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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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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Virtual Reality in Physics Class: A Learning Guide For Secondary School Teachers

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Abstract

This thesis presents a detailed guide for high school teachers on the integration of Virtual Reality (VR) technology into physics education, aimed at enhancing students' understanding and engagement with the subject. Employing the ADDIE model for instructional design, the project develops a VR-based learning platform featuring video lectures, an AI instructor, interactive scenarios. This initiative addresses existing challenges in VR applications for physics learning, including issues of fidelity, alignment with learning theories, and accessibility, and provides solutions to overcome these barriers. The research outlines the necessary hardware and software requirements for implementing the VR platform in a classroom setting. While the project underscores the transformative potential of VR in enriching physics education, it also critically examines its limitations, such as its focused scope and the necessity for further effectiveness assessments. Future directions include broadening the platform's content to encompass additional physics concepts and conducting extensive evaluations to ascertain its impact on learning outcomes. This work serves as a comprehensive manual for educators seeking to leverage VR technology to foster a deeper engagement and understanding of physics among high school students, highlighting its significant benefits while acknowledging areas for further research and application expansion.

Keywords: virtual reality, physics education, instructional design, ADDIE model, VR-based learning platform, AI instructor, interactive scenarios, functionality test, system testing, fully immersive virtual reality, and SUS questionnaire.

INTRODUCTION

The traditional methods of teaching physics have not undergone significant changes for centuries. These methods primarily focus on memorization, understanding, and testing of knowledge. While modern technology like online resources and videos have improved learning, virtual reality (VR) still needs to be widely used in physics education. VR can provide immersive learning experiences, addressing issues such as lack of interest in the subject, poor grasp of STEM concepts, limited opportunities for hands-on experimentation, and insufficient retention of physics knowledge. Integrating VR into physics education could enhance students' understanding, test performance, and overall interest in the subject, potentially leading to increased participation in STEM fields. However, current VR applications in physics education face challenges regarding accuracy, alignment with learning theories, assessment tools, and accessibility (Steidtmann et al., 2022).

LITERATURE REVIEW

Learning Style

This section explores various teaching and learning styles for physics education, focusing on learning styles, online lectures, gamification, and mobile applications. Learning styles play a crucial role in the learning process, with different students benefiting from visual, auditory, kinesthetics, or active learning approaches. Online lectures, particularly during the Covid-19 pandemic, have provided flexibility but vary in effectiveness depending on the subject (Hanakawa et al., 2022). Gamification, incorporating game elements into learning, promotes engagement and collaboration among students (Katanosaka et al., 2023). Mobile applications offer unique learning experiences but require attention to usability factors such as user interface design (Martinez et al., 2014). A comparison table highlights the suitability of each approach for a proposed virtual reality (VR) application in physics education.

Table 1: Learning Style Comparison

Domain	**Online Lectures**	**Gamification**	**Mobile Applications**	**Suitability for proposed VR app**
Teaching Style	Presentation-based, instructor-led	Interactive and game-based	Interactive and self-paced	☒Online Lectures ☒Gamification ☐ Mobile App
Learning Style	Passive consumption of content	Active engagement and problem-solving	Interactive exploration and problem-solving	☒Online Lectures ☒Gamification ☐ Mobile App
Delivery Format	Video presentations, slideshows	Game-like interface and challenges	Interactive apps and simulations	☒Online Lectures ☒Gamification ☐ Mobile App
Flexibility	Anytime, anywhere access	Anytime, anywhere access	Anytime, anywhere access	☒Online Lectures ☒Gamification ☐ Mobile App

Engagement	Dependent on student motivation	Motivating through game elements	Motivating through interactive experiences	☐ Online Lectures ☒Gamification ☐ Mobile App
Collaboration	Limited interaction between students	Encourages collaboration and teamwork	Limited interaction between students	☒Online Lectures ☒Gamification ☐ Mobile App
Subject Suitability	Effective for drill learning, less effective for conceptual knowledge and skills	Effective for drill learning, less effective for conceptual knowledge and skills	Interactive exploration and problem-solving	☒Online Lectures ☒Gamification ☐ Mobile App
Accessibility	Requires internet connection and compatible devices	Requires internet connection and compatible devices	Requires compatible mobile devices	☒Online Lectures ☒Gamification ☐ Mobile App
User Interface	Typically, video-based and slide-driven	Game-like interface and elements	Interactive interface and user-friendly design	☒Online Lectures ☒Gamification ☐ Mobile App
Learning Experience	Primarily visual and auditory	Interactive and immersive	Interactive and immersive	☒Online Lectures ☒Gamification ☐ Mobile App

Virtual Reality Based Learning

This section delves into Virtual Reality (VR) based learning, examining fully immersive VR, low immersive VR, and augmented reality (AR). Fully immersive VR (FIVR) provides users with a fully authentic virtual experience through VR headsets, allowing for interaction with virtual objects and environments, making it suitable for immersive training and education (Rendevski et al., 2022). Low immersive VR (LiVR) offers virtual interactions and activities through regular 2D monitors and input devices, providing cost-effective options for education, training, and entertainment (Kaplan-Rakowski, 2019). Augmented reality (AR) overlays virtual content onto the real world, allowing users to interact with virtual objects in their actual environment through mobile devices or AR glasses (Laviola et al., 2022).

A comparison table highlights the unique features and applications of each method, with fully immersive VR offering high fidelity and accuracy, while low immersive VR focuses on virtual interactions, and AR combines virtual and real-world elements (Rendevski et al., 2022; Kaplan-Rakowski, 2019; Laviola et al., 2022). Considering the objectives of creating engaging and immersive experiences, fully immersive VR is recommended for creating virtual labs and immersive environments (Rendevski et al., 2022).

Table 2: Virtual Reality Comparison

Method	Full Immersive VR (FIVR)	Low Immersive VR (LIVR_	Augmented Reality (AR)	Suitability for VR
Immersive Level	Fully authentic virtual experience	Limited sensory experience	Overlay of virtual content on real world	☒FIVR ☐ LIVR ☐ AR
Hardware Requirement	VR headset, HMD with screens	Regular 2D monitor, input devices	Mobile devices, AR glasses	☒FIVR ☐ LIVR ☐ AR
User Interaction	Realistic interactions with virtual objects	Virtual interactions and activities	Interacting with virtual objects overlayed on real world	☒FIVR ☐ LIVR ☐ AR
Accuracy of Simulation	High fidelity and accuracy	Less accurate modeling of physical world	Blend of virtual and real-world elements	☒FIVR ☐ LIVR ☐ AR
Cost	Expensive equipment and systems	Affordable and accessible	Varied, depending on device used	☒FIVR ☐ LIVR ☒AR
Applications	Immersive training, education	Exploration, training, entertainment	Education, gaming, healthcare, etc.	☒FIVR ☐ LIVR ☒AR
Examples	Virtual physics labs, immersive training	Virtual environments, simulations	AR games, educational apps	☒FIVR ☐ LIVR ☒AR

METHODOLOGY (HEADING 1)

This section introduces the methodolog, 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. In figure 1 the flowchart will display.

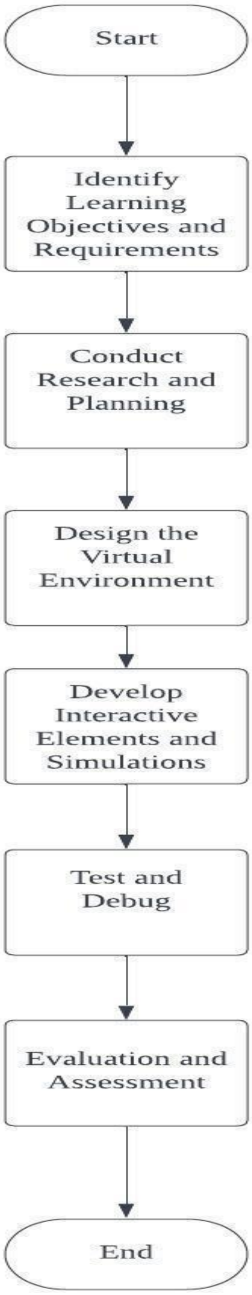

Figure 1: Flowchart of the research

The system's software requirements include the utilization of Unreal Engine 5 for its advanced graphics rendering and simple visual programming through Blueprint. 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 3: Computer Hardware Requirements

Hardware	Specification
Device	MSI
Operating System	Windows 10
Processor	Intel I7-5700U
Memory (RAM)	16.00 GB
Graphic Card (GPU)	NVIDIA GeForce RTX 2060
Storage	SSD 500 GB

Table 4: VR Hardware Requirements

Hardware	Specification
Device	MSI
Operating System	Windows 10
Processor	Intel I7-5700U
Memory (RAM)	16.00 GB
Graphic Card (GPU)	NVIDIA GeForce RTX 2060
Storage	SSD 500 GB

Evaluation is a crucial aspect of instructional design, ensuring the effectiveness and usability of educational materials. In this study, a comprehensive evaluation process was conducted to assess the system's functionality, usability, and effectiveness. The functionality test was meticulously designed to evaluate the system's performance, with defined objectives, test scenarios, and expected outputs outlined. Additionally, the System Usability Scale (SUS) questionnaire was utilized to gauge user perceptions of the system's usability, covering aspects such as satisfaction, ease of learning, and efficiency. Participants rated statements on a Likert scale, with scores calculated to provide a quantitative measure of usability. Furthermore, a multiple-choice quiz consisting of 20 questions was administered to evaluate participants' knowledge acquisition. These evaluation tools ensure that the instructional objectives are met, resources are user-friendly, and knowledge or skills are effectively imparted, contributing to the overall success of the educational intervention.

RESULT AND DISCUSSION (HEADING 1)

Table 6: 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	Play and pause video	After pressing “A”, video will play and pause	Pass
4	AI interaction	After holding “A” while talking, AI will response question with an answer.	Pass
5	Task 1 : Pendulum Activity	User should be able to grab and swing the pendulum.	Pass
6	Task 2 : Cart Activity	User should be able to grab and push the cart.	Pass
7	Task 3 ; Slope Activity	User should be able to grab barrel and drop it on the slope.	Pass
8	Reset Orientation at Option menu	After clicking, The user’s orientation should be reset.	Pass
9	Reset Level at Option Menu	After clicking, level will reset.	Pass
10	Quit Game on Option Menu	After clicking, app will end	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 6, demonstrated that all tested functions performed as expected.

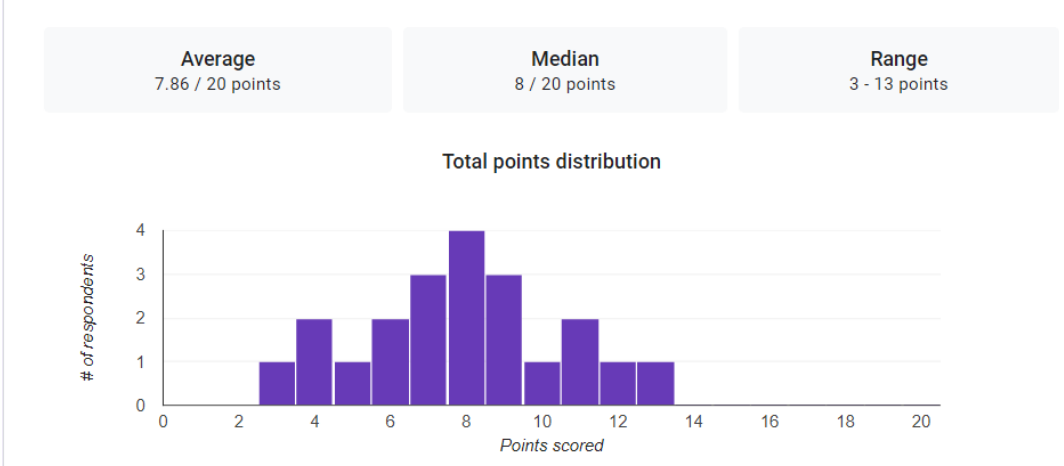

Figure 2: Pre-Test Results

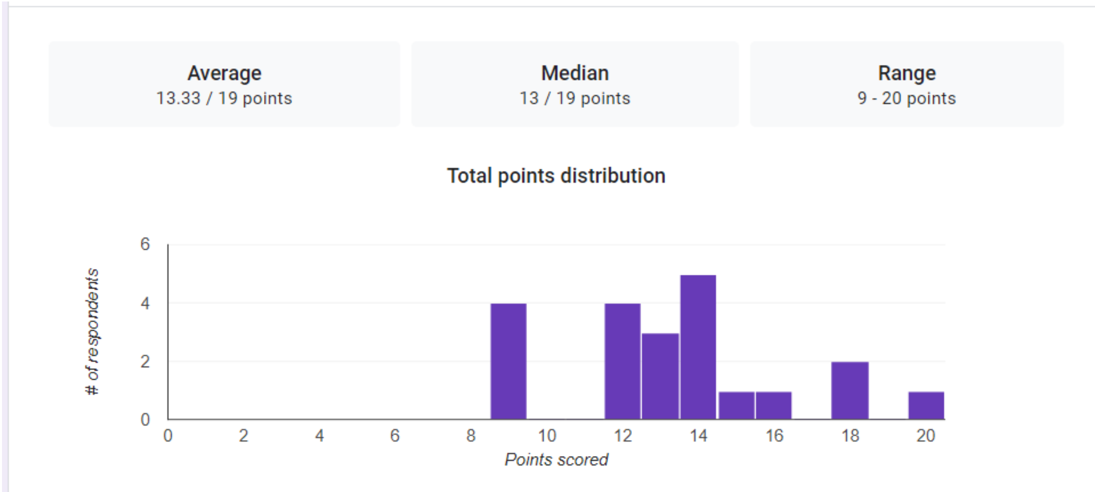

Figure 3: Post-Test Results

System evaluation, conducted with 21 form four students, aimed to measure the performance of the system under real-life conditions. The evaluation procedure included pre-testing, learning through the app, and post-testing. Pre-testing involved administering a set of 20 questions to assess participants' knowledge before using the app. After interacting with the app, students took a post-test consisting of the same set of questions. The results showed a significant improvement in students' understanding, with an average post-test score of 13.33 out of 19 points compared to 7.86 in the pre-test.

No	0	1	2	3	4	5	6	7	8	9	Total
1	5	1	5	1	5	1	5	1	5	1	100
2	5	1	5	1	5	1	5	1	5	1	100
3	4	2	5	2	5	2	5	1	4	2	85

4	4	2	4	1	5	2	4	2	4	1	82.5
5	3	2	4	1	5	3	4	2	3	1	75
6	5	1	5	1	5	1	5	1	5	1	100
7	5	2	5	1	4	3	5	1	4	3	82.5
8	5	1	5	3	5	2	5	1	5	4	85
9	5	2	4	3	4	1	4	2	4	3	75
10	4	3	5	1	4	2	4	2	5	3	77.5
11	5	2	4	2	5	2	5	2	5	2	85
12	3	2	3	4	5	3	5	1	4	3	67.5
13	2	4	2	5	5	5	2	4	2	5	25
14	5	1	3	5	5	1	5	3	4	4	70
15	4	2	4	4	3	2	4	3	5	4	62.5
16	2	5	4	5	2	3	5	4	3	4	37.5
17	4	2	4	5	5	2	4	2	2	4	60
18	5	1	3	4	4	2	5	2	4	3	72.5
19	3	4	4	3	5	2	5	2	5	5	65
20	3	3	5	3	3	4	4	2	4	4	57.5
21	5	1	5	3	5	2	5	1	4	3	85
					Average						73.809 52381

The system usability scale (sus) questionnaire was used to evaluate the usability of the system. Participants rated various aspects of usability on a Likert scale, and the aggregated responses were analysed to determine the system's usability. The average sus score of 73.80% indicated that the system was perceived as valuable and user interaction was effortless. Overall, the findings suggest that the system positively impacted participants' learning experience, providing an easy-to-use and enjoyable platform for learning physics concepts.

In conclusion, project systematically developed a VR-based learning system comprising video lectures, an AI teacher, an interactive playground, and quizzes. The system aims to address limitations in traditional physics education methods and improve students' understanding and interest in the subject. Through rigorous testing and evaluation, promising results were obtained, demonstrating the system's functionality and potential impact on learning outcomes. Despite the project's advancements, limitations such as equipment costs, quality requirements, teacher training, and access disparities must be acknowledged and addressed for widespread implementation. Future work includes enhancing system features, conducting usability testing, and integrating with other physics education resources to further enhance the effectiveness of VR in physics education. Overall, the project's findings and recommendations contribute valuable insights for educators, curriculum developers, and technology providers seeking to enhance physics education through immersive and interactive learning solutions.

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