenshot of placeable).

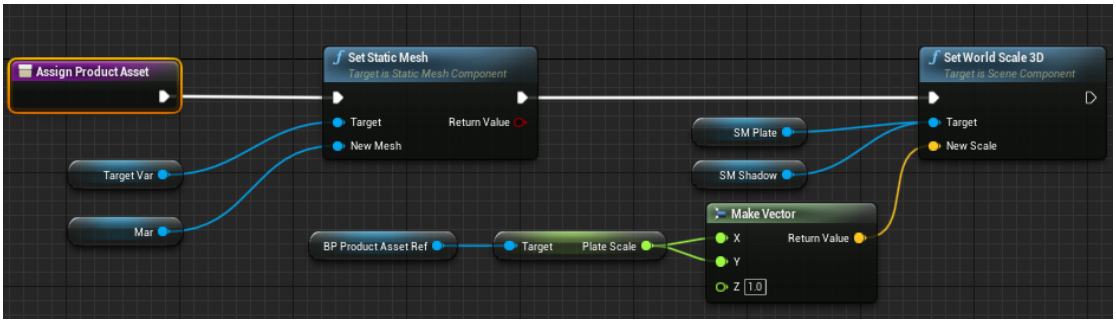

Fig. 4.1: 'Placeable' blueprint scripting.

We have collected and created the planet's materials. After that we have created the planet's static mesh and used the materials on them to create real looking planets.

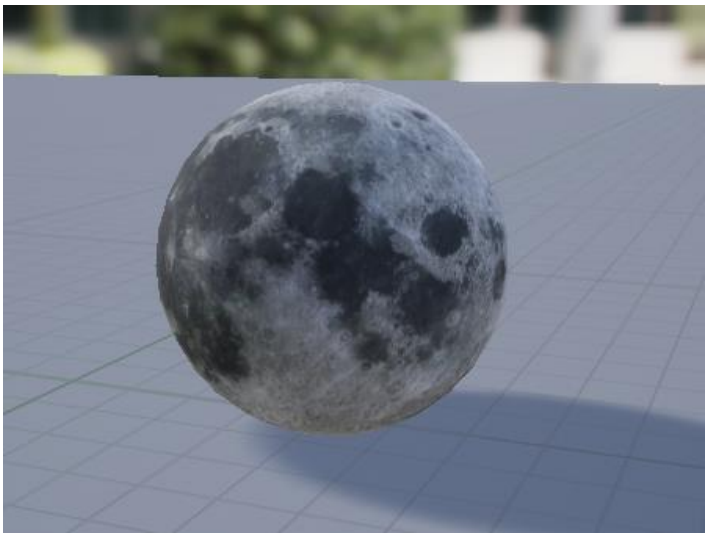

Fig. 4.2: Static mesh of "Moon".

Then we have created widget buttons.

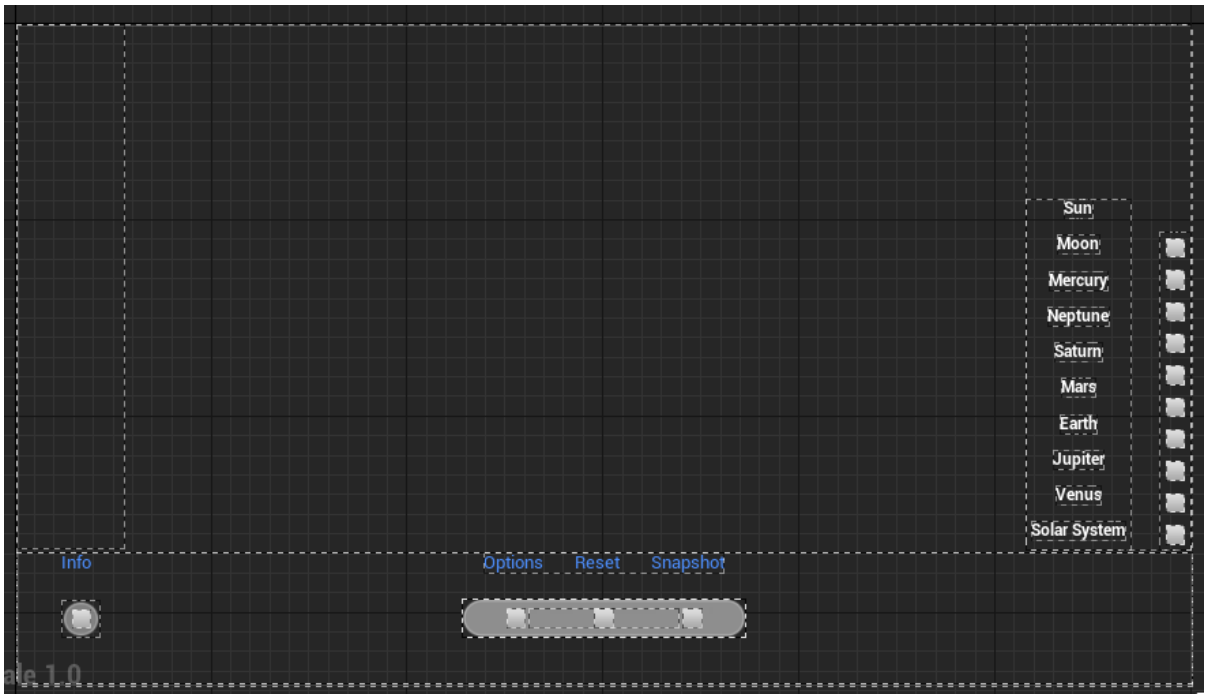

Fig. 4.3: User Interface (UI) after placing a planet.

After that we have bound those buttons to first remove the preplaced/spawned planet and place the clicked one. This button calls first the reset function which invokes surface scanning again and then replaces the static mesh in "Placeable".

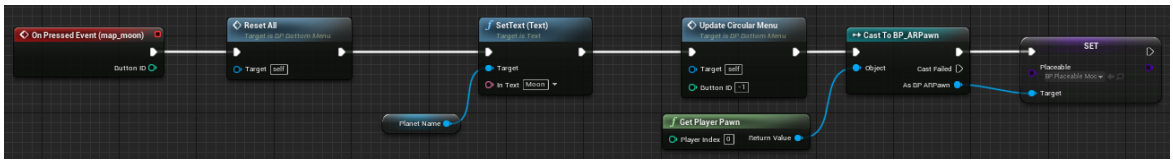

Fig. 4.4: Blueprint script to remove static mesh and place new mesh.

Here, we have made a custom event named “reset_all” to destroy objects or planets from the AR screen (Fig. 4.5). After that we only called that custom event before placing any objects or planets on the AR screen (Fig. 4.6).

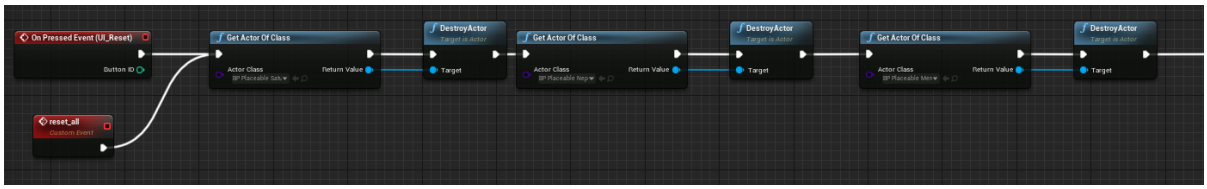

Fig. 4.5: “reset_all” Function to destroy all objects.

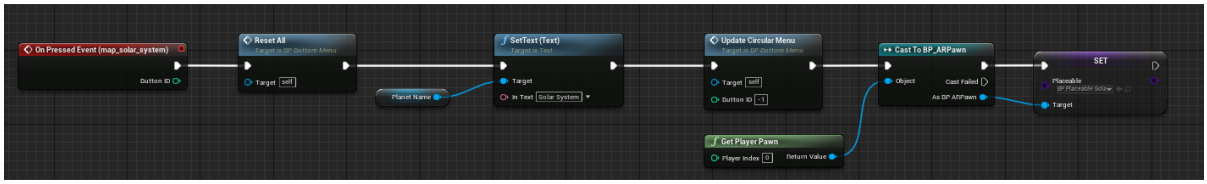

Fig. 4.6: Calling the “reset_all” custom event before placing object.

We have also implemented rotation of every planet. For that we had to add a component which is known as Rotating Movement Component (RotatingMovement). But this only works on a single object of a scene. Rotation of those objects are set in the Z-axis only as it shows only a single object.

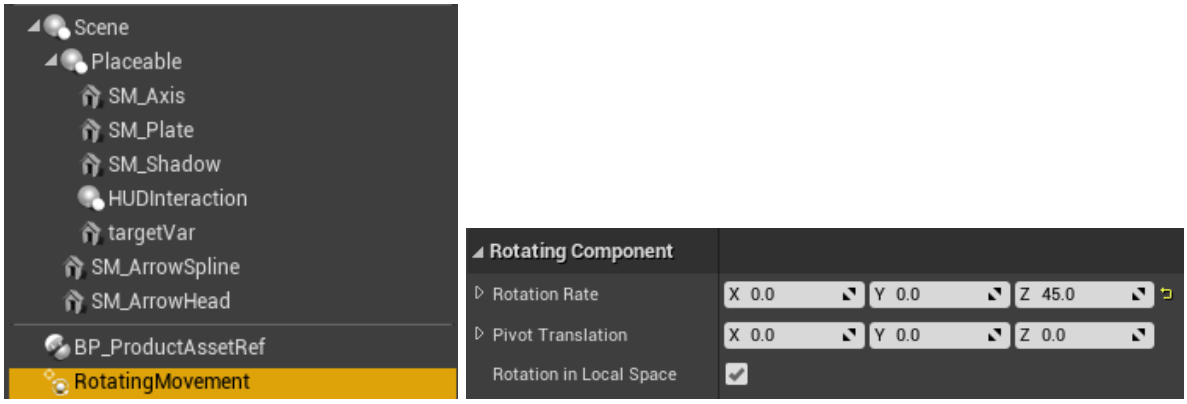

Fig. 4.7: For rotation we added RotatingMovement (Left Picture) and speed rate of Z-axis.

As rotating movement works only for single object, we had to use different approach for rotating the solar system. We placed the Sun in the middle and make it the primary object. We placed all the other planets inside the primary object or the Sun. We inserted different positions for the planets. Then, we added a local rotation function to the Sun.

Fig. 4.8: Placed Sun in the middle and all other planets are at a distance.

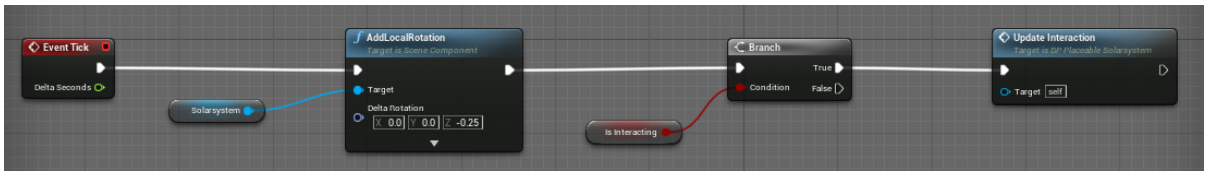

Fig. 4.9: Local Rotation function to rotate the solar system.

Implementation of VR: We have used unity and XR rig plugin to develop this application for google VR as google VR is cheap and widely available. We have used C# to write code for the application. First, we have created the Mars environment on a terrain.

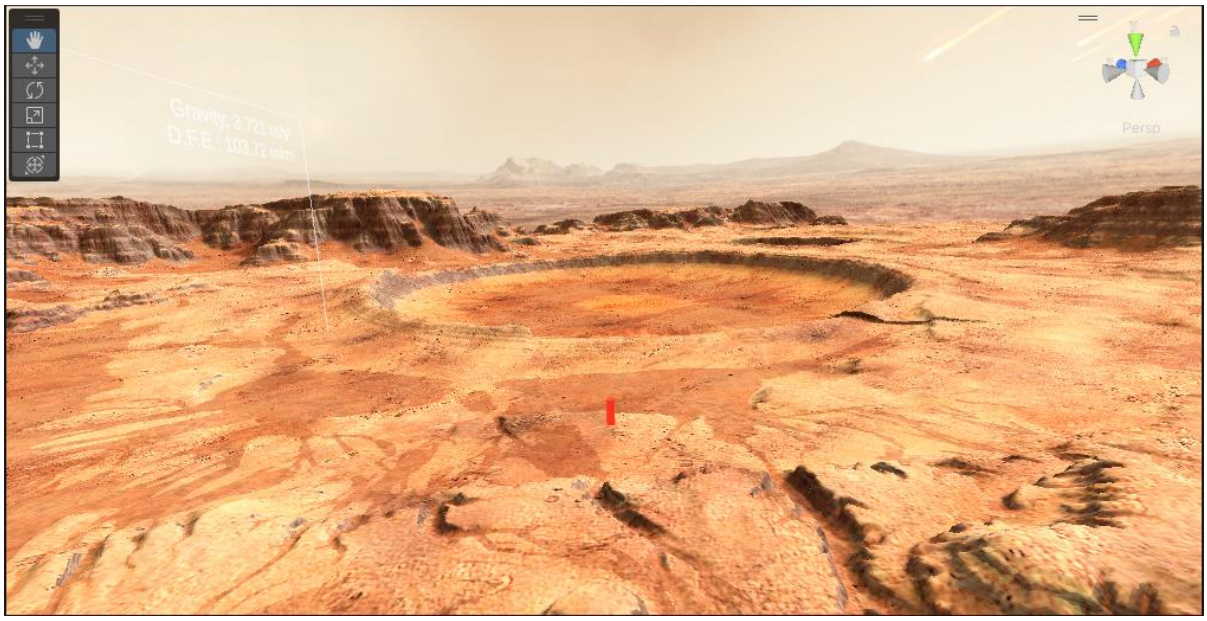

Fig. 4.10: Mars Environment.

Then we have placed a cylinder as a character and attached the camera with it. Then we have created a movement script for forward, backward, left, and right movement and for jump.

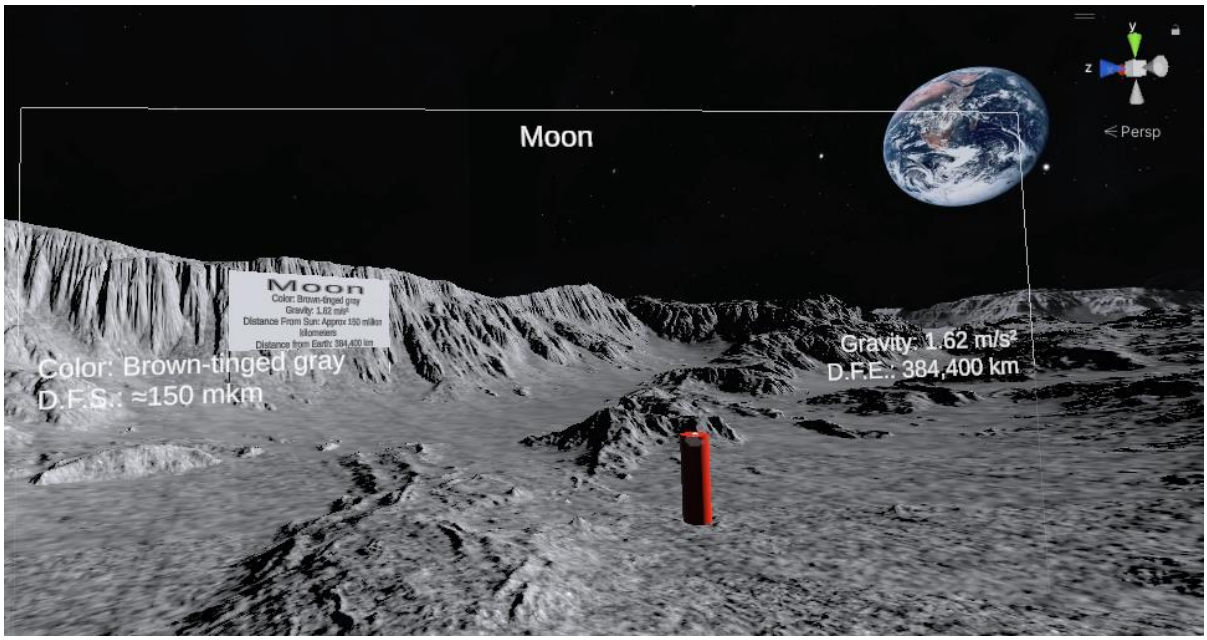

Fig. 4.11: Moon Environment.

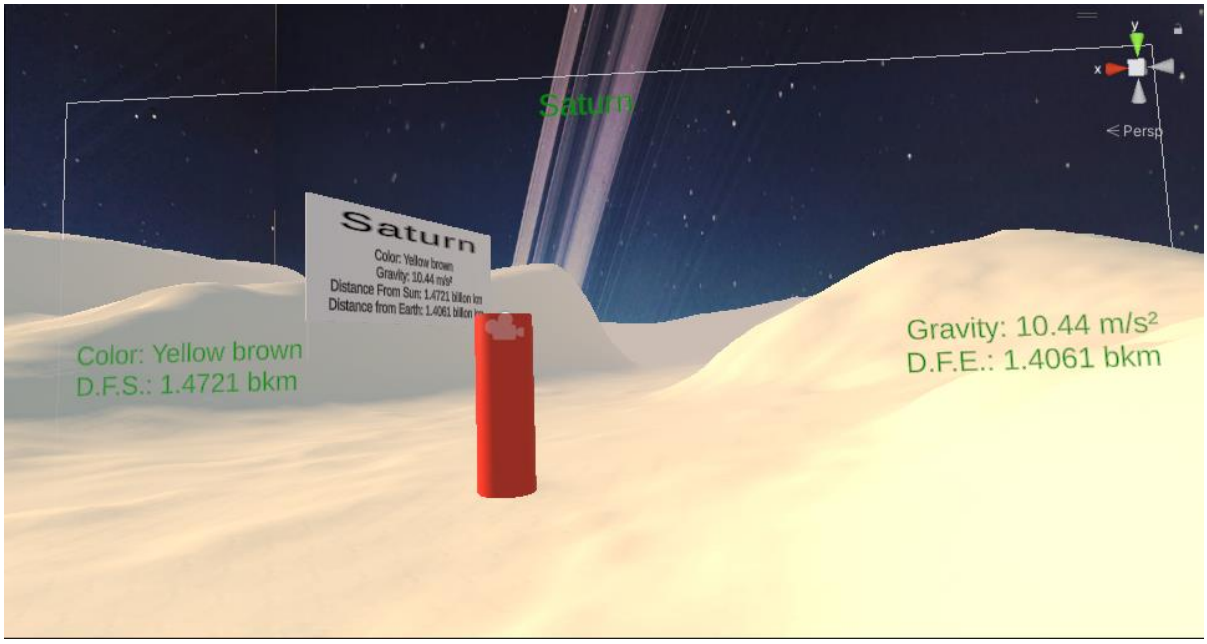

Fig. 4.12: Saturn Environment.

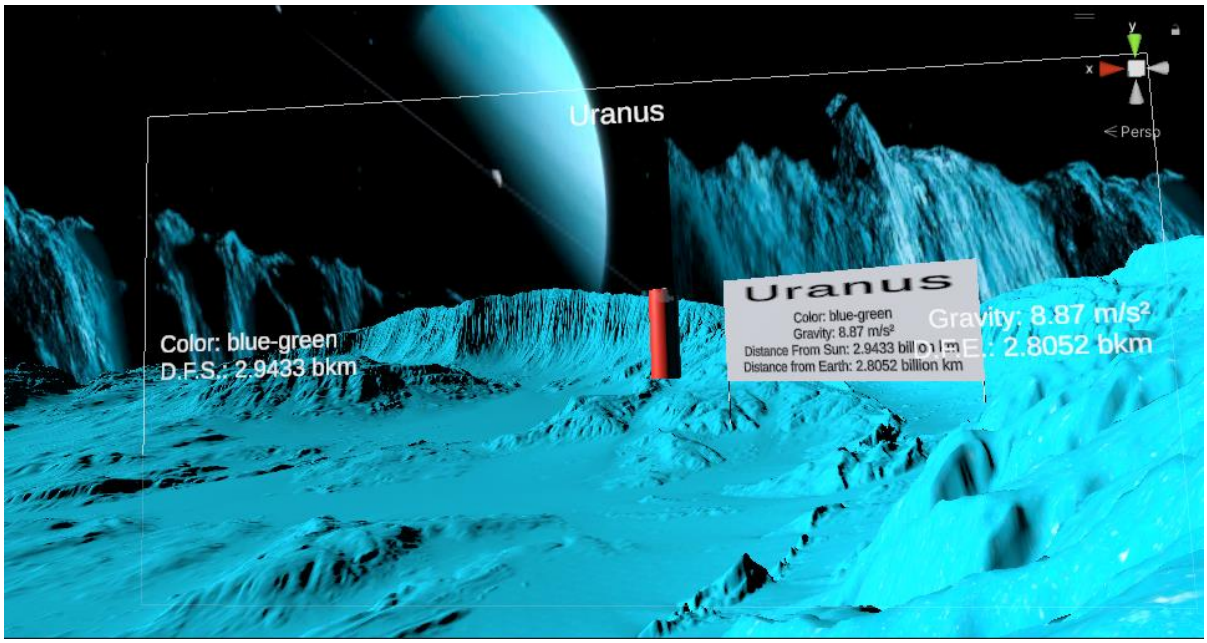

Fig. 4.13: Uranus Environment.

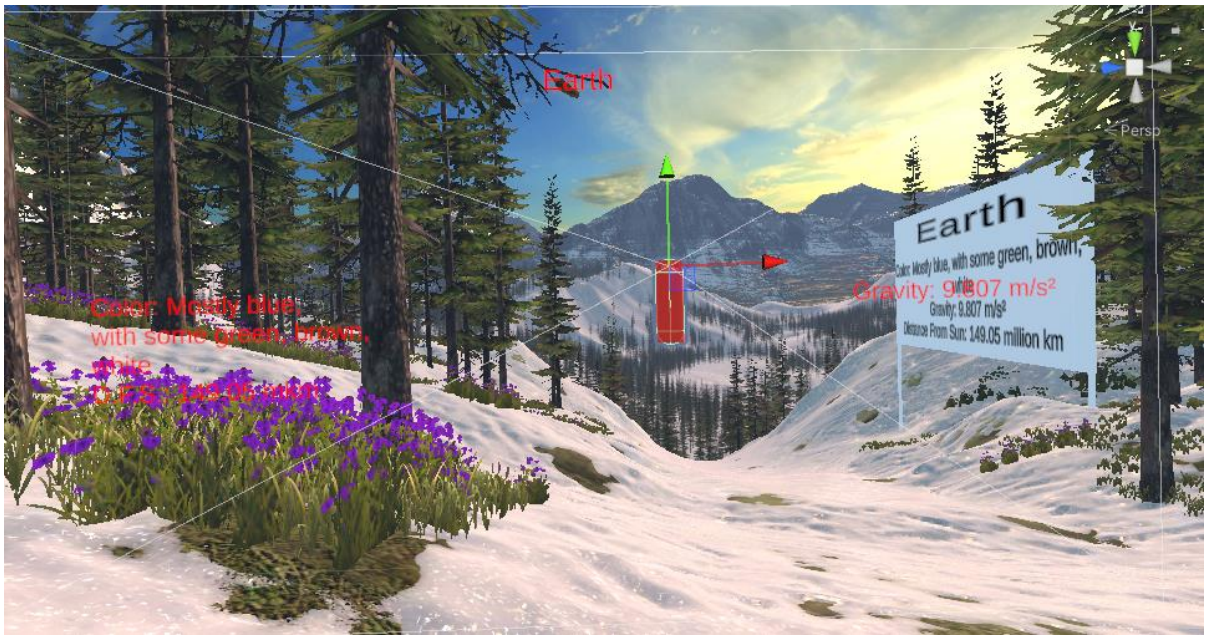

Fig. 4.14: Earth Environment.

We have also added a canvas which is showing information of planets. It is attached with the Main Camera because of that it is always embedded in our viewing screen wherever we want to explore the planet. The planets we have shown in our app are Mars, Moon, Saturn, Miranda (Uranus Moon) and Earth.

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

public class PlayerMovement : MonoBehaviour
{

    public CharacterController controller;
    public float speed = 12f;
    public float gravity = -9.81f;
    public float jumpHeight = 3f;

    public Transform groundCheck;
    public float groundDistance = 0.4f;
    public LayerMask groundMask;
    bool isGrounded;

    Vector3 velocity;


    // Update is called once per frame
    void Update()
    {
        isGrounded = Physics.CheckSphere(groundCheck.position, groundDistance, groundMask);

        if(isGrounded && velocity.y <0){
            velocity.y = -2f;
        }

        float x = Input.GetAxis("Horizontal");
        float z = Input.GetAxis("Vertical");

        Vector3 move = (Camera.main.transform.right * x) + (Camera.main.transform.forward * z);

        controller.Move(move * speed * Time.deltaTime);

        //|| Input.GetButtonDown("joystick 1 button 0")

        if((Input.GetButtonDown("Jump")) && isGrounded){
            velocity.y = Mathf.Sqrt(jumpHeight * -2f * gravity);
        }

        velocity.y += gravity * Time.deltaTime;

        controller.Move(velocity * Time.deltaTime);

    }
}
```

Fig. 4.15: Player movement script.

Then we have attached the script with the player controller. After that, we cloned the terrain and created a new environment for the rest of the planets and attached the character along with the script. Then we have created key binding in the project setting to control with the VR controller. After that, we have set controllers to change the map to next and previous, move, jump etc.

```
void Update()
{
    //next scene
    if(Input.GetKeyDown(KeyCode.H) || Input.GetButtonDown("Fire2")){
        changeScene();
    }
    //prev scene
    if(Input.GetKeyDown(KeyCode.G) || Input.GetButtonDown("Fire3")){
        changeScene2();
    }
}
//next scene
public void changeScene()
{
    if(SceneManager.GetActiveScene().name=="welcomeScene"){
        SceneManager.LoadScene("MarsScene");
    }
    if(SceneManager.GetActiveScene().name=="MarsScene"){
        SceneManager.LoadScene("Moon_terrain_4");
    }
    if(SceneManager.GetActiveScene().name=="Moon_terrain_4"){
        SceneManager.LoadScene("uranus");
    }
    if(SceneManager.GetActiveScene().name=="uranus"){
        SceneManager.LoadScene("saturn");
    }
    if(SceneManager.GetActiveScene().name=="saturn"){
        SceneManager.LoadScene("Snow_mountain_scene");
    }
}
//prev scene
public void changeScene2()
{
    if(SceneManager.GetActiveScene().name=="MarsScene"){
        SceneManager.LoadScene("welcomeScene");
    }
    if(SceneManager.GetActiveScene().name=="Moon_terrain_4"){
        SceneManager.LoadScene("MarsScene");
    }
    if(SceneManager.GetActiveScene().name=="uranus"){
        SceneManager.LoadScene("Moon_terrain_4");
    }
    if(SceneManager.GetActiveScene().name=="saturn"){
        SceneManager.LoadScene("uranus");
    }
    if(SceneManager.GetActiveScene().name=="Snow_mountain_scene"){
        SceneManager.LoadScene("saturn");
    }
```

Fig. 4.16: Scene changer script.

If we press ‘A’ button in our controller it will move the next Planet and we press ‘B’ it will move to the previous Planet.

Chapter 5

Result and Analysis

We have taken 20 students and teach half of them basic information about the solar system traditional way and rest of them using out AR and VR application.

Fig. 5.1: VR app used by a student.

We have taken a quiz after teaching them. The quiz had 8 multiple choice questions. The questions were:

1. Who is the solar system's dominant force?

Result: 90% of the student talked in AR answered correctly compared to 70% of the student taught in traditional way.

2. What is the total number of planets in our solar system?

Result: 90% of the student talked in AR answered correctly compared to 70% of the student taught in traditional way.

3. What is the second largest planet in the solar system?

Result: 80% of the student talked in AR answered correctly compared to 30% of the student taught in traditional way.

4. What is the color of Saturn?

Result: 100% of the student talked in AR answered correctly compared to 50% of the student taught in traditional way.

5. What is the distance between the earth and the sun?

Result: 90% of the student talked in AR answered correctly compared to 20% of the student taught in traditional way.

6. What is the gravity of the moon?

Result: 60% of the student talked in AR answered correctly compared to 20% of the student taught in traditional way.

7. Which planet has a ring around it?

Result: 80% of the student talked in AR answered correctly compared to 70% of the student taught in traditional way.

8. Which planet is often called “The Red Planet”?

Result: 100% of the student talked in AR answered correctly compared to 60% of the student taught in traditional way.

The results of the students who were taught in traditional way is:

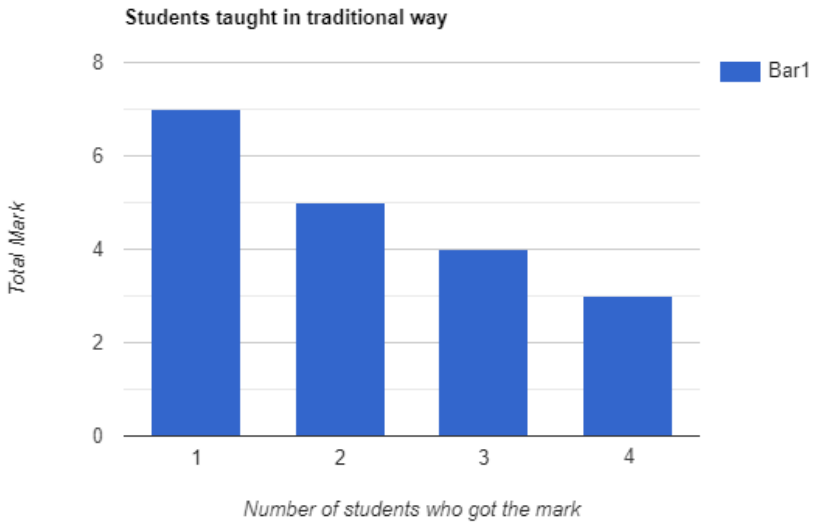

Fig. 5.2: Students taught in traditional way result.

The results of the students who were taught in AR-VR is:

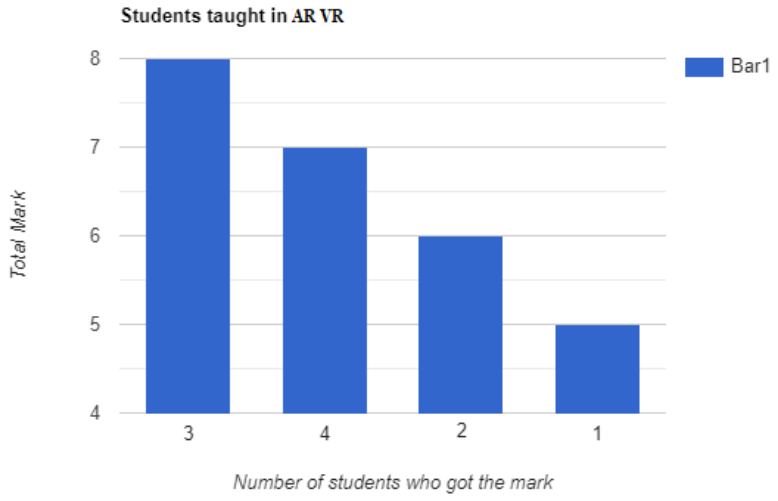

Fig. 5.3: Students taught in AR VR result.

The students who were taught using AR and VR performed much better than the students who were taught traditionally. From the survey result, we can say that our way of teaching the students about solar system was effective than traditional way.

Chapter 6

Conclusion

6.1 Summary

The participants in our study were 20 primary school students who were split into two groups. One group received typical classroom education on the solar system, while the other group used augmented reality and virtual reality software to explore the solar system.

The study's findings revealed that the group that used the augmented reality and virtual reality app knew a lot more about the solar system than the group that received regular classroom education. The group using augmented reality and virtual reality also demonstrated better levels of motivation and involvement in their study of the solar system.

The study's findings generally indicate that augmented reality and virtual reality technologies may be useful tools for improving students' comprehension and engagement in challenging scientific ideas like the solar system.

6.1.1 Strength

The strength of this study is showing the Virtual Environment of planets and Augmented objects and rotation of planets. Watching planets and they are rotating inside a real world through Augmented Reality and watching, enjoying the planets environment through Virtual Reality is the importance of our study.

6.1.2 Weakness

The weakness lies in detection of surface or known as surface tracking of AR application in low light and for low-spec devices VR application is quite laggy because of the usage of High-end textures.

6.1.3 Limitations

The limitation in the study is the unavailability of planet environments resources for VR Applications. Our target was to use every planet’s surface in VR application. Because of the lack of resources, we had to build planet surfaces from scratch like Miranda (Uranus Moon) and Saturn from a concept art.

6.1.4 Social, Cultural, and Environmental Impact

- Virtual reality is an excellent solution for people in this position because it allows children and adults to practice social skills in an environment that seems safer and more under their control until their confidence and skills have grown sufficiently for them to practice in real life.
- Autism is a disorder that frequently causes social anxiety. They may struggle to pick up on social signs and make eye contact with others. Some autistic persons report feeling distant and lonely, anxious in public, or overwhelmed when they can't express their emotions. Virtual reality is assisting people with autism in learning to communicate more efficiently and being more comfortable in social situations. Autistic people are using virtual reality programs to practice talks, identify emotions, and learn about finding friends and evaluate friendship quality. Several people who have used VR in this manner report feeling more at ease in the virtual setting than they would in real life. VR appears to be a highly useful medium for those with autism.
- The impact of augmented reality on society has been enormous. Technology has enabled individuals to interact with their surroundings in entirely new ways, spawning new forms of entertainment and communication. AR has also had a substantial impact on how we live and work. For example, augmented reality can now be used to overlay information about our surroundings, such as instructions or the location of neighboring businesses. This technology has the potential to transform education by allowing students to visualize concepts in a far more immersive way than previous methods. Augmented reality is going to become progressively more prevalent and interwoven into our daily lives in the future. It can alter our interactions with the world around us, as well as to open new opportunities for organizations and individuals alike.

6.2 Future Work

1. Implementing detail solar system architecture.
2. Enhancing students' knowledge of solar systems in Bangladeshi school’s classrooms with the use of our project.
3. Adding attraction and tourist places in planet.

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Appendix A

Program and Course Outcomes

CSE400-A

Program Outcomes

PO1 (Engineering Knowledge): Computer vision technology is used in augmented reality to identify the physical surroundings and add digital content to it. Real-time tracking of movement and position is necessary as well as a comprehension of the geometry and external appearance of things in the physical environment. 3D modeling and rendering methods are crucial for building a realistic virtual reality simulation of the solar system. This entails using computer software to build a 3D model of the solar system and rendering it in real-time to provide the user an immersive experience. How people will engage with the technology needs to be carefully considered for both augmented reality and virtual reality. Sensor fusion techniques may be used to precisely track the position and motion of a user's head. To do this, data from many sensors, including accelerometers, gyroscopes, and magnetometers, are combined to produce a more precise and reliable tracking system. Mobile app development abilities are crucial since augmented reality frequently uses smartphones or other mobile devices to overlay digital content on the actual environment. Creating apps for iOS or Android, connecting with various sensors and camera hardware, and tuning performance for various devices are a few examples of what this may entail.

PO4 (Investigation): In order to perceive the physical surroundings and add digital content to it, augmented reality uses computer vision technologies. Understanding the geometry, appearance, and real-time monitoring of moving and stationary objects in the physical environment are required for this. 3D modeling and rendering methods are crucial for producing a solar system that appears realistic in virtual reality. In order to give the viewer an immersive experience, a 3D model of the solar system is created using computer software and rendered in real-time. The way students will engage with the technology is important to take into account for both augmented reality and virtual reality. This includes creating user-friendly interfaces, enhancing performance, and reducing motion sickness or other adverse user effects. To do this, data from many sensors, including accelerometers, gyroscopes, and magnetometers,

are combined to produce a more precise and reliable tracking system. Mobile app development abilities are crucial since augmented reality frequently uses smartphones or other mobile devices to overlay digital content on the actual environment. Creating apps for iOS or Android, connecting with various sensors and camera hardware, and tuning performance for various devices are a few examples of what this may entail.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO1	We have identified the education based complex problem as our capstone project. We chose this topic because solving this problem will improve how the students will learn from new technologies.	**(i) Identify a real-life problem [K1, K2, K3]** K1: We used gravity to make the character jump and stick to the ground. We used coordinate mapping to implement character movement. K2: Use gravitational law in a planet surface. Mathematics based movement analysis. Statistical data to find out student's interest on solar system. K3: Interactive experience of a real-world environment. Simulated 3-dimensional environment presentation.	**(i) Identify a real-life problem [EP1, EP2, EP6, EP7]** EP1: 3-dimensional and interactive environment development. Planet surface and planet structure designing. Real-time 3D projects for various industries across games, animation, automotive, architecture, and more. EP2: If the world to explore is too big, students can explore more places and learn more things. But this will cause the application to take a lot of space into user's device. Also, to render more details, it requires more computational power. EP6: AR and VR are being used by big companies like google, meta etc. to enhance user experience.

			EP7: Design of the environment is a sub-problem. Implementing character movement is another sub-problem. Displaying designed environment through AR and VR is another sub-problem.
CO2	Augmented reality uses computer vision technologies to understand the geometry, appearance, and real-time monitoring of moving and stationary objects in the physical environment. 3D modeling and rendering methods are used to create a solar system that appears realistic in virtual reality. Sensor fusion techniques are used to precisely track the position and motion of a user's head or other body parts. Mobile app development abilities are needed to create apps for iOS or Android, connecting with	**(i) Define the problems [K8]** K8: Papers on Augmented Reality in Education System. Papers on AR & VR Based Child Education in Context of Bangladesh. Papers on education System for Bangladesh Using Augmented Reality, Virtual Reality, and Artificial Intelligence. Papers on virtual reality education expansion.	‖

	sensors and camera hardware, and tuning performance for various devices.		

CSE400-B

Program Outcomes

PO2 (Problem Analysis): Our AR & VR app is built to increase Fun, virtual tour, and existing simulation learning. Virtual reality and Augmented reality improve learning and keeps students engaged. The importance of virtual reality is that it can revolutionize instructional content by creating a virtual world. A genuine and imagined world is established, assisting the students in comprehending what is being taught. It enables students to view and interact with a virtual world.

PO3 (Design/Development of Solutions): Our project is based on programming. Our project goal is to improve learning efficiency though new technology like AR and VR. There is no usage of harmful components for public health in the project. Students can improve their knowledge visually, so their mental health improved. This project improves to grow paperless system, green efficient system and environmentally sustainable.

PO5 (Modern Tool Usage): For programming the AR application, we have used Blueprint visual scripting which is a modern programming language developed by Unreal Engine. Most of the modern games are developed using unreal engine visual blueprint scripting. We have used mobile's camera to track surfaces and place objects in the augmented environment. For programming the VR application, we have used C# which is a widely used programming language for game development, web development, app development etc. We have used google VR box and VR controller to simulate virtual reality environments. We have VR controller to simulate virtual reality environments. We have used our GPU to render shaders to our application.

PO6 (The Engineer and Society): Our capstone project has no harmful societal and environmental impact. Our project is not limited to a particular age group of people. There is no gender discrimination. Both males and females can use this system very easily. This is a

software-based application. Therefore, there is no chance of releasing harmful elements. This system only requires a mobile phone. This system tracks the surface and places objects in there to explore. Also, this system creates a virtual environment to enjoy via VR glass. This system is faster and simpler to use, and all the guidelines are provided. This system allows users to experience Augmented reality and virtual reality environments through mobile devices which ensures no touching of any surface and users don't have to go outside which ensures 100% safety from bacteria or viruses that may be present in the environment. There are no cultural or legal issues. People from every religious group can use this system.

CO	Details	Knowledge Profile (K)	Engineering Problem (EP)
CO3	Analyze various aspects of the objectives for designing a solution for the capstone project. **How we acknowledged:** Our AR & VR app is built to increase Fun, virtual tour, and existing simulation learning. Virtual reality and Augmented reality improve learning and keeps students engaged. The importance of virtual reality is that it can revolutionize instructional content by creating a virtual world. A genuine and imagined world is established, assisting the students in comprehending what is being taught. It enables students to view and interact with a virtual world.	**(i) Problem Analysis [K1, K2, K3, K4]** K1 - Knowledge of linear algebra and calculus has been used to understand the mechanism. K2 - Numerical Analysis and Statistical Analysis have been used. K3 - Programming Language, Augmented Reality, Virtual Reality, and development knowledge is being used to build the project concept. K4 - Forefront Engineering Specialist Knowledge: Augmented Reality knowledge, Reality knowledge have been used for project development.	**(i) Problem Analysis [EP1, EP2, EP3, EP6, EP7]** EP1 - VR & AR in solar system type research papers to acquire knowledge about their objectives. EP2 - Multiple Stakeholders may have different requirements. These changing requirements are considered. EP3 - To identify the probable solutions, we use augmented reality and virtual reality to improve solar system. utilizing the interactivity and experimentation that AR & VR devices provide. So, depth analysis is being performed to build an efficient model to solve this problem. EP6 - The Point of view of stakeholders for this project is considered.

			EP7 - Interdependent modules are implemented. Removing pre-spawned planet/s requires checking the scene whether any object or planet is present.
CO4	Design and develop solutions for the capstone project that meet public health and safety, cultural, societal, and environmental considerations. **How we acknowledged:** Our project is based on programming. Our project goal is to improve learning efficiency though new technology like AR and VR. There is no usage of harmful components for public health in the project. Students can improve their knowledge visually, so their mental health improved. This project improves to grow paperless system, green efficient system and environmentally sustainable.	**(i) Design and Implementation [K5]** **K5: Engineering design:** K5 - Engineering design is one of the core parts of our project. In the design and implementation part, we have identified the probable problems that can arise. Then, we designed a project model that can solve the problem.	**(i)Design and Implementation [EP1, EP2, EP4, EP5, EP6, EP7]** EP1 - Knowledge about surface tracking was used to build the AR application. A 3-dimensional and interactive environment was developed, and Planet surface and planet structure designing was used in this project. EP2, EP6 - Multiple Stakeholders can have different design requirements. We have identified the probable requirements of different stakeholders. EP4 - There were different opinions of Team members about project design. This issue was solved by group discussion and effective communication. EP5 – Some features work on. So, have had to do an Architecture Performance analysis for fewer features. EP7 - Interdependent modules are implemented.

			Removing pre-spawned planet/s requires checking the scene whether any object or planet is present.
CO5	Identify and apply modern engineering and IT tools for the design and development of the capstone project. **How we acknowledged:** For programming the AR application, we have used Blueprint visual scripting which is a modern programming language developed by Unreal Engine. Most of the modern games are developed using unreal engine visual blueprint scripting. We have used mobile's camera to track surfaces and place objects in the augmented environment. For programming the VR application, we have used C# which is a widely used programming language for game development, web development, app development etc. We have used google VR box and VR controller to simulate virtual reality environments. We have	**(i) Materials and Devices [K6]** K6 - Knowledge about movement, gravity and player control was programmed and implemented using blueprint visual scripting and C#.	**(i) Materials and Devices [EP1, EP2, EP4, EP5]** EP1 - Knowledge about surface tracking was used to build the AR application. A 3-dimensional and interactive environment was developed, and Planet surface and planet structure designing was used in this project. EP2 - Tools used to develop the project have been selected considering the given aspects. EP4 - There were different opinions of Team members about project design. This issue was solved by group discussion and effective communication. EP5 - Standard project management and development practice is used for project management.

	used our GPU to render shaders to our application.		
CO6	Assess and address societal, health, safety, legal and cultural aspects related to the implementation of the capstone project considering the relevant professional and engineering practices and solutions. **How we acknowledged:** Our capstone project has no harmful societal and environmental impact. Our project is not limited to a particular age group of people. There is no gender discrimination. Both males and females can use this system very easily. This is a software-based application. Therefore, there is no chance of releasing harmful elements. This system only requires a mobile phone. This system tracks the surface and places objects in there to explore. Also, this system creates a virtual environment to enjoy via VR glass. This system is faster and simpler to use, and all the guidelines are	**(i) Social and Environmental Impact of Engineering [K7]** K7: Does not show any harmful activities economically, socially, economically and culturally.	**(i) Social and Environmental Impact of Engineering [EP2, EP5, EP6]** EP2 - Tools used to develop the project have been selected considering the given aspects. EP5 - Standard project management and development practice are used for project management. EP6 - Stakeholders can change their needs considering societal, health safety and cultural issues.

	provided. This system allows users to experience Augmented reality and virtual reality environments through mobile devices which ensures no touching of any surface and users don't have to go outside which ensures 100% safety from bacteria or viruses that may be present in the environment. There are no cultural or legal issues. People from every religious group can use this system.		

CSE400-C

Program Outcomes

PO7 (Environment and Sustainability): Priority should be given to avoid environmental damage before beginning any project. Our capstone project has no such negative environmental impact. This is a software-based application. As a result, there is no risk of harmful elements or substances being released. The tools utilized for this study, such as the mobile phone, Laptop, and other software-type tools, cannot be deemed environmentally hazardous. The system does not require a lot of space or a lot of electricity to function. As a result, it is a sustainable and environmentally beneficial enterprise.

PO8 (Ethics): In the project planning phase, we have considered the ethical point of view regarding our work. Our application deals with education purposes. To implement planet surfaces or assets, we had to go through many resources to planet components. We also have given credit to their work and mentioned that this assets were collected from their sources. Also, these apps don’t collect any personal information. So, we have maintained privacy for those who use our apps.

PO9 (Individual Work and Teamwork): Developing this project required teamwork, though we each have our contributions to this project. Implementing these apps required a great deal of programming experience and designing knowledges. We contributed as per our capability and completed the project to some extent. We've learnt that communication is essential for teamwork, and team members must listen to and assess each other's ideas.

PO10 (Communication): Any project will succeed if communication is effective. "Discord" is the platform that we have used to interact with each other. We had some face-to-face meetings, but most of the time " Discord " was the priority when communication was required.

PO11 (Project Management and Finance): This project is quite a large project, which needed a lot of effort and time to complete the application. For that reason, we have divided our work into milestones and assigned team members to do that in time. If any issue arises, we held a meeting to solve the problem. We have used WBS (World Breakdown Structure) which we have learned in CSE495 course, to track our project completion.

The project requires very little hardware like a mobile, pc and these things are already present to all the students of the CSE department, there was no necessity for financial support to complete the project. But a high-end Computer is better for these apps' development. In the future, if we plan to extend our project by polishing and creating other planets, then we may need some financial support for assets like planet textures, and a highly configured computer that can maintain rendering and efficient these applications.

PO12 (Life-Long Learning): The concepts we have learned and applied to implement this project were self-initiated learning. We have explored many new concepts and languages which were unknown to us. We have learned to apply those concepts in our implementation and made two separate apps in different platforms which was quite challenging for us. It helped us to reach the depth of knowledge and use that knowledge practically. We learned to give our proper attention and find a solution when a problem arises. We get inspiration to apply our new ideas or techniques which may help future students to work with AR and VR technology.

CO	CO Descriptions	Knowledge Profile (K)	Engineering Problem (EP)
CO7	Priority should be given to avoid environmental damage before	**(i) Societal and environmental contexts [K7]**	**(i) Societal and environmental contexts [EP2, EP5, EP6]**

	beginning any project. Our capstone project has no such negative environmental impact. This is a software-based application. As a result, there is no risk of harmful elements or substances being released. The tools utilized for this study, such as the mobile phone, Laptop, and other software-type tools, cannot be deemed environmentally hazardous. The system does not require a lot of space or a lot of electricity to function. As a result, it is a sustainable and environmentally beneficial enterprise.	**K7: Comprehension of engineering in society:** We addressed ethical and public safety problems when creating and implementing the project. We also evaluated the economic, social, and cultural implications of developing this initiative at no cost for setup and operation.	**EP2: Range of conflicting requirements:** Low-end devices may face some issue launching apps. **EP5: Extent of applicable codes:** VR application requires to have a controller for movement in the planet surfaces and AR application requires AR core enables mobiles and have a good camera phone to place planets. **EP6: Extent of stakeholder involvement and conflicting requirements:** Stakeholders can view our apps using mobile phone. But they must have a controller to move around in the VR application where AR application needs proper surface for placing planets.
CO8	In the project planning phase, we have considered the ethical point of view regarding our work. Our application deals with education purposes. To implement planet surfaces or assets, we had to go through many resources to planet	**(i) Ethical principle and practices [K7]** **K7: Comprehension of engineering in society:** In designing and implementing the project we have considered ethical and public safety issues.	

	components. We also have given credit to their work and mentioned that these assets were collected from their sources. Also, these apps don't collect any personal information. So, we have maintained privacy for those who use our apps.		
CO9	Developing this project required teamwork, though we each have our contributions to this project. Implementing these apps required a great deal of programming experience and designing knowledges. We contributed as per our capability and completed the project to some extent. We've learnt that communication is essential for teamwork, and team members must listen to and assess each other's ideas.		
CO10	We have produced a compelling report on the capstone project. We have explored the design and implementation elements of our project in depth in the report's		**EA1: Range of resources:** To implement our applications we have involved two websites. To make planet's surface, we used those two resources. All the resources were

	design and implementation section, which refers to Chapters 3 and 4.		available in those two websites. **EA2: Level of interaction:** At first, we faced issues collecting planets components like terrain and textures. Also, we faced numerous of problems while implementing these apps. **EA3: Innovation:** Use of emerging technologies, AR and VR are relatively new technologies in education that are still in their early stages. The application of these technologies in the Solar System project can be viewed as a novel approach to integrating cutting-edge technology into education. **EA4: Consequences to society and the environment:** Significant positive consequences to the students as we are working towards a goal of making educational application through newest technology which has no identical impact on the environment. **EA5: Familiarity:** We have built this project

			because we wanted to show that newest technologies should be used for educational purpose. It develops the affection towards the topic they are learning when they see it by themselves.
CO11	This project is quite a large project, which needed a lot of effort and time to complete the application. For that reason, we have divided our work into milestones and assigned team members to do that in time. If any issue arises, we held a meeting to solve the problem. We have used WBS (World Breakdown Structure) which we have learned in CSE495 course, to track our project completion. The project requires very little hardware like a mobile, pc and these things are already present to all the students of the CSE department, there was no necessity for financial support to complete the project. But a high-end Computer is better for these apps'		

	development. In the future, if we plan to extend our project by polishing and creating other planets, then we may need some financial support for assets like planet textures, and a highly configured computer that can maintain rendering and efficient these applications.		
CO12	The concepts we have learned and applied to implement this project were self-initiated learning. We have explored many new concepts and languages which were unknown to us. We have learned to apply those concepts in our implementation and made two separate apps in different platforms which was quite challenging for us. It helped us to reach the depth of knowledge and use that knowledge practically. We learned to give our proper attention and find a solution when a problem arises. We get inspiration to apply our		

	new ideas or techniques which may help future students to work with AR and VR technology. We learned to give proper attention and focus on a point. We also learned to find a solution when a problem arises. We get inspiration to apply our new ideas or techniques which perhaps can take mankind one step further.		