VIRTUAL REALITY FOR SCIENCE EXHIBIT

2019 Group 11-16

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Abstract

By conducting a survey among a group of sec 4 students to test their understanding about a specific experimental set-up, this project found that most students could not apply their physics concept well to predict the experimental results, and many of them were still unable to explain the reasons for their observation after watching the experiment. In order to enhance students' understanding of the physics concept behind the model, this project aimed to improve their learning process with the application of Virtual Reality (VR). Virtual models are created in accordance to the real set-up, with changeable experimental variables which are fixed in reality. Students are able to conduct the virtual experiment by themselves more conveniently and explore the principles behind it with provided data and observed results. It is shown that this type of VR technology is very effective for educational purposes and promising for further application in experimental demonstration.

Introduction

The use of VR has changed the mode of unification and suppleness in traditional teaching. VR enables students to experience high-quality educational visualization so that they can easily understand complex concepts, theories, and subjects. Nowadays, VR has been identified as one of the four key frontier technology focus areas of Singapore's digital economy.

In 2019, the pilot project tested the feasibility of introducing VR to local Singapore schools as a tool in teaching and learning of social studies. However, the use of VR to teach physics has not yet been introduced to Singapore schools due to complexity and difficulty in constructing real physics models. This project aimed to fill up the blank by using VR to help students better understand physics concepts.

To start with, this project initially focused on a physics setup (Shown in Figure 1.1) in the Science and Research Center (SRC) laboratory. Students are expected to learn the concept of conservation of energy, in this case, the interconversion of potential and kinetic energy, by rolling two balls from the top of the two tracks and observing which ball will reach the end first.

Figure 1.1

(For the convenience of presentation, the straight track is named Track A while the concave one is named Track B. Ball A refers to the ball rolling on the Track A and Ball B refers to the ball rolling on the Track B)

As a result, Ball B always takes a shorter time to reach the end. This can be explained as when Ball B reaches the concavity, the speed of Ball B is always greater than the speed of Ball A until Ball B rolls up to the left slope of the concavity where their speeds become equal again.

A survey was conducted among Sec 4 students to test their understanding of the physics setup. Students were required to predict the result of the setup before they were able to carry out the experiment by themselves. The result of the survey is shown below as Figure 1.2.

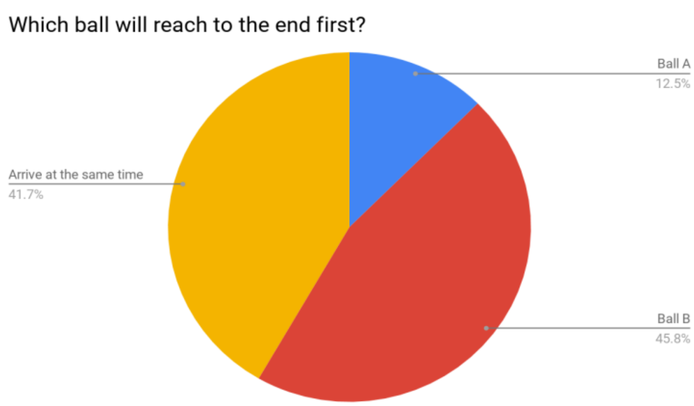

Figure 1.2 (Sample size: 48 sec 4 students)

As the correct answer should be Ball B, about 54.2% of the respondents were not clear about the concept. Among those students who got the correct answer, a further investigation found out that nearly half of them chose the correct answer by random guessing. In conclusion, about three quarters of the sec 4 students failed to analyse the concept behind the physics setup. This project aimed to investigate and address why students had failed to understand the physics concepts behind and thus enhance their learning by using VR.

The implementation of VR offers students with an interactive learning experience as they are able to access their own virtual world. Compared to the fixed settings in the real world, VR allows students to change variables such as gravity and friction so that students are able to link different factors all together. This enhances the learning process because students have to learn independently rather than passively accepting what teachers are teaching. Hence, students will have a deeper understanding of the physics concepts behind the experiment.

Solution Design

This project originally aimed to apply Augmented Reality (AR) to better demonstrate the data collected from the experiment. With the real set-up shown on the screen, this project tried to add a virtual velocity-time graph playing simultaneously as the two virtual balls are rolling on the real tracks, to show the speeds of the balls at different positions on the track. In addition, the velocity-time graph was measured (by light gate) and plotted in advance, which was examined by a Junior College (JC) physics professor as well to ensure its accuracy. The proposed solution design is shown as Figure 2.1 and 2.2 in Appendix.

However, as there is only one set of data, the velocity-time graph is fixed, hence the function of this solution design is very limited. Moreover, the physics concept -- conservation of energy is not well reflected in this design, which means students can only get the provided data without doing the measurement by themselves, but hardly learn further about the principle, such as possible factors that will affect the results. This adds little value to students' learning.

After discussing with a National University of Singapore (NUS) professor specialising in Virtual Reality, this project changed its study object to Virtual Reality, which is considered to be more beneficial than Augmented Reality, since the fixed variations in reality such as gravity and friction are now able to be changed in the virtual world. Therefore students can explore more by observing the effect of different factors to the experimental results and have a better understanding about the physics concept.

In the beginning, this project chose Unity, a free software, as the engine for VR demonstration. An asset called ProBuilder was then downloaded in the Unity store to construct the virtual models. Based on the cuboid created, part of the face could be selected (Shown in Figure 2.3) and by shifting the edge vertically upwards, a slope is constructed (Shown in Figure 2.4). Similar process could be applied to create the concavity.

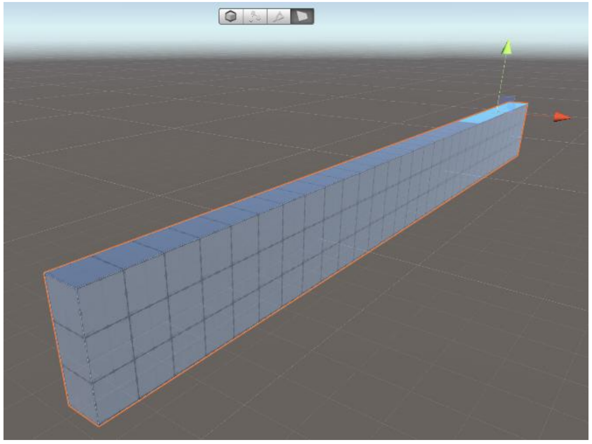

Figure 2.3

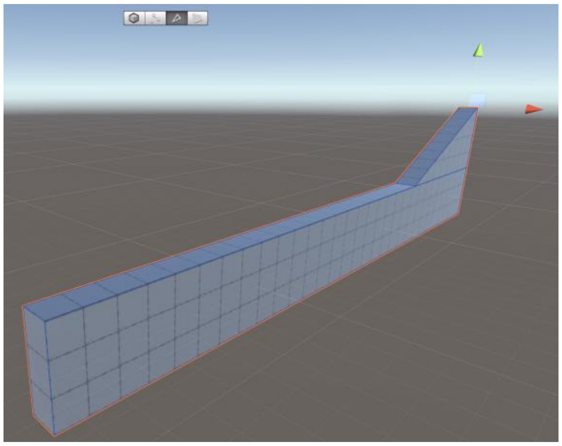

Figure 2.4

In the first prototype, there was a relatively significant difference in terms of shape and proportion between the virtual models and real ones. After adding the balls onto the tracks, it was found that one of the balls flew upon the incline instead of rolling on it (Shown in Figure 2.5). In addition, due to the bouncing effect after rolling down the slope, both balls could not roll smoothly any more.

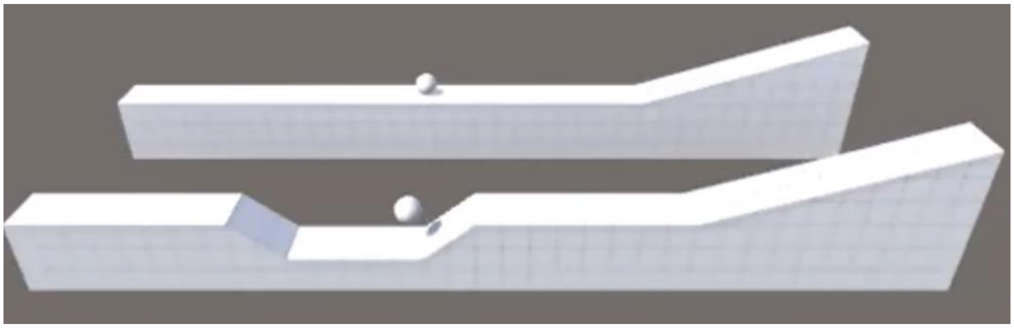

Figure 2.5

In order to ensure the successful rolling, the angle of inclination of the slope was then reduced so that the ball will not hit the bottom of concavity. In addition, different libraries and functions in

Unity makes it available to control the movement of the ball as well as to track the speeds of the balls. Also, it offered the project means to change all the intended physical variables such as gravity and friction. Part of the coding is shown as Figure 2.6 and Figure 2.7 in Appendix, and the coding language used is C#.

The final product is shown in Figure 2.8 below. After modification of the model, the result obtained from the virtual experiment coincides with the real one, which means ball B does reach the end faster. The instantaneous speed of the two balls is shown respectively and users are able to pause the demonstration at any point of time to read the data. Moreover, three sliders representing gravity, friction and mass were added so that users can also change the variables by themselves and observe the effect directly.

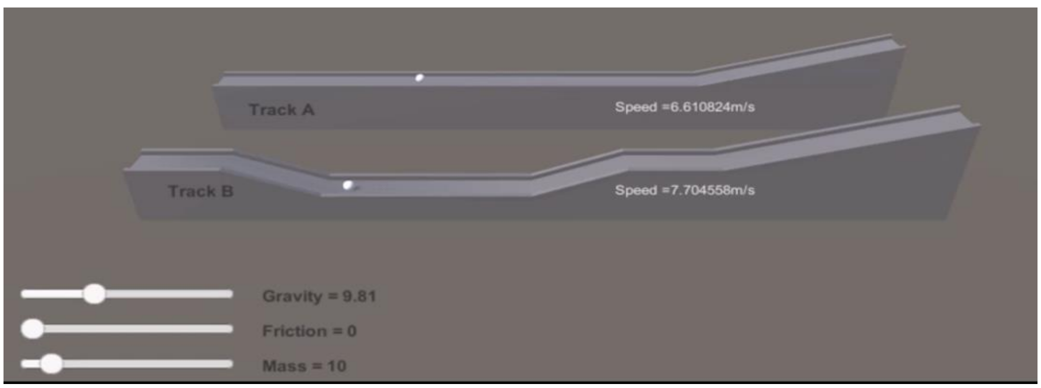

Figure 2.8

Results & Discussion

A survey including several physics questions based on this demo had been conducted among 39 secondary 4 students again to test the effectiveness of our latest prototype. Students were randomly divided into two groups A and B respectively. The former group was asked to answer the survey without using VR prototype while the latter one attempted the VR prototype first before they were ready to answer the survey. According to the results of these two surveys, students with the assistance of virtual reality did a better job in answering corresponding questions compared to those simply watching the video demo. They were also better at explaining the exact reason for why ball B actually rolls faster than ball A. The results are shown in figure 3.1, 3.2 and 3.3 below.

Will the size of gravitational acceleration affect the ending speed of the ball?

33 / 36 correct responses

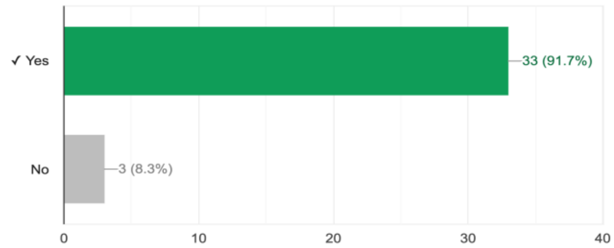

Figure 3.1

Will the friction affect the result?

31 / 36 correct responses

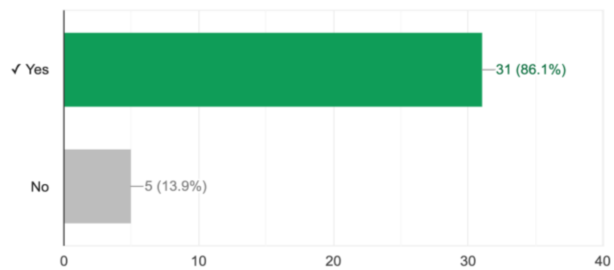

Figure 3.2

Will the density of the ball affect the result?

34 / 36 correct responses

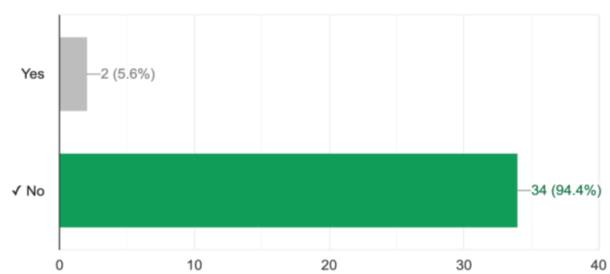

Figure 3.3

Conclusion

This project successfully used Virtual Reality to better display the rolling-ball experiment, facilitating students' learning process and found that there is a promising prospect in the application of VR for educational purposes, especially for other ideal science experiments which cannot be achieved in reality. As an experimental demonstration, though the principles behind the experiment is not explained, which means students still need to explore the reason by themselves, it has achieved significant improvement compared to conventional laboratorial experiments.

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evaluating the effectiveness of our product in enhancing their learning experiences. SRC physics lab staff, for allowing us to conduct the experiment and ensure our proper use of measuring devices.

Appendix

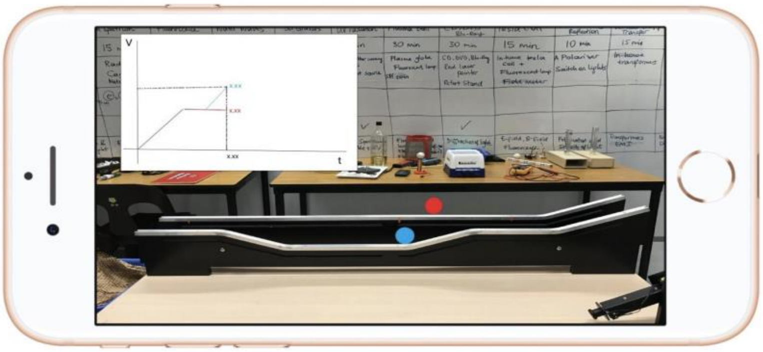

Figure 2.1

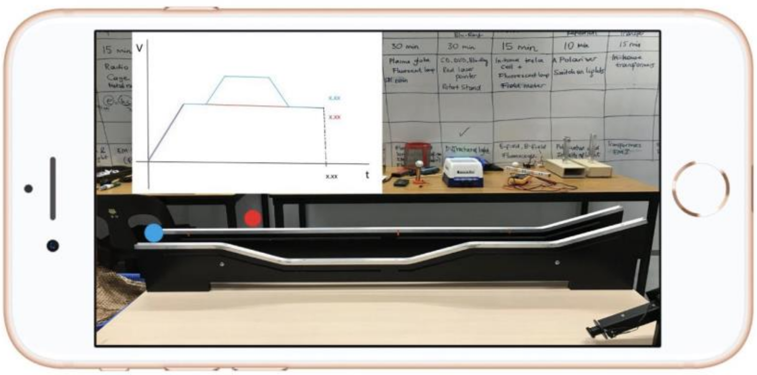

Figure 2.2

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

public class GetGravity : MonoBehaviour
{
    public Slider gravitySlider;
    private Text textSliderValue;
    void Start()
    {
        textSliderValue = GetComponent<Text>();
    }

    // Update is called once per frame
    void ShowSliderValue()
    {
        string SliderText = "Gravity = " + gravitySlider.value;
        textSliderValue.text = SliderText;
    }
    void Update()
    {
        ShowSliderValue();
    }
}
```

Figure 2.6 (Coding sample used to display the value of gravity)

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

public class Gravity : MonoBehaviour
{
    public float gravity = 9.81f;
    public Slider mainSlider;
    Vector3 vecotrGravity;
    // Start is called before the first frame update
    void Start()
    {

    }

    // Update is called once per frame
    private void FixedUpdate()
    {
        gravity = mainSlider.value;
        Physics.gravity = new Vector3(0f, -gravity, 0f);
    }
}
```

Figure 2.7 (Coding sample used to display the value of gravity)