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Youth Perception in Using Virtual Reality Technology in Science Learning

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Abstract
The shift to online education and the closure of physical learning institutions showed critical challenges for youth learners that rely heavily on hands-on practical experience. Analysing youth perceptions of using virtual reality (VR) technology in learning science subjects is reflected as the starting point towards a more effective and engaging learning environment. Previous research highlighted that the latest technology, such as smartphones, wearable technology, augmented reality (AR) technology, and virtual reality (VR) technology, can help close the gap in learning practical subjects via online platforms. Due to this, this study found a research gap in improving the usage of VR technology in science learning. This study aims to identify the youth learners' perceptions of using VR technology to support the teaching and learning process, specifically in hands-on practical subjects like science. This study adopted the case study methodology approach with quantitative analysis. The instruments used in this study include the SUS questionnaire and SUS scoring analysis. A total of 65 youth learners were involved in this study. The result of the SUS score resulting in a total of 75.04, which can be concluded as the acceptable range, achieves a grade of C on the grade scale, and has an adjective rating of "good." This reflected that the suggested VR application for learning science had demonstrated positive results regarding system usability for its effectiveness, efficiency, and satisfaction for respondents when learning science subjects. In the future, this study will target implementing the proposed model on another science topic.
Keywords: Youth Learner, VR Lab, Plant Science, Youth Perception, COVID-19 Pandemic

Introduction

Amendment to the Youth Societies and Youth Development Act (Amendment) 2019 (Act 668) redefines the definition of Malaysian youth age by lowering the age range from 15 to 40 to 15 to 30. This has effectively narrowed down the definition of youth, which can have implications on various policies and programs aimed at addressing the needs of this age group. Statistics by Department of Statistics Malaysia (2023) showed that more than 29% of the total Malaysian population fell within the age range of 15 to 30, amounting to approximately 9.9 million individuals, were considered youth. These figures highlight the significance of the youth demographic in the country.

Given the COVID-19 pandemic's impact on various aspects of society, it is understandable that youth development is a priority for Malaysia's national development agenda. Like many countries worldwide, Malaysia's youth have likely faced challenges during the pandemic, such as disruptions to education, job market difficulties, mental health issues, and social isolation. Youth leaners in schools and higher education institutions have also been directly affected. Youth leaners between the age of 15-30 years as stated in Youth Societies and Youth Development Act (Amendment) 2019 can be enhanced through wider exposure and professional training (Mursyid et. al., 2021). The closure of physical learning institutions and the shift to online education presented critical challenges specifically for youth learners that rely heavily on hands-on practical experience subjects. Example of the subjects are science, engineering, and other technical disciplines that require the use of laboratories (Stecuła & Wolniak, 2022). A study of engaging youth learners by Quigley et al (2020) highlighted on the use of connected learning theory that involve previous and new knowledge by digital technology and online information throughout the learning process.

For subjects that do not involve laboratory work, online learning platforms and digital resources can be effective tools. Youth learners can access learning materials, lectures, readings, and even participate in discussions and assignments remotely. These resources can provide a level of continuity in education during times when physical classes are not possible (Mukhtar et al., 2020).

In contradicting, interesting study by Stecuła and Wolniak (2022) highlighted that for subjects where laboratory work is essential for better comprehension and skill development. The transition to online learning poses significant challenges for subjects that required hands-on practical experience such as lack of hands-on experience, limited equipment and resources, and reduced interaction and guidance between the learners and the educators (Stecuła & Wolniak, 2022).

In order to address these challenges, it is crucial for the educators and learning institutions to focus on implementing initiatives to support the youth learners which suits their learning capabilities during these challenging times to foster and engage them with the learning process. Therefore, the purpose of this study is to identify the youth learners' perception on the use of virtual reality (VR) technology in supporting teaching and learning process specifically for hands-on practical subject which is science subject.

The objectives of this study are: (i) to propose a model for designing VR technology in learning science subject; (ii) to design the VR Plant Science application; and (iii) to test the perception of the youth learners on the proposed VR application using usability questionnaire. In conclusion, this study aims to yield a suggested solution that enhances students' comprehension of Plant Science through the application of VR technology, fostering an immersive and captivating learning atmosphere.

Literature Review

Challenges of Practical Subjects in Online Learning Platform

In education, the roles of technology have directly and indirectly changed the design and delivery of teaching and learning process (Attallah & Ilagure, 2018). Devices like smartphones, tablets, and wearable technology are starting to replace the conventional classroom teaching and learning system specifically adopted by the youth learners. The impact of technology-based learning affects the teaching practices, and the ways of learners acquire knowledge (Al-Taweel, Abdulkareem, Gul, & Alshami, 2020). Figure 1 illustrates a general overview of model for applying different technology in education platform (Fesol, Salam, & Bakar, Wearable Technology in Education to Enhance Technical MOOCs, 2018).

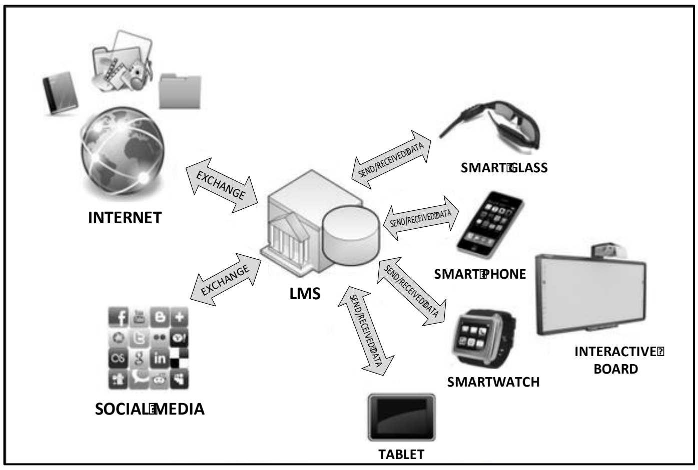


Figure 1. Model for applying divest integrated technology in education.
(Fesol et al., 2018)

The success of remote education relies on various factors, and simply introducing online learning platforms is not enough. Current studies like (Nambiar, 2020; Elhaty et al., 2020; Al-Taweel et al., 2020; Stecuła & Wolniak, 2022) also emphasized challenges with regards to teaching and learning practical subjects using online platform. Some of these challenges include:

i. Lack of hands-on experience: Laboratory work allows youth to apply theoretical knowledge in a practical setting, fostering a deeper understanding of concepts. Without access to physical laboratories, youth miss out on this critical aspect of their education.
ii. Limited equipment and resources: youth may not have access to the necessary laboratory equipment or materials at home, making it difficult to replicate experiments and practical exercises remotely.
iii. Reduced interaction and guidance: In a physical laboratory, instructors can directly observe and guide youth through experiments. This personalized interaction is harder to replicate in an online setting, leading to potential gaps in understanding.
iv. Group work limitations: Collaborative group work is common in laboratory settings, promoting teamwork and communication skills. Online environments may hinder the seamless coordination needed for effective group experiments.
v. Assessment challenges: Grading laboratory work remotely can be more complex than traditional methods, and ensuring academic integrity in remote lab assessments can be a concern.

Solutions for Teaching Practical Subjects in Online Learning Platform

While online resources have been valuable during the pandemic, the challenges for practical subjects highlight the importance of finding innovative solutions to ensure a comprehensive and well-rounded education for youth, regardless of the circumstances. Educators and institutions may explore some strategies such as implementing hybrid approaches that combines online theoretical learning with occasional in-person or supervised lab sessions could provide a balance between safety and practical experience (Triyason et al., 2020).

Tabatabai (2020) also suggested on implementing simulations and virtual learning which can offer youth some exposure to practical concepts and experiments, even if they cannot access physical labs. Based on further analysis of the literature on the implementation of digital technology solutions being adopted in learning platforms such as smart phones Mella-Norambuena et al (2021); Alshurideh et al (2022), wearable technology Fesol et al (2022), augmented reality (AR) technology Fesol & Salehuddin (2022); Ciloglu & Ustun (2023), and virtual reality (VR) technology Tsekhmister et al (2021); Raja & Priya (2022), we have found the research gap in improving the usage of VR technology in learning platform.

Virtual Reality (VR) Technology in Education

Virtual reality is a branch of computer science that aims to create, immerse in, and interact with a virtual world, using specific devices to simulate an environment and stimulate the user with inputs to make the experience as realistic as possible (Radianti et al., 2020). VR technology has described a 3-dimensional (3D) computer generated environment that allows users to look through a special display called head-mounted displays (HMDs) and see a computer-generated world instead of the normal world (Angelov et al., 2021). They see a virtual image, and the user's head movements are monitored electronically and sent back to the computer, which generates the images so that objects in the scene remain immobile as the user moves their head - just like in real life. The 3D environments can vary depending on their level of immersion. VR can be classified as immersive, semi-immersive and non-immersive (García-López, et al., 2021).

Immersive VR is a powerful phenomenon and has a strong affinity with the concept of "flow," where the sense of time and self-awareness are lost and attention is focused entirely on the current activity (Manaf & Rambli, 2021). Immersive display and interaction environments have been used in simulation, visualization, entertainment, art, and museum contexts for a long time before VR re-emerged just a few years ago. Immersive environments offer a special platform for the distribution of digital content in ultra-high resolution at a real-world size and for numerous concurrent viewers (Manaf & Rambli, 2021).

In non-immersive VR systems, users interact with a digital scenario displayed on a screen (e.g., a computer monitor or tablet). However, they remain aware of the real world around them because they can still see their physical surroundings. These systems are considered "non-immersive" because the user's experience is not fully multisensory, and they are not completely immersed in the virtual environment. Interaction with the virtual world is typically through input devices like a joystick or keyboard, which allows them to control their actions in the digital scenario (García-López, et al., 2021).

Semi-immersive VR takes users a step further into the virtual environment compared to non-immersive systems. In semi-immersive VR, users are surrounded by a larger display, such as a projection screen or a cave automatic virtual environment (CAVE). This setup provides a more immersive experience than non-immersive VR, as users have a more extensive field of view and a sense of being "inside" the digital scene. They can interact with the virtual environment through body movements, gestures, or other input devices, which enhances the feeling of immersion and presence in the virtual world. Figure 2 illustrates the comparison between immersive, semi-immersive and non-immersive, case study that implemented in the education field (García-López, et al., 2021).

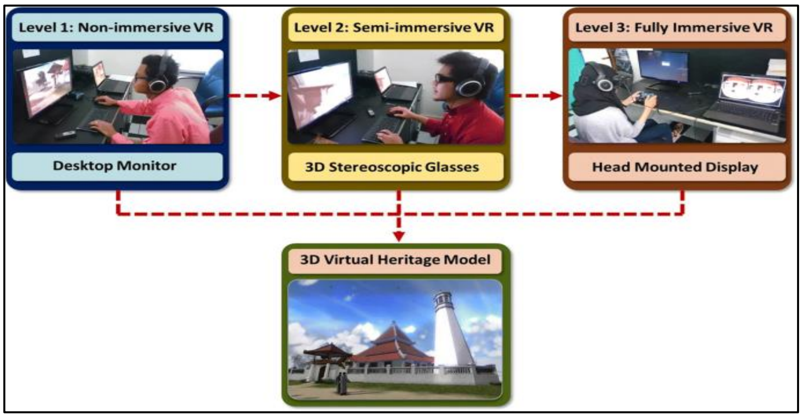


Figure 2. Example of different types of VR technology in learning history.
(Ghani et al., 2022)

Researchers believed that VR technology had enormous potential implications and benefits for teaching and learning environments. Some of the potential advantages in education are: (a) VR technology able to stimulate, motivate, and engage youth to explore learning materials from different perspectives Ghani et al (2022); (b) VR technology offers learners for improving concentration and giving trainees a measure of control over the environment Radianti et al (2020); (c) VR technology offers educators an ability to explain topics where learners can only gain the understanding by experience it by using virtual reality features Tsekhmister et al (2021); García-López, et al (2021); (d) VR technology also can foster youth creativity and imagination, help youth manage their learning suited their own pace and on their own path Le May et al (2021); Raja & Lakshmi Priya (2022); and (e) wearable technology able to stimulate an engaging learning environment appropriate to different type of youths' learning styles (Raja & Priya, 2022; Ghani et al., 2022).

Methodology

A quantitative, case study-based approach was chosen as the method in this study. To address the first and second objectives, the research adopts the Rapid Application Development (RAD) methodology for designing and developing the proposed model and application, as recommended by (Fesol and Salehuddin, 2022). RAD comprises four phases: requirement planning, user design, construction, and cutover. Figure 3 illustrates the flow of RAD.

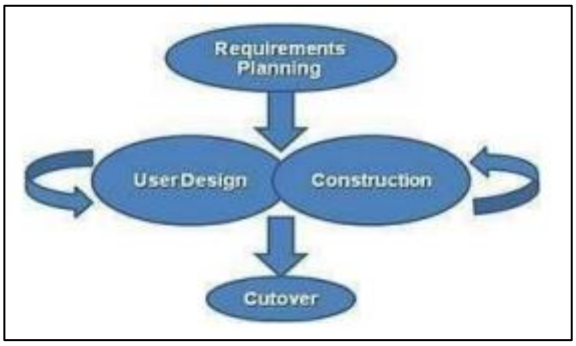


Figure 3. Rapid Application Development (RAD) phases.
(Fesol & Salehuddin, 2022)

Requirement Planning Phase

The requirement phase is the first step in the project development process. During this phase, all information and data must be gathered to determine the primary problem, the desired outcome, and the method for resolving the issues. Thus, a preliminary survey has been conducted which involved a total of 27 youth in science studies. The purpose of this survey is to identify problems facing by the science learners during COVID-19 pandemic, Online Distance Learning (ODL) class. The finding of the survey highlighted two (2) main problems: (1) Youth learners found it is difficult to access lab equipment during ODL class; and (2) Youth learners to understand the plant science topic due to a lack of hands-on experiment.

For the first problem, educators and learners experiencing major problems due to the closure of educational institutions because of the sudden spread of the pandemic. Youth have difficulty physically performing the activities in the laboratory which causes them to not be able to see the results of their studies visually and on a real scale. Educators in turn, have difficulty explaining and giving exposure because of this problem. Based on a survey conducted among the science learners, it revealed that majority of the respondents agreed on having less access to the laboratory during the ODL class (77.8%). On average, participants were only able to access the lab at a maximum rate of only once a week. This shows that it is difficult for them to access the equipment they need to perform the experiments on their subjects. This problem is because the epidemic is still rampant and their movement to be restricted and controlled (Debacq, et al., 2021).

For the second problem, learners have difficulty understanding plant science topics because of the lack of hands-on experiments. This difficulty causes youth learner to fail in this subject. They can only learn from books and not through hands-on experiments that could give them a better understanding. From the survey, it shows that 51.9% of the respondents reached only 3 out of 5 levels of their highest understanding on plant science topic. This modest percentage is evidence that they have difficulty understanding the topic unless they conduct experiments at the correct frequency. Moreover, through the survey, 96.3% of participants agreed that longer and more frequent access to conduct the experiments can contribute to a better understanding of the subject.

The alarming issues highlighted earlier indicates that learners feel that they need more time to access the laboratory to gain a deeper and more detailed understanding of the topic. With the development of this application, it is possible to achieve a better understanding because youth do not need to go to the classroom to perform the experiments, but they can perform these experiments anywhere and at any time with the used of RV technology.

User Design Phase

This section further explained on the design of the proposed model and the design of the VR application. Figure 4 illustrates an overview model proposed for this study to measure the youth perception using VR technology in science learning. The model cooperated the VR key concept design in the development of the proposed VR application to improve youth learner understanding in learning science subject.

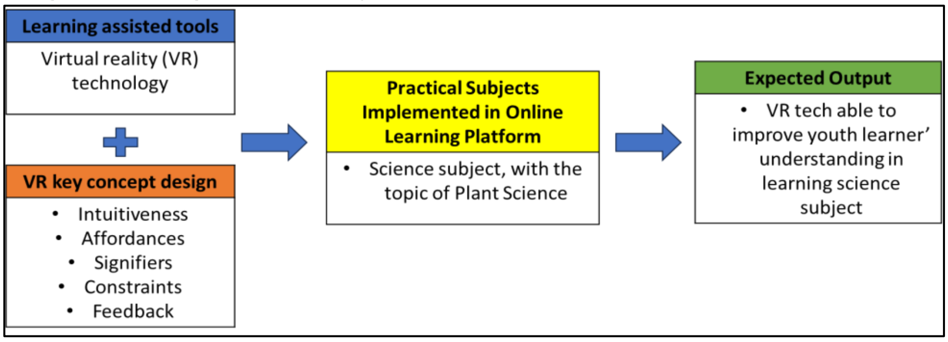


Figure 4. Model for designing VR technology in learning science subject.

The phase of VR technology application design includes constructing the flowcharts and storyboard of the proposed VR technology application. The major goal of the flowchart is to display the non-immersive VR's sequence as well as the flow where the user should browse the entire software application's progress. The Play, How to Play, About, and Setting buttons are the four main buttons on the main menu page. After clicking the Play button, the player is free to move around the lab and to explore the lab environment as they pleased. Player can learn how to move their hands and the virtual reality by pressing the How to Play button. The Learn Plant Science with VR Lab description was further explained under the About button. The setting button allow the player to control the audio features including the master volume and background music. Figure 5 shows the overall flowchart for Learn Plant Science through VR Lab.

The software programs that are essential for the design and development process include 3Ds Max, Blender Unity 3D, Adobe Illustrator (CS6), and Adobe Photoshop (CS6). the use of these software programs is vital for the design and development of the Learn Plant Science through VR Lab.

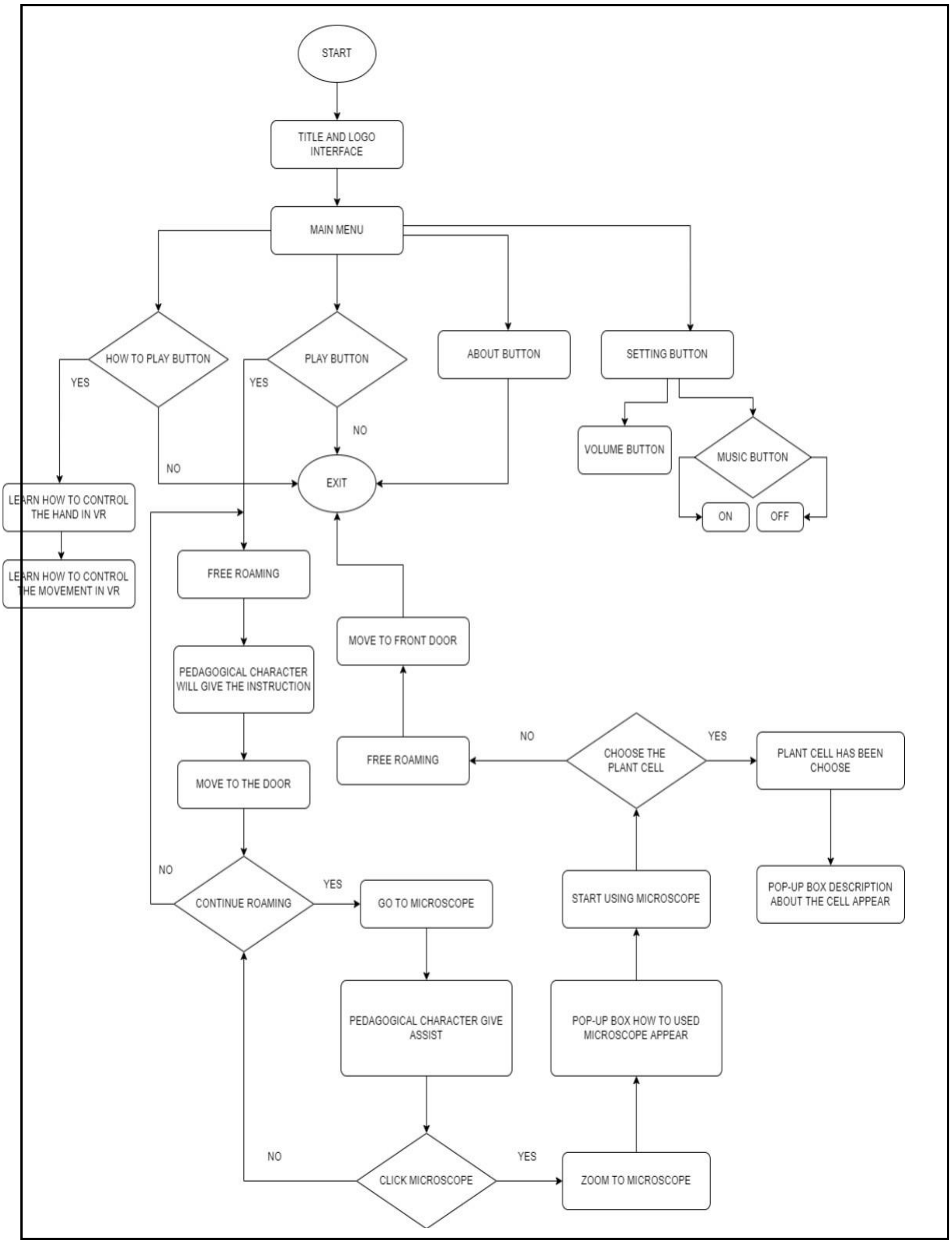


Figure 5. The flowchart for Learn Plant Science through VR Lab

Next, the storyboard shows the complete planning process graphically. A preliminary drawing, a straightforward schematic, and a development plan for the proposed VR application. The storyboard is also used as a reference point or a manual to help player comprehend the finished product better. The explanation for each storyboard of the non-immersive VR application for the Learn Plant Science through VR Lab as shown in Table 1.

Table 1 . The storyboard of non-immersive VR program for Learn Plant Sciencethrough VR Lab

SCENE 3: SCENE START

DESCRIPTION
The user will start by being in front of the lab, a 3D human character will give a description to the user, this 3D human character serves as a teacher in this VR simulation.

SCENE 2: MAIN MENU

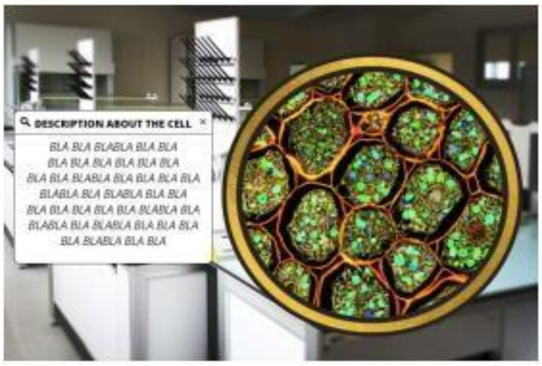
DESCRIPTION
On this page, users will be able to see five option buttons namely "PLAY" to play the VR, "HOW TO PLAY" button is to to give understanding to the user how to play this VR, "SETTING" button, is where the volume button display and the music on/off button, "ABOUT" button is will show the description about this VR and "X" button, which are red button is to exit the VR.

SCENE 4: INSIDE THE LAB

DESCRIPTION
The 3D character will provide step-by-step instructions for using the tools available in the lab.

SCENE 5: LEARN TO USE MICROSCOPE

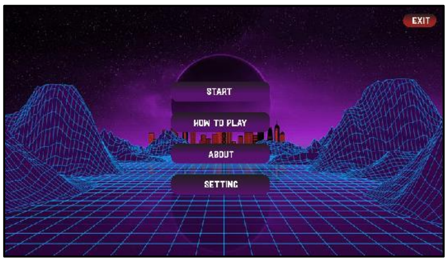
DESCRIPTION
When pressing the microscope, the display will zoom to the microscope, each part of the microscope can be held and used like a real microscope, pedagogical text will appear and provide instructions for using the microscope. The user has to complete all the steps for the next screen.

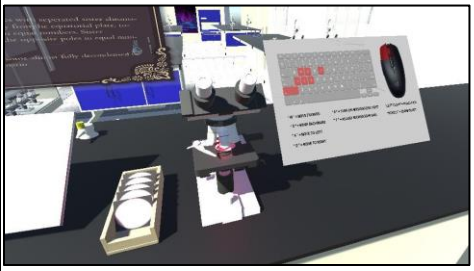
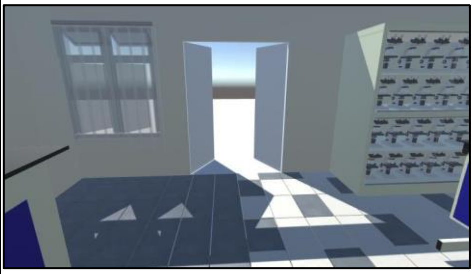
SCENE 6:

DESCRIPTION
After completing each step to use the microscope before, the user will enter the display inside the microscope, the user will be able to see the plant cell they studied, and there is a pedagogical text that will appear to explain what the user is looking at now.

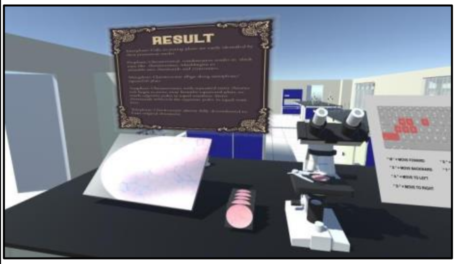
Construction Phase

The development phase is also known as the construction phase. This stage involved the programming and application development, coding, unit integration, and system testing. To design and develop an effective VR application, this study adopted the VR key concepts design model suggested by Jerald (2015) as the guidelines in designing and developing the proposed application to enhance youth learners' understanding and enjoyment in learning Plant Science subject via VR technology. The five (5) adopted VR key concepts design are intuitiveness, affordances, signifiers, constraints, and feedback (Jerald, 2015). Table 2 explains the VR key concepts design that has been implement to the proposed VR application.

Table 2
The VR key concepts design for interaction design

VR Key Concepts	**Explanation**
Intuitiveness 	The intuitiveness principles are used when a user can understand how the VR application operates in accordance with their expectations. When the users step into the lab 3D environment, the user surely can understand what they need to do.

	
Affordances  	The principles of affordances are used to specify what actions are permissible and how a user might interact with something. Instructions on using the application will be provided to the user. In the non-immersive VR software, all movement, including running, jumping, andinteracting with the equipment, has also been explained in the application.
Signifiers 	The signifiers principle places a strong emphasis on any visible cue or indication that informs the user about the appropriate function, operation, and behavior of a selected object.
Constraints 	Setting up boundaries for users requires the application of the constraint’s principles. The project's region of movement is one of the boundaries that have been established. This was put in place with the intention of keeping users from wandering off the path and getting lost in the unknown. For example, the user cannot walk through the wall. If they walk pass it they will be back to main menu.

Feedback 	The feedback principle focusses to communicates to the user the result of an action. For example, users can see the result and see the output at the screen.

Cutover Phase

In the RAD methodology, the cutover phase is the final phase. The cutover phase marks the transition from the design and development of the VR application to its deployment. This phase ensures that the application is ready for end-users and was tested for its usability which were adopted from the System Usability Scale (SUS) as suggested by Lewis and Sauro (2018). The SUS is a simple, 10-item instrument measuring user perceptions of a product's usability (Lewis & Sauro, 2018). The authors suggested that measure of system usability should cover the effectiveness (the ability of users to complete tasks using the system, and the quality of the output of those tasks), efficiency (the level of resource consumed in performing tasks), and satisfaction (users' subjective reactions to using the system) (Lewis & Sauro, 2018). Table 3 listed the SUS 10-items instrument adopted in this study.

Table 3

The SUS 10-item instrument. (Lewis & Sauro, 2018)

	SUS Question
1	I think that I would like to use this system frequently.
2	I found the system unnecessarily complex
3	I thought the system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found the various functions in this system were well integrated.
6	I thought there was too much inconsistency in this system.
7	I would imagine that most people would learn to use this system very quickly
8	I found the system very cumbersome to use
9	I felt very confident using the system
10	I needed to learn a lot of things before I could get going with this system

Results and Analysis

An online questionnaire was used as the main data collection method. The questionnaire was produced in bilingual format, and the language has been improved to make it easier for anybody to interpret and appropriately assess. This section discusses the details of participants, data collection procedure, survey instruments, outcomes, and findings of the proposed Learn Plant Science through VR Lab. The learners' perception was analysed based on the effectiveness, efficiency, and satisfaction, which were adopted from the System Usability Scale (SUS) as suggested by (Lewis and Sauro, 2018).

Case Study Participants

The targeted respondents for this study were youth learners who enrolled into the Plant Science subject and public learners who are interested to learn about Plant Science and voluntarily took part for the evaluation of the "Learn Plant Science through VR Lab". There is a total of 65 learners (n=65), with valid respond who took part in this study. As mentioned earlier, as this study implemented a case-study approach, the number of sampling (n=65), would reflect as enough as suggested by Fesol and Salehuddin (2022). Among them 58.5 percent (38) are male, and the remaining 41.5 percent (27) are female respondents. Majority of the respondents comes from the age group of 20-29 years (81.5%), currently in their 3rd and 4th semester of study in a degree programme, who has more experience with the online learning. Thus, the bias in the different level of learning understanding was believed avoidable to have the youth to answer the online questionnaire. The remaining respondents falls under 19 years (7.7%), 30-39 years (6.2%), and 40 years and above (4.6%). The participants were asked a diverse range of questions, covering various aspects of the application's usability and effectiveness.

Data Collection Procedure

The data collection involved three major phases. In the first stage, the respondents were asked to download and installed the "Learn Plant Science through VR Lab" application into their devices through the provided link shared to them. Next, the respondents were given a duration of 1 to 3 days to experience playing the VR application. Lastly, the respondents were asked to evaluate the "Learn Plant Science through VR Lab" application's usability via the online questionnaire platform.

Results

The SUS questionnaire was used to assess the usability of the proposed VR application. The SUS questionnaire consists of 10-tems, on a scale of Strongly Disagree to Strongly Agree (on a scale of 1 to 5). To calculate the overall usability score, the SUS formula will be used. The score for the system usability is computed based on contributions on each item. To calculate the SUS score, first sum the score contributions from each item, range from 0 to 4. For items 1,3,5,7, and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Next, multiply the sum of the scores by 2.5 to obtain the overall value of system usability (Lewis & Sauro, 2018). Table 4 shows the system usability result and the overall score of the SUS.

Table 4
The overall SUS results.

SUS Item	Total Frequency						Total Score					
	SD	D	N	A	SA	Total	SD	D	N	A	SA	Total
Q1	0	0	12	24	29	65	0	0	24	72	116	212
Q2	31	18	7	4	5	65	124	54	14	4	0	196
Q3	0	2	3	28	32	65	0	2	6	84	128	220
Q4	15	22	5	8	15	65	60	66	10	8	0	144
Q5	1	3	17	23	21	65	0	3	34	69	84	190
Q6	22	26	7	5	5	65	88	78	14	5	0	185
Q7	0	2	8	28	27	65	0	2	16	84	108	210
Q8	19	31	6	5	4	65	76	93	12	5	0	186
Q9	0	1	4	22	38	65	0	1	8	66	152	227
Q10	21	26	5	9	4	65	84	78	10	9	0	181
Total SUS Score												**1951**
Total SUS Score ((Total Score / 65) * 2.5)												**75.04**

*SD-Strongly Disagree, D-Disagree, N-Neutral, A-Agree, SA-Strongly Agree

SUS Scoring Analysis

As a guideline of analysis, the SUS Grade scale ranges from A to F, follow by the Adjective rating are classified as worse imaginable, poor, ok, good, excellent, and best imaginable, as well as the Acceptability ranges from not acceptable, low marginal, high marginal, and acceptable (Brooke, 2013). Figure 6 shows the grading analysis for the SUS score including the grade scale, acceptability ranges, and adjective ratings as suggested by (Brooke, 2013). (Brooke, 2013).

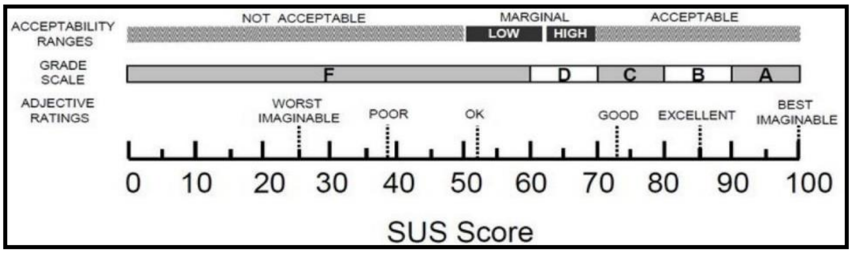


Figure 6. Grade rankings of SUS scores (Brooke, 2013)

The result of the SUS score resulting in a total of 1951. This total score was divided by the number of respondents (65) and then multiplied by 2.5 to derive the final SUS score, which was determined to be 75.04. Based on the earlier analysis, the SUS score for Learn Plant Science through VR Lab can be concluded as the acceptable range, achieves a grade of C on the grade scale, and has an adjective rating of "good."

This reflected that the suggested VR application for learning science has demonstrated positive results in terms of system usability in terms of its effectiveness, efficiency, and satisfaction of the respondents when learning science subject using the VT technology approach.

Conclusion

As a conclusion, the primary aim of this study is to assess the perception of young learners regarding the use of VR technology in learning Plant Science. This is achieved through three research objectives. The first objective is fulfilled by proposing a model for designing VR technology in the learning of science subjects (see Figure 4) during the design phase. The second objective is accomplished by presenting the VR application flowchart, storyboard, and final application construction throughout the design and construction phases. The final objective involves testing the perception of young learners on the proposed VR application using a usability questionnaire, which reflects positive results in terms of effectiveness, efficiency, and satisfaction among respondents when learning through the VT technology approach.

The incorporation of VR technology into science subjects can be successfully achieved with this application. Recent research also provides evidence that VR technology is a revolutionary tool for educating the youth. Consequently, a model of VR application for learning science subjects is proposed and further tested among the target audience to enhance their knowledge and experience using VR. In the future, educators can utilize the proposed model to teach and engage young learners, making it more appealing by incorporating additional 3D models covering various subtopics in other science subjects.

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