Universiti Teknologi MARA | Cawangan Melaka

PCMJ

Progress in Computing and Mathematics Journal

volume 1

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Progress in Computing and Mathematics Journal
College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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EDITORS

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
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College of Computing, Informatics, and Mathematics
UiTM Cawangan Melaka

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VIRTUAL REALITY (VR) FOR TEACHING AND LEARNING HUMAN ANATOMY IN SECONDARY SCHOOL

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Article Info | **Abstract**

Human anatomy teaching has evolved significantly, transitioning from tedious rote memorization to more engaging and immersive approaches facilitated by technological advancements. Traditional methods often needed help to convey the intricate 3D nature of human anatomy, leading to difficulties in comprehension and engagement among students. However, recent developments, particularly in virtual reality (VR) technology, have revolutionized anatomy education. This research project focuses on designing, developing, and evaluating a VR-based educational tool, "Humanatomy VR," aimed at secondary school students. The tool offers an immersive and interactive learning experience, allowing students to explore anatomical structures in a three-dimensional environment while receiving detailed explanations. Through storytelling techniques, developing Humanatomy VR transcends conventional teaching methods, providing a memorable and engaging learning experience. Evaluation of the tool's usability using System Usability Scale (SUS) questionnaires yielded positive feedback from 15-year-old Form Three students at Sekolah Menengah Kebangsaan Putrajaya Presint 16(1) with an average score of 86.25%, indicating high levels of accessibility and enjoyment. Future recommendations include making the game compatible with various devices, simplifying it with tutorials, and adding engaging content driven by the players.

Keywords: virtual reality, science education, secondary school, VR-based learning platform, simulations, interactive scenarios, functionality test, system testing, fully immersive virtual reality, and SUS questionnaire.

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INTRODUCTION

Although anatomy is frequently referred to as the "foundation of the medical sciences," it is also seen as a demanding and challenging subject in secondary and medical school. In the past, anatomy instruction was considered tedious, time-consuming, and based on rote memorization. However, with the adoption of contemporary philosophies, approaches, and efficient teaching and learning strategies, the teaching of anatomy is undergoing an evolutionary change.

The development of the Internet as an information superhighway has been a significant driver of technology's astonishing advancement of humanity (Schwab et al., 2018). Being able to advance communication speed and facilitate information exchanges and business dealings within the space of a millisecond is nothing short of amazing, especially with the Industrial Revolution 4.0 rapidly approaching (Ahmad et al., 2019). Technology development has, directly and indirectly, impacted modifying and creating instructional pedagogies, along with social improvements in most countries worldwide.

Because formal education was more teacher-oriented throughout that time in human history, the settings in formal classrooms before the year 1990 were better suited for the face-to-face technique. Following that, as more technology tools were accessible and as access to these tools increased, classrooms that combined in-person instruction with electronically mediated learning became increasingly widespread. The popularity of "flipped classrooms," where the pedagogy is mainly student-centered, is another current teaching strategy widely seen (Bontly et al., 2019). Because of this, it is not unexpected that practitioners and scholars in tertiary education are driven and tenacious in their pursuit of knowledge about and exploring ways to utilize 21st-century Higher Education 4.0 technology to enhance and improve the teaching and learning dyad.

This project aims to consider the resources and teaching strategies that must be integrated into an anatomy curriculum to provide a better learning experience. More robust sensory experiences and an active learning and teaching approach will efficiently encode the information presented. This may entail adding more pertinent visuals, using various manipulative models and specimens, or repeatedly presenting the same information in various contexts. Recent technological advancements have impacted the resources available for teaching anatomy. Computer-assisted learning tools like digital imaging and 3D modeling, video resources, augmented reality, and virtual reality are new technology-based teaching resources. The benefit of technology-assisted learning is that it allows students to use the resources at their own pace.

Technology-based teaching resources can be used anywhere without expensive facilities, unlike conventional resources, which are only accessible within the anatomy laboratory. Additionally, these resources can be tailored to the needs of each learner, and tutorials can be added to provide students with the different directions they require to move on to the next stage of their education (Abdullah et al., 2021). This initiative serves to enlighten individuals about human anatomy while promoting increased engagement and comprehension by enhancing their understanding of the 3D nature of anatomy. Computer-assisted learning tools have emerged as significant contenders in the educational methodology and have gained popularity as a culturally relevant phenomenon, valued for their high level of immersion.

LITERATURE REVIEW

A Brief History of Science Education in Malaysia

The history of education in Malaysia spans significant developments and challenges over the past five decades. Since gaining independence in 1957, Malaysia initially adopted the British education system, structured around primary, lower secondary, and upper secondary education. The country's commitment to education is evident in substantial funding allocations, facilitating the expansion of the school system and teacher training. Managed centrally by the Ministry of Education, the system primarily operates in Bahasa Malaysia, with provisions for Chinese and Tamil in national-type schools, despite the federal structure of the country.

Science education in Malaysian schools has evolved with notable changes in curriculum, teaching methodologies, and language policies. Influenced by international studies like TIMSS and PISA, reforms aim to enhance student achievement in science, addressing challenges such as teacher quality and curriculum rigor. Initiatives include implementing a new science curriculum, emphasizing English language instruction, and introducing STEM education. STEM integrates science, technology, engineering, and mathematics, fostering interdisciplinary learning and 21st-century skill development. Despite efforts to improve science education, challenges persist, including the Smart School concept's implementation issues and language policy complexities.

The Malaysian government's efforts to enhance science education include initiatives like the Smart School concept, English language policy (PPSMI), and the integration of STEM education. The Smart School project, initiated in 1999, aimed to revolutionize teaching and learning through multimedia technology. However, challenges arose due to inadequate involvement of experts and academics, language policy discrepancies, and difficulties in teacher adaptation to multimedia technology. Despite these challenges, efforts continue to incorporate innovative teaching methods like problem-based learning and project-based learning, reflecting ongoing adaptations required in educational initiatives implementation.

Science Education in Malaysia: Human Anatomy

The Malaysian science education system relies significantly on science textbooks as a primary information source for students. However, there is a need for analysis to determine their appropriateness. Errors have been identified in other textbooks approved by the Ministry of Education. Some textbooks, including those in Bahasa Malaysia, English, Science, and Mathematics, have been criticized for lacking content that fosters environmental awareness, focusing primarily on language aspects (Savita et al., 2017). Despite rigorous vetting, there are still issues to address to improve science learning. Textbooks approved by the Ministry of Education must be aligned with the national Science Curriculum Standard (KSSM) requirements to achieve its objectives (Ministry of Education, 2016). In the 2018 edition of the KSSM science textbook for Form 3 Malaysian students, there are topics related to human anatomy, including the human nervous and respiratory systems. These topics are part of the science curriculum and aim to provide students with a comprehensive understanding of the human body's systems and functions.

The reliance on science textbooks in Malaysia's education system is crucial, yet recent evaluations reveal issues such as errors and a need for more content fostering environmental awareness. The 2018 Form 3 science textbook aligns with the National Science Curriculum Standard (KSSM) and covers human anatomy topics, including the nervous and respiratory systems. This inclusion aims to provide students with a comprehensive understanding of bodily functions. The coverage spans the central and peripheral nervous systems, human stimuli and responses, and the respiratory system, supported by illustrative figures. These educational materials contribute to students' science knowledge, emphasizing continuous evaluation for relevance and effectiveness in enhancing science education in Malaysia.

Type of Teaching and Learning Style for Anatomy

This section explores various teaching and learning styles for science education, focusing on learning styles, virtual reality-based learning, surgical training simulation, medical counselling and contemporary operating theater training. Educators, in their pursuit of effective teaching and learning strategies, often seek to identify learners based on their preferences, such as visual, auditory, read/write, or kinesthetic styles. This exploration extends to examining the curriculum, teaching methods, delivery quality, and infrastructure. Such analyses are pivotal in optimizing the teaching-learning process, ensuring alignment between educational practices and students' learning needs and preferences.

They offer advantages such as immersion, engagement, safety, cost-effectiveness, and the opportunity for unlimited practice in a controlled environment. Examples of applications include virtual anatomy simulations, frog dissection surgical training simulations, nursing simulations and virtual counseling environments. Table 1 shows the elaborated key aspects in immersion and realism, student engagement, safety and controlled environment, practical application, skill acquisition, resource requirements and potential application for the comparisons on each type of teaching and learning style for anatomy. specifically caters to the needs of surgeons, replicating surgical environments with meticulous detail and offering valuable insights into effective anatomy education.

Table 1: Type of Teaching and Learning Style for Anatomy Comparisons

Key Aspects	**Virtual Reality Based Learning**	**Surgical Training Simulation**	**Medical Counseling**	**Contemporary Operating Theater Training**
Immersion and Realism	Provides immersive and realistic virtual environments	Creates virtual environments that closely resemble real surgical scenarios.	Creates a virtual environment for counseling, tailored to specific clinical needs.	Enhances surgical skill set in an operating room-like setting
Student Engagement	Promotes high student engagement by capturing their complete focus.	Encourages active participation and engagement in simulated surgical procedures	Offers an engaging and interactive counseling experience through avatars and realistic settings.	Ensures active participation and engagement in simulated surgical scenarios.
Safety and Controlled Environment	Provides a safe and controlled environment for learning and practice.	Offers a safe and controlled environment for learners to practice surgical procedures without endangering real patients.	Creates a safe and secure environment for counseling patients with mental health issues.	Provides a safe and controlled environment for surgical skill development.

Practical Application	Allows practical application through interactive virtual environments and simulated surgeries.	Provides practical application opportunities for learners to practice surgical procedures.	Primarily focuses on therapeutic interventions and addressing mental health issues.	Offers practical application opportunities for surgical skill development.
Skill Acquisition	Facilitates skill acquisition through hands-on practice and immersive learning experiences.	Enhances skill acquisition by allowing learners to practice and refine surgical techniques.	Focuses on therapeutic interventions and addressing mental health issues rather than skill acquisition.	Aims to enhance surgical skills and competency through proficiency-based training.
Resource Requirements	Requires specific VR equipment, such as headmounted displays (HMDs) or CAVEs	Involves specialized equipment, such as haptic systems and head-mounted displays, to create a realistic training experience.	Requires head-mounted 3-D equipment and software for virtual counseling.	Requires VR equipment and software for creating simulated surgical environments.

Based on the comparisons in Table 1, surgical training simulation emerges as the preferred method for teaching and learning anatomy due to its specialized focus on training surgeons in realistic operating room environments. While VR-based learning offers immersive experiences for broader educational purposes, surgical simulation provides proficiency-based training, ensuring surgeons meet specific performance benchmarks before operating on real patients. Simulation-based learning, including surgical training, offers a safe and interactive environment for learners to practice real-life scenarios and develop skills without risk. While other simulation methods cover various medical fields, surgical training simulation specifically caters to the needs of surgeons, replicating surgical environments with meticulous detail and offering valuable insights into effective anatomy education.

Extended Reality (XR) Technology

This section delves *e*xtended reality (XR) technology, comprising virtual, augmented, and mixed reality, is actively investigated and utilized by researchers in the HCI and other research communities for its potential in creative, social, and psychological experiments. While initially conducted primarily in lab settings, the XR research community has increasingly adopted remote participant recruitment methods, particularly accentuated by the Covid-19 pandemic, underscoring the importance of comprehending and utilizing remote techniques within XR research. Despite numerous trials and tests in primary and secondary education over the past decade, XR faces challenges in universal design, hindering widespread integration into schools, especially for students with disabilities and varying abilities, due to logistical and structural obstacles. Nonetheless, XR serves as a powerful tool for mediating experiential learning, providing students with unique experiences such as virtual trips and interactions with objects inaccessible in the physical world. XR applications, grounded in learning theory, demonstrate teaching benefits by addressing student interaction, manipulation of virtual components, and teaching complex concepts, particularly valuable for procedural, practical, or affective skills training in areas challenging to address with traditional methods, thereby enhancing student motivation and engagement in education.

Table 2: Virtual Reality, Augmented Reality, and Mixes Reality Comparisons

Aspects	**Fully Immersive Virtual Reality**	**Augmented Reality**	**Mixed Reality**
Technology Description	Creates a completely virtual environment that immerses the user through headsets and hand controllers	Overlays digital content onto the real-world view, typically using smartphones or wearable devices.	Combines virtual elements with the realworld environment to create an interactive and seamless experience.
User Interaction	Users can freely move and interact with objects in the virtual environment using hand controllers.	Users can view and interact with virtual objects overlaid on the real-world environment through smartphones or wearable devices.	Users can observe and interact with both virtual and real-world objects simultaneously, allowing for collaboration and interaction.
Integration in Education	Used in teaching and learning for immersive experiences, practical training, and procedural knowledge acquisition.	Implemented in various educational levels and disciplines, offering advantages to students and enhancing learning experiences.	Explored for creating Mixed Reality smart classrooms to enhance the learning process through real-time analytics and personalized user control

Applications	Diverse applications in teaching anatomy, surgery, construction, law enforcement, and more.	Used in education for visualizing and interacting with virtual content, enhancing real-world experiences, and gamified learning.	Used for collaborative design, training, distant collaboration, and creating immersive learning environments in smart classrooms.
Real-World Integration	Creates a fully virtual environment, isolating the user from the physical world.	Overlays digital content onto the user's real-world view, blending virtual and physical elements.	Combines virtual elements with the realworld environment, allowing simultaneous interaction with both.
Hardware Requirements	Requires VR headsets, hand controllers, and sensors for tracking position and orientation.	Relies on smartphones, tablets, or wearable devices with AR capabilities.	Utilizes devices like mixed-reality headsets (e.g., Microsoft HoloLens) to enable mixed-reality experiences.
Examples	Oculus Rift, HTC Vive, PlayStation VR	Pokemon Go, Snapchat filters	Microsoft HoloLens, Magic Leap

Each form of extended reality (XR) technology, including virtual reality (VR), augmented reality (AR), and mixed reality (MR), offers distinct advantages and disadvantages. VR provides a fully immersive experience but requires dedicated hardware and may lack real-world interaction. AR enhances real-world experiences by overlaying digital information but can have limited visual fidelity. MR integrates virtual and natural elements, requiring specialized headsets and presenting challenges in hardware requirements. Fully Immersive VR stands out as the best type of XR technology, offering a highly immersive learning environment where users can freely interact with virtual objects using hand controllers, enhancing engagement and realism. This technology has been widely utilized in education for practical training and immersive learning experiences, particularly in fields like anatomy, surgery, and construction.

While AR and MR also have their merits, such as enhancing real-world experiences and creating smart classrooms, Fully Immersive VR excels in providing realistic simulations and hands-on experiences crucial for learning. Its ability to enhance procedural knowledge acquisition aligns with research objectives, offering valuable insights into immersive learning experiences. However, it's important to recognize that the choice of XR technology depends on specific research goals and contexts, acknowledging the strengths and applications of each technology.

Related Work on Anatomy of VR Based Learning Environment

These three studies collectively highlight the advantages of VR in education, such as improved learning outcomes, increased engagement, and the potential for individualized and adaptive learning experiences. While the first study focuses on data capture in mobile-based VR applications, the second and third studies specifically explore the benefits of VR simulations and immersive environments in science education. Table 3 shows the research paper, authors, objective, methodology, findings, data analysis, participant, tools and devices, durations, key findings among the three related works.

Table 3: Comparison Among Three Related Work Studied

Study Title	**Mechanism to capture learner's interaction in VR-based learning environment: design and application**	**Teaching Science Lab Safety: Are Virtual Simulations Effective?**	**Effects of an immersive virtual reality-based classroom on students' learning performance in science lessons**
Authors	Pathan et al. (2019)	Savvides et al. (2018)	Liu et al. (2020)
Objective	To capture learners' VR interactions for enhanced learning	To examine the effectiveness of VR simulations for teaching science lab safety	To investigate the effects of immersive VR-based classrooms on students' learning performance in science
Methodology	Mobile-based static VR system capturing learner interactions through screen recordings	High, medium, and low immersion groups using VR simulations, video, and reading	Experimental group using head-mounted displays (HMD) for IVR-based science lessons, control group using traditional teaching methods

Findings	Potential of capturing learner behavior and enabling personalized support through interaction data capture	Higher academic achievement and engagement scores in the high and medium immersion groups compared to the low immersion group	Significantly higher academic achievement and engagement scores in the experimental group using IVR-based science lessons
Data Analysis	Capturing duration, co-occurrence, and sequence of actions through screen recordings	Two-way mixed ANOVA for lab safety knowledge scores	T-tests and pretestposttest comparisons for academic achievement, engagement, and technology acceptance
Participants	Three 8th grade students in a preliminary test	108 participants randomly divided into high, medium, and low immersion groups	Ninety sixth-grade students divided into experimental and control groups
Tools and Devices	Android mobile with Google Expedition app, VR headset, screen recording application	Lenovo Mirage Solo headset for high immersion group, computer for medium immersion group, video and reading for low immersion group	Interactive whiteboards, IVR devices (HMD, controllers), mobile tablet with IVR lessons
Duration	Preliminary test	Pretest, posttest, follow-up test after one week	Eight-week experiment with six 45-minute classes per week
Key Findings	Comprehensive understanding of learners' behavior and adaptive learning potential	Higher knowledge scores and engagement in high and medium immersion groups compared to the low immersion group	Significant improvement in academic achievement, engagement, and technology acceptance in the experimental group

The study titled "Teaching Science Lab Safety: Are Virtual Simulations Effective?" by Savvides et al. (2018) was chosen to assess the efficacy of virtual simulations in teaching science lab safety. The research compared different immersion levels, utilizing VR headsets, computers, and traditional methods, to deliver lab safety training. Results indicated higher academic achievement and engagement scores in the high and medium-immersion groups compared to the low-immersion group, highlighting the effectiveness of virtual simulations over traditional methods. Moreover, students showed high acceptance of VR-based learning, signifying its engaging nature.

By focusing on teaching science lab safety, this study aims to contribute to existing research by further exploring the effectiveness of virtual simulations in enhancing students' understanding and application of safety protocols. Insights gained from this research, including assessments of knowledge retention and engagement through pretests, posttests, and questionnaires, will inform instructional practices for teaching lab safety more interactively. Factors such as cognitive load and presence will be considered, enriching the understanding of immersive learning experiences and their impact on science education.

METHODOLOGY

This section introduces the methodology, highlighting its significance in guiding the study's approach to data collection and achieving the research objectives. It focuses on creating the system architecture, specifying hardware and software requirements, and designing user interfaces based on the analysis and design phases' specifications. The flow of development process is shown in Figure 1. Figure 2 provides an approximate representation of the sequential steps involved in performing the suggested project, starting from the beginning, and continuing until its completion.

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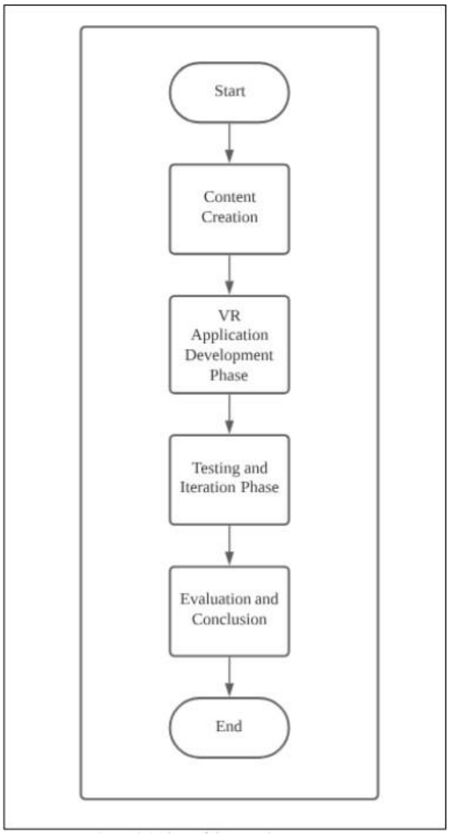

Figure 1: Flowchart of the research

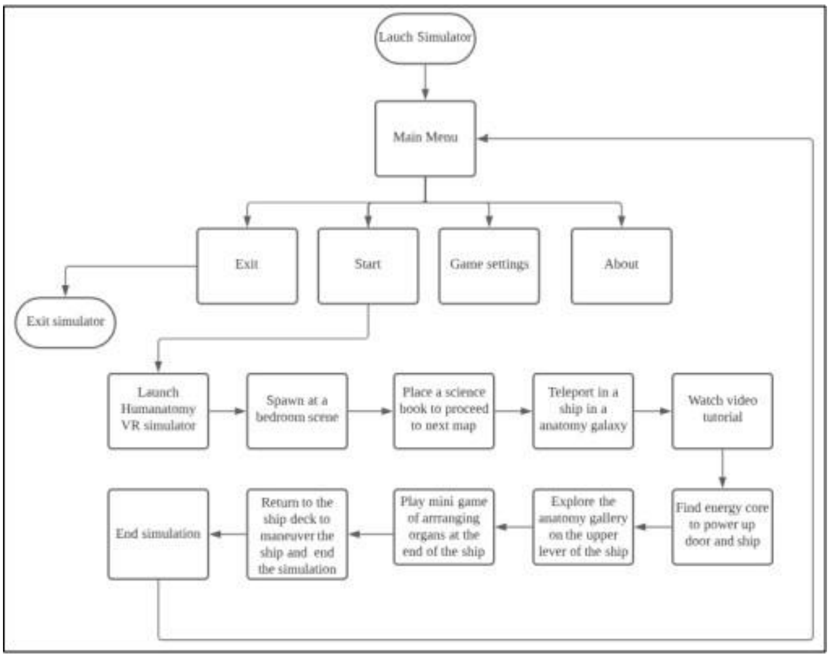

Figure 2: Flow of the Simulator

The system's software requirements include the utilization of Unity for its advanced graphics rendering. It must also have cross-platform development compatibility. Blender will be utilized for modelling, rigging, animation, simulation, and rendering capabilities. The hardware requirements will be below in table form.

Table 4: Computer Hardware Requirements

Hardware	Specification
Device	Gigabyte
Operating System	Windows 10
Processor	Intel i7-10870H
Memory (RAM)	16.00 GB
Graphic Card (GPU)	NVIDIA GeForce RTX 3060
Storage	SSD 500 GB

Table 5: VR Hardware Requirements

Hardware	Specification
VR Setup	Quest 2 VR Headset Quest 2 Controller
Tracking	Supports 6 degrees of freedom (6Dof)
Memory (RAM)	6GB LPDDR5 RAM
Chipset	Qualcomm Snapdragon XR2 (7 nm), Adreno 650
Audio	Built-in stereo speakers and microphone, 3.5mm audio jack, support for 3D audio
Storage	256GB

The Evaluation Phase is the last phase in the ADDIE process. Users from Humanatomy VR will answer a survey on their video gaming experiences whether it is usable or not. SUS is a questionnaire to assess users' usability of the system. The SUS is a productive, resource-saving, and time-efficient method of evaluating the usability of a system. (Lin et al., 2011) The assessment is done on a 5-point scale, with 1 being strongly disagreed and 5 highly agreeing. The higher the score, the more beneficial the system and the easier it is for people to engage with it. Table 6 shows the survey

Table 6: SUS Questionnaire

No	Function
1	This VR application is easy to use
2	I don't think I would enjoy using this game regularly
3	I feel comfortable when using this VR application.
4	I think I cannot get things done fast with this VR application.
5	If I make a mistake, it's easy to fix quickly with this VR application
6	The messages on the screen and the papers that come with this VR application are hard to understand
7	The information helps me do tasks and scenarios well with this VR application
8	The interface of the VR application looks terrible and cluttered.
9	This VR application has all the functions and capabilities I expect it to have
10	The VR application is stuttering and not playing smoothly

The ADDIE Model was chosen for this proposed project to generate a satisfactory project output within the time limit specified. ADDIE is a method that may meet all of the project's needs and major goals. To avoid mistakes and development issues, each phase of ADDIE must be carried out attentively. The major software and procedures will then be used, which include Unity. These are the greatest tools for creating game-based learning software that may boost productivity and effectiveness

RESULT AND DISCUSSION

Table 7: Functionality Test Results

No	Function	Expected Output	Actual Output
1	Start button at menu page	After clicking, app will start.	Pass
2	Exit button at menu page	After clicking, app will end	Pass
3	Setting button at menu page	After clicking, app will open setting page	Pass
4	About button at menu page	After clicking, app will open about page.	Pass
5	Task 1: Text Book Placement	User should be able to grab and place the book on the book holder.	Pass

6	Task 2: Enter Portal	User should be able to teleport to the next map when collide with the portal.	Pass
7	Task 3; Push Red Button	User should be able to push the red button after watching tutorial video.	Pass
8	Task 4: Break Rock	User should be able to break the rock using the energy gun.	Pass
9	Task 5: Energy Core Placement	User should be able to grab and place the energy on the energy reader.	Pass
10	Task 6: Climbing The Ladder	User should be able to grab and climb the ladder	Pass
11	Task 7: Play Claw Machine Game	User should be able to play the claw machine with human anatomy theme	Pass
12	Task 8: Steer The Ship Home	User should be able to steer using the steering wheel and a lever to end the game	Pass

The evaluation and testing phase of the study focused on assessing the functionality and usability of the system. Functionality testing involved evaluating various features and functions of the software application to ensure they operated as intended and met the specified requirements. Test cases were designed to cover scenarios such as regular operation, boundary conditions, and error handling. The results of the functionality test, presented in Table 7 above, demonstrated that all tested functions performed as expected.

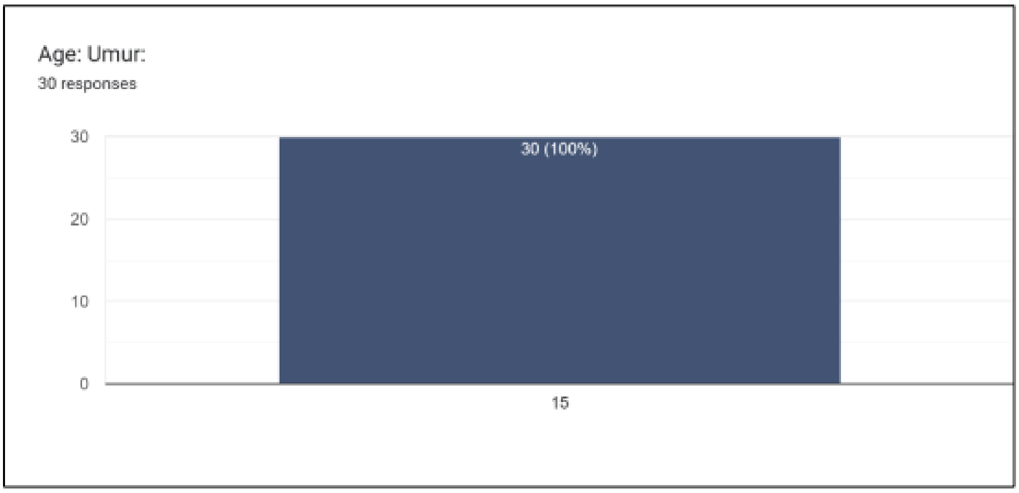

Figure 3: Horizontal bar graph of participants' age

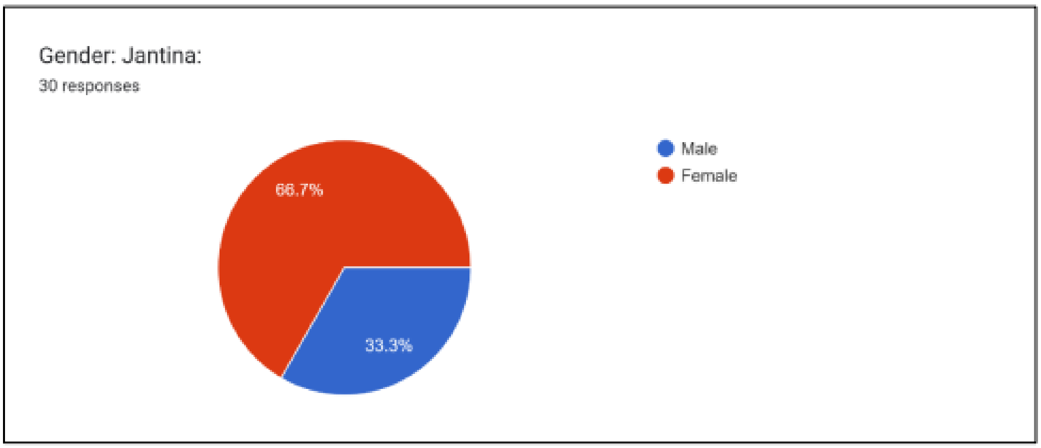

Figure 4: Post-Test Results

Based on the questionnaire of SUS results, participants are all 15 years old (n=30. There were no participants from any other age. Majority of the participants are female (n=20, 66.7%), meanwhile for the female participants' frequency are (n=10, 33.3%). The horizontal graph of participants' age is showed in Figure 3, while the pie chart of participants' gender is showed in Figure 4.

The System Usability Scale (SUS) questionnaire comprises ten items, with respondents rating their agreement on a scale of 1 to 5 for each statement. Guerci (2020) recommends a specific scoring method: odd-numbered items are scored by subtracting 1 from the response, while even-numbered items are scored by subtracting the response from 5. The scores are then totaled, multiplied by 2.5, and averaged to obtain the overall usability score. This process is typically facilitated using a spreadsheet with preset formulas, as illustrated in Figure 5. Table 8 present the individual scores for each item, the total score for each respondent, and the average score across respondents.

```
fx =((E2-1)+(5-F2)+(G2-1)+(5-H2)+(I2-1)+(5-J2)+(K2-1)+(5-L2)+(M2-1)+(5-N2))*2.5
```

Figure 5: Post-Test Results

Table 8: Total SUS Score for Each Respondent and Total Average

N / Item	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**Total**
1	5	1	5	1	5	1	5	1	5	1	100

2	4	2	4	1	5	2	4	1	5	1	87.5
3	5	1	5	1	5	1	5	1	5	1	100
4	5	1	5	1	5	1	5	1	5	1	100
5	4	2	4	2	4	2	4	2	4	2	75
6	5	1	5	1	5	1	5	1	5	1	100
7	5	2	5	1	5	1	5	1	5	1	97.5
8	4	2	4	2	4	2	4	2	4	2	75
9	4	2	4	2	4	2	3	2	4	3	70
10	3	3	3	3	3	3	3	3	3	3	50
11	5	1	5	1	5	1	5	1	5	1	100
12	4	2	4	2	4	2	4	2	4	2	75
13	4	2	4	2	4	2	4	2	4	2	75
14	5	1	5	1	5	1	5	1	5	1	100
15	5	1	5	1	5	1	5	1	5	1	100
16	4	2	4	2	4	2	4	2	4	2	75
17	5	1	5	1	5	1	5	1	5	1	100
18	3	3	3	3	3	3	3	3	3	3	50
19	5	3	5	3	5	2	5	2	5	1	85
20	4	1	4	1	4	2	5	2	5	1	87.5
21	5	3	5	2	4	3	3	2	5	1	77.5
22	5	1	5	1	5	1	5	1	5	1	100
23	5	1	5	2	4	2	4	2	4	3	80
24	5	1	5	1	5	2	5	2	5	2	92.5
25	5	1	5	1	5	1	5	1	5	1	100
26	5	1	5	2	5	2	5	2	5	2	90
27	5	1	5	2	5	2	5	2	5	1	92.5
28	4	3	4	2	4	2	4	2	5	2	75
29	5	3	5	3	5	2	5	2	5	2	82.5
30	5	1	4	1	4	1	5	1	5	1	95
					Average						86.25

The System Usability Scale (SUS) is a widely utilized questionnaire to gauge the perceived usability of a system, consisting of 10 statements rated on a 5-point scale. In evaluating a virtual reality (VR) application for teaching human anatomy in a secondary school, participants' responses yielded an above-average SUS score of 86.25, indicating high usability. While the SUS provides a quick and reliable measure of usability, it may not pinpoint specific usability concerns, suggesting its complementarity with other evaluation methods for a comprehensive understanding of a system's usability.

In conclusion, Humanatomy VR represents an innovative educational tool that seamlessly integrates immersive virtual reality experiences with guided tours and narratives, offering users in-depth insights into anatomical concepts in a captivating manner. Despite initial challenges during development, the application received commendable feedback, reflected in a higher usability score. However, to further enhance its accessibility and engagement, future improvements are recommended, including enabling multi-platform compatibility, providing comprehensive tutorials, and incorporating player-driven content. Despite existing limitations, such as system requirements and platform restrictions, Humanatomy VR emerges as a promising platform that amalgamates immersive technology with educational content, paving the way for enhanced learning experiences in human anatomy.

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