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# PCMJ

## Progress in Computing and Mathematics Journal

## volume 1

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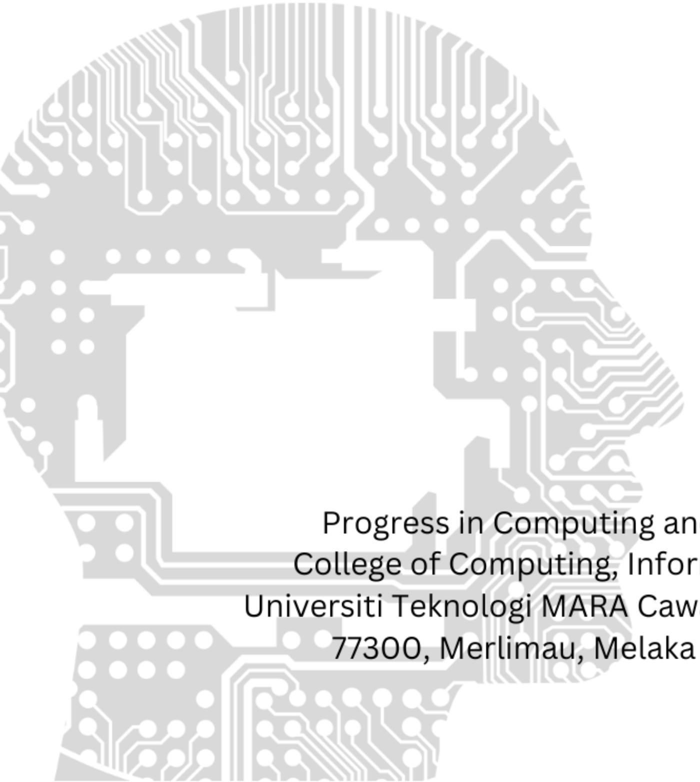

Progress in Computing and Mathematics Journal
College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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# EDITORS

PCMJ
Progress in Computing and Mathematics Journal
volume 1

# 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**
**Progress in Computing and Mathematics Journal (PCMJ)**
**College of Computing, Informatics, and Mathematics**
**UiTM Cawangan Melaka**

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**Progress in Computer and Mathematics Journal (PCMJ)**
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# VIRTUAL REALITY (VR) IN CHEMISTRY LEARNING FOR SECONDARY SCHOOLS STUDENTS

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**Article Info**

**Abstract**

This research aims to create a chemistry learning application using virtual reality and the Unity Game Engine. The focus is on secondary school students, providing an interactive, immersive experience that helps them understand scientific concepts by visualizing chemical reactions. The complexity of Virtual Reality (VR) in learning chemistry for secondary school is the effective implementation of VR in chemistry education requires addressing the diverse learning needs of students, providing access to appropriate technology, and ensuring that the VR experiences align with the curriculum standards and learning objectives. Traditional methods of learning chemistry are less attractive than what is needed to deal with this complexity, requiring the development of innovative solutions. The proposed approach utilizes a 3D simulation game using the Simulation-Based Edutainment Model in the ADDIE methodology to enhance deep learning among students. Virtual Reality (VR) is widely recognized as an effective tool for improving learning outcomes. Creating a fully interactive and immersive experience enables students to practice and apply their knowledge in a realistic simulation of real-life situations. The Virtual Reality (VR) in Chemistry Learning for Secondary School Students uses the systematic approach of the ADDIE Model to analyse, design, develop, implement, and evaluate VR applications enables instant feedback, personalized learning experiences, and the ability to revisit and review the content, improving student understanding and retention of complex concepts. The ADDIE Model was chosen as a methodology to create a VR experience with good instructional learning and is acceptable as an alternative way of learning. The usability evaluation conducted through the System Usability Score (SUS) questionnaire produced positive results with a score of 91.25%, demonstrating the effectiveness of Virtual Reality applications in improving chemistry learning for high school students. Future work will enrich the immersive VR chemistry education platform through advancements like realistic liquid simulations, simulated breakage, multiplayer capabilities, and enhanced physics realism, promoting collaborative learning among high school students.

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**Keywords**: Virtual Reality; Simulation-Based Edutainment Model; ADDIE methodology

# INTRODUCTION

Learning chemistry can be challenging, as it comprises various concepts ranging from atomic structure to chemical reactions. Due to the complex nature of this discipline, students need to understand abstract theories and apply them to real-world scenarios, making it a difficult task (Gia-Huy et al.,2022). Furthermore, conventional approaches to teaching chemistry only rely on theoretical instruction and do not provide enough opportunities for hands-on experimentation. This further complicates the learning process, as students find it challenging to connect theoretical knowledge with practical application, which hinders their overall understanding of the subject (Ting et al.,2021).

There is a need for innovative solutions to simplify the complexities of learning chemistry. One practical approach is to use technology to create interactive and immersive learning environments, such as virtual reality simulations. This method allows students to experience practical learning without physical laboratories. By simulating laboratory experiments and chemical reactions in a virtual setting, students can better understand abstract concepts and develop curiosity and experimentation skills, essential elements for effective learning in chemistry (Matt et al., 2020).

The proposed system aims to revolutionize chemistry education by introducing a high-quality virtual reality simulation platform tailored to the needs of students. This system will offer a comprehensive range of virtual laboratory experiments covering essential topics in chemistry, like rate reaction. Students can explore complex concepts in a safe and controlled environment through visually immersive and interactive simulations, enhancing their understanding and retention of critical principles. The proposed system seeks to democratize chemistry education by providing access to virtual laboratories, ensuring that all students have equal opportunities to engage in practical learning experiences regardless of resource constraints. Additionally, by offering virtual laboratory experiments, the proposed system provides a cost-effective alternative to traditional physical chemistry labs, mitigating the financial burden of procuring expensive equipment and hazardous chemicals.

## LITERATURE REVIEW

This chapter comprehensively reviews the literature on learning chemistry using Extended Reality (XR). It covers constraints in learning chemistry, adapting the ADDIE Model to related learning problems. This literature review is a basis for developing and evaluating a proposed virtual reality-based system to create personalized chemistry learning using the ADDIE Model.

### Constraints in Chemical Learning

Learning chemistry involves navigating various constraints to ensure a practical and comprehensive educational experience. These constraints are crucial in shaping the curriculum and determining the strategies to facilitate learning in this complex subject area. Several key constraints must be addressed in chemical learning to optimize the learning process and effectively meet the educational objectives.

- Safety Concerns

Chemical learning faces constraints related to safety concerns in laboratory settings. Hazardous materials, flammable substances, and breakable equipment pose risks to student safety, necessitating strict safety protocols and teacher supervision.

- Financial Limitations

The high cost of laboratory supplies, including equipment, materials, safety measures, and chemicals, poses a significant constraint to effective chemical learning.

- Availability of Resources

Constraints related to the availability of laboratory resources, such as equipment and facilities, can impact the scheduling and execution of experiments.

### *Type of Teaching and Learning Style for Chemistry Learning*

Genetic Educators have been exploring innovative techniques to enhance the study of chemical reactions. Inquiry-based learning methods are practical and encourage active engagement and deep understanding among students. Rather than passively receiving information through lectures, students are encouraged to actively investigate chemical reactions through hands-on experiments, problem-solving activities, and real-world applications. This approach fosters a deeper understanding of the underlying principles and cultivates critical thinking skills and scientific inquiry abilities. Inquiry-based learning promotes a sense of ownership and curiosity by allowing students to explore and discover concepts independently, making the learning process more engaging and meaningful.

Moreover, incorporating multimedia resources and technology can significantly enhance the study of chemical reactions. Interactive simulations, virtual labs, and multimedia presentations give students dynamic visualizations and simulations of complex chemical processes. These resources offer opportunities for students to observe phenomena that may be difficult to replicate in traditional laboratory settings and can accommodate diverse learning styles. Additionally, incorporating multimedia elements can make abstract concepts more tangible and accessible, enabling students to grasp challenging concepts more effectively. By leveraging technology and multimedia resources, educators can create engaging learning experiences that inspire curiosity and promote a deeper understanding of chemical reactions among students.

Table 1: Type of Teaching and Learning Style for Chemical Learning

| **Key Aspects** | **Virtual and Simulation Based Learning** | **Lecture-Based Learning** | **Demonstration Learning** | **Visual Aids and Multimedia** | **Hands-On Experiment** | **Case Studies** |
|---|---|---|---|---|---|---|
| Immersion and Realism | Fully immersed in simulated environment using VR technology. | Limited immersion, primarily theoretical understanding. | Limited immersion, observation of live experiments. | Limited immersion, visual and auditory aids. | High realism, direct interaction with chemical reactions. | Real-world scenarios may vary in immersion. |
| Student Engagement | High engagement | Varied engagement, | Moderate engagement | High engagemen | High engagement | High engagement, |

| | | | | | | |
|---|---|---|---|---|---|---|
| | due to interactive nature of simulations. | depends on instructor's delivery and student interest. | through observation and limited interaction. | t with interactive multimedia content. | through active participation in experiments. | particularly when applied to practical problem-solving. |
| Safety and Controlled Environment | Safe and controlled environment for experimentation without risk. | Safe environment but limited hands-on experience may reduce practical skills. | Safe environment for demonstrations, but limited hands-on participation. | Safe learning environment with no risk of physical harm. | Hands-on experience with safety measures and supervision. | Safe environment, although practical scenarios may present varying levels of safety concerns. |
| Practical Application | Practical application through simulated experiments, enhancing understanding. | Limited practical application, more theoretical understanding. | Practical application through observation of real reactions. | Practical application through visual representations. | Direct practical application of concepts and skills. | Application of theoretical knowledge to practical scenarios. |
| Skill Acquisition | Emphasis on theoretical understanding and technical skills. | Emphasis on theoretical understanding with limited hands-on skills. | Development of observational and analytical skills. | Emphasis on visual and auditory comprehension. | Development of practical skills and critical thinking. | Development of critical thinking and decision-making skills. |
| Resource Requirement | Requires VR equipment and software, may be costly and technically challenging. | Requires minimal resources beyond classroom setup. | Requires laboratory equipment and materials, along with time for preparation. | Requires access to multimedia tools and technology. | Requires laboratory facilities, equipment, and safety measures. | Requires access to case studies and relevant materials. |

Virtual Reality (VR) technology offers a range of benefits for teaching and learning. Immersing learners in simulated environments creates interactive experiences that increase interest and engagement (H.Park et al., 2019). It provides a safe space for students to experience scenarios and environments that may be impractical or dangerous. This aids in understanding complex concepts through 3D visualization, virtual experiments, and realistic simulations (Asmma et al., 2017). Additionally, VR enables self-paced, personalized learning that caters to different learning styles. It allows for practical application of knowledge and skills in a safe yet realistic environment (Jason et al., 2020). By exposing students to real-world simulations, VR helps improve problem-solving abilities, although challenges such as equipment costs and technical complexities must be addressed (Dipam et al., 2018). While VR may not entirely replicate physical sensations or social interactions, its practical implementation offers enriched engagement, personalized instruction, and real-world readiness. This requires careful consideration of resources, technical feasibility, and educational objectives.

### *Extended Reality (XR) Technology*

Extended Reality (XR) merges the physical and virtual worlds through computer technology and wearable sensors, facilitating entirely virtual user experiences (Sanika et al., 2020). XR encompasses Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR), offering a broad spectrum of possibilities across real and virtual environments. Industries ranging from engineering to entertainment and healthcare are leveraging XR to enable user interaction with virtual objects (Santoso et al., 2021). XR technology holds significant promise in language learning and teaching, as evidenced by research indicating improved fluency and engagement (Grandhi et al., 2021). By providing hands-on simulation and visual explanations, XR fosters practical learning experiences, enabling instructors to monitor student progress and deliver real-time feedback (Nourga et al., 2021). The XR ecosystem has VR, AR, and MR categories linked in real and virtual environments (Milgram et al., 2020).

Table 2: Extended Reality (XR) Technology

| **Key Aspects** | **Mixed Reality (MR)** | **Virtual Reality (VR)** | **Augmented Reality (AR)** |
|---|---|---|---|
| Definition | MR combines VR and AR for interaction with digital objects in the real world. | VR tech creates computer-generated environments for users to experience a simulated reality. | AR technology enhances users' perception and interaction with their surroundings by adding digital content to the real world. |
| Experience | Headsets, known as MR devices, allow users to interact with virtual content while remaining aware of their physical surroundings. | To use virtual reality, users wear a headset that covers their eyes and may come with motion-tracking controllers. | Experienced through a smartphone, tablet, or wearable device that uses cameras to capture and overlay virtual elements. |
| Use Case | - Design<br>- Engineering<br>- Architecture<br>- Healthcare<br>- Remote collaboration<br>- Interactive storytelling | - Gaming<br>- Virtual Tours<br>- Entertainment Experiences<br>- Simulation Training | - Mobile Gaming<br>- Navigation<br>- Advertising<br>- Industrial Maintenance<br>- Educational Tools |

Virtual Reality (VR) is an innovative technology that provides immersive and practical learning experiences. It allows learners to explore complex concepts, architectural designs, or medical procedures with remarkable realism, leading to a deeper understanding of the subject and developing practical skills (McGovern et al., 2019). Industries dealing with high-risk or expensive environments find VR particularly appealing due to its cost-effectiveness and safety features in training scenarios (Dipam et al., 2018). While Augmented Reality (AR) and Mixed Reality (MR) have their advantages, VR is considered the most suitable option for research studies due to its unparalleled immersion, experiential learning capabilities, personalized instruction, cost-effectiveness, and safety considerations (Frane et al., 2021). It focuses on VR as the primary platform and aims to comprehensively explore its benefits and potential applications to advance educational and training practices in Extended Reality.

### *Related Works on Chemistry Learning of Extended Reality*

The three studies presented demonstrate how Extended Reality (XR) technology can enhance chemistry education. Each system, ARChem, Chemisim, and Nanome, uses VR to provide immersive and interactive lab experiences, overcoming limitations such as accessibility, cost, and safety concerns. ARChem uses Augmented Reality (AR) to create a blended learning environment, allowing students to conduct practical chemistry experiments on their mobile devices. This approach is beneficial during the COVID-19 pandemic when access to physical labs is limited. Similarly, Chemisim's web-based VR simulator provides high school students with a realistic and accessible platform for conducting chemistry experiments, addressing the lack of resources in such settings. Nanome extends the use of VR to biochemistry, giving students a chance to safely and interactively explore complex molecular structures. These studies collectively demonstrate that VR technology can enhance engagement, deepen understanding of abstract concepts, and promote active learning. They show that VR is revolutionizing chemistry education by making it more accessible, practical, and immersive.

Table 3: Related Works

| Feature | ARChem | Chemisim | Nanome |
|---|---|---|---|
| Technology | Augmented Reality (AR) | Virtual Reality (VR) | Virtual Reality (VR) |
| Purpose | Learning and assessment in chemistry. | Chemistry experiment simulation. | Molecular exploration and protein interaction. |
| Integration of game elements | Y | N | N |
| Device Requirements | Mobile devices | Mobile devices, Google Cardboard | Oculus Quest VR headset, hand controllers |
| Simulation Realism | Realistic visualization | Highly realistic | Realistic molecular exploration |
| Fluid Simulation | Y | Y | N |
| Assessment Method | Pre- and post-questionnaire | User study evaluation with questionnaire | Post-lab survey |
| Findings | Quick operation on various devices. | Mostly positive user reactions. | Positive student experience with VR in lab. |
| Cost and Access Considerations | Agnostic to operating software and platform | Web-based availability | Wireless, PC-less portable VR laboratory |

Nanome is an ideal reference for this project because it focuses on molecular exploration and protein interaction within a cutting-edge Virtual Reality (VR) platform. Its immersive VR capabilities provide a highly realistic environment for researchers to visualize and interact with molecular structures, enhancing their understanding of molecular intricacies and facilitating in-depth exploration of chemical phenomena.

Nanome's specific focus on molecular exploration and protein interaction sets it apart from other related methods under investigation. Its specialized features cater explicitly to the complex needs of the chemistry research field. The ability to manipulate and examine intricate molecular structures in real time within a virtual environment empowers researchers to delve deeper into the fundamental aspects of chemical interactions and gain a more comprehensive understanding of molecular behavior.

Furthermore, Nanome's integration of immersive elements and interactive functionalities further enhances the research experience. Through its VR interface and hand controllers, researchers can engage in hands-on interactions with molecular structures, enabling them to manipulate and examine them from different angles and perspectives. This level of interactivity fosters a deeper connection with the research subject matter, stimulating critical thinking and enabling researchers to uncover intricate patterns and correlations within chemical systems.

In summary, selecting Nanome as a pivotal reference for research provides an unparalleled opportunity to gain valuable insights into complex chemical structures, advance the understanding of molecular behaviour, and contribute to significant advancements in the field of chemistry research.

## METHODOLOGY

The methodology outlined in this section employs Instructional System Design (ISD), particularly the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) methodology, to guide the development of instructional materials for the proposed study. ISD, also known as instructional design, focuses on creating learning experiences that are both educational and enjoyable, aligning with the concept of edutainment. By systematically analysing, designing, developing, implementing, and evaluating instructional experiences, ISD ensures the effectiveness of the training and the attainment of desired learning outcomes. By utilizing diverse instructional materials, including both animate and inanimate objects, the concentration and engagement of students in the learning process are enhanced, making the educational experience more exciting, interesting, and interactive. The ADDIE model, a commonly used framework within ISD, provides flexibility and customization throughout the development process, allowing for adjustments to virtual reality applications to ensure their relevance and effectiveness in meeting the needs of secondary school students. Following this model enables a thorough analysis and design of the virtual reality tool to effectively achieve learning objectives and engage students in the educational process. This can be referred to Figure 1 and Figure 2.

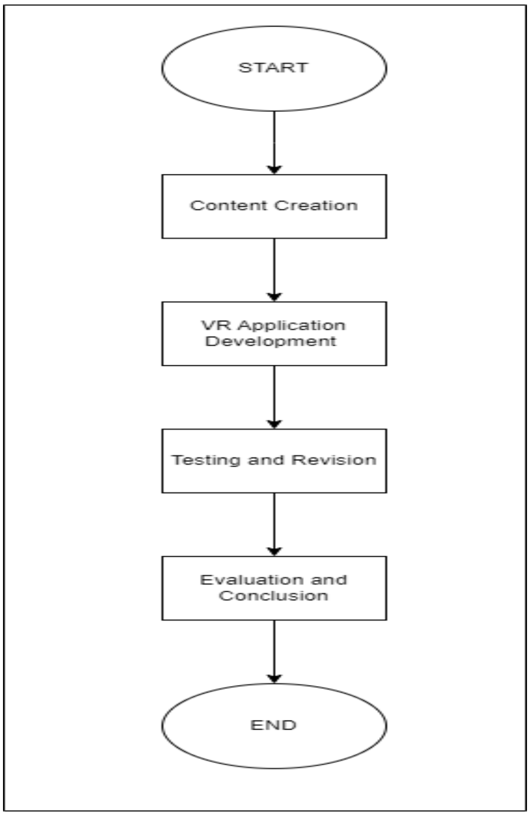


Figure 1: Flowchart of the research

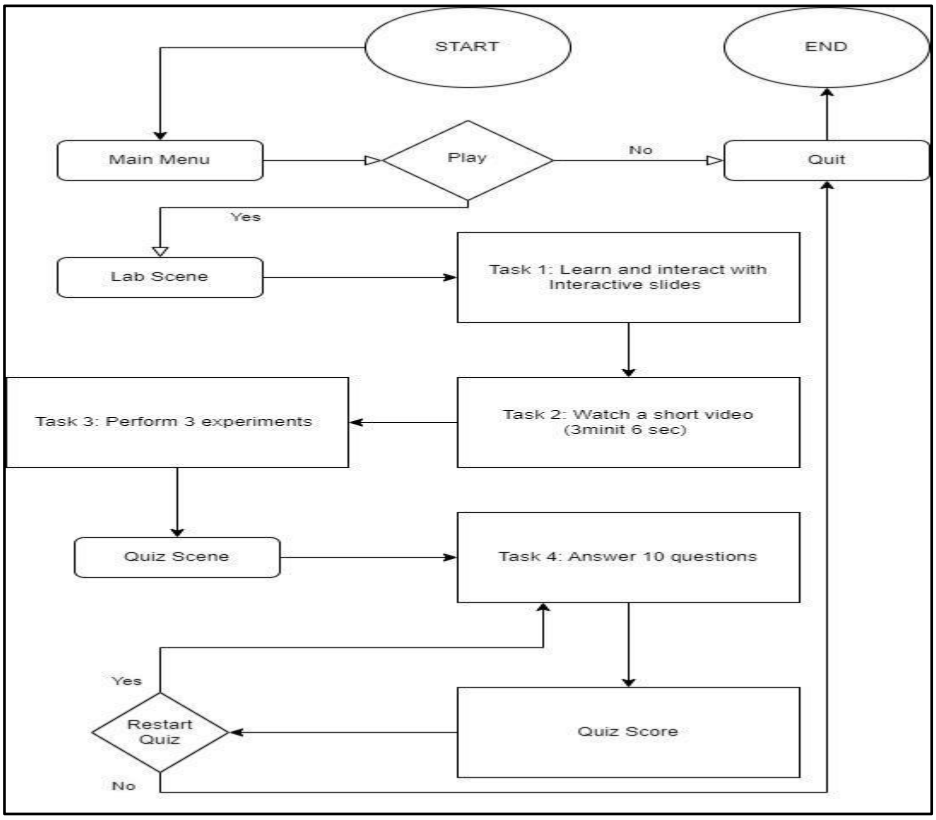


Figure 2: Flow of the Simulator

### *Hardware Requirements*

The software requirements for the system involve using Unity to provide advanced graphics rendering. Additionally, cross-platform development compatibility is mandatory. Blender will be utilized for modelling, rigging, animation, simulation, and rendering capabilities. The hardware requirements will be presented in the form of a table.

Table 4: Computer Hardware Requirements

| Hardware | Specification |
|---|---|
| Device | MSI Bravo 17 |
| Operating System | Windows 11 Home 64-bit |
| Processor | AMD Ryzen 7 4800H @ 2.90 GHz |
| Memory (RAM) | 16.00 GB RAM |
| Graphic Card (GPU) | Radeon RX 5500M |
| Storage | Kingston Al1 SSD 477GB |

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 |

### *Questionnaire*

The Evaluation Phase is the final phase in the ADDIE process. During this phase, users of VR will be asked to complete a survey about their video gaming experience, assessing whether it is usable. A System Usability Scale (SUS) questionnaire will be used to evaluate the system's usability. The SUS is a productive, resource-saving, and time-efficient method for assessing the usability of a system, as stated by Lin et al. (2011). The assessment is conducted on a 5-point scale, with one meaning strongly disagreed and five meaning highly agreed. 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 | Specification |
|---|---|
| 1 | This VR application is simple to use. |
| 2 | I don't enjoy playing this game consistently. |
| 3 | This VR application provides a comfortable experience for me. |
| 4 | I can't do things quickly using this VR application. |
| 5 | If I mess up, it's easy to fix things with this VR application immediately. |
| 6 | The VR applications screen messages and accompanying papers are difficult to understand. |
| 7 | The information helps me do tasks and scenarios well with this VR application. |
| 8 | The interface of the VR application is horrible and confusing. |
| 9 | This VR application provides all of the functions and capabilities that I expected. |
| 10 | The VR application is encountering problems and is not playing smoothly. |

The proposed project has chosen the ADDIE Model to achieve a satisfactory project output within the specified time limit. ADDIE is a comprehensive method that can meet all the project's requirements and significant goals. To avoid any mistakes and development issues, each phase of ADDIE must be carried out carefully. The primary software and procedures used include Unity, the best tool for creating game-based learning software to enhance engaging and effective VR tools.

## RESULT AND DISCUSSION

### *Testing & Implementation*

The Implementation Phase of the ADDIE model focuses on executing lesson plans to deliver them effectively to students. Clear communication is paramount, alongside the establishment of monitoring and feedback mechanisms to ensure smooth training sessions. Quality assurance measures are implemented, and meticulous process documentation is maintained for future reference. Simultaneously, planning for the Evaluation phase is initiated, and real-time feedback informs adjustments, fostering adaptability and continuous improvement. The successful implementation sets the stage for the final evaluation of training effectiveness. This simulation employed three distinct methods to convey the study's purpose to students. Figure 3 illustrates the most effective engagement technique, ensuring students were supported throughout the implementation process.

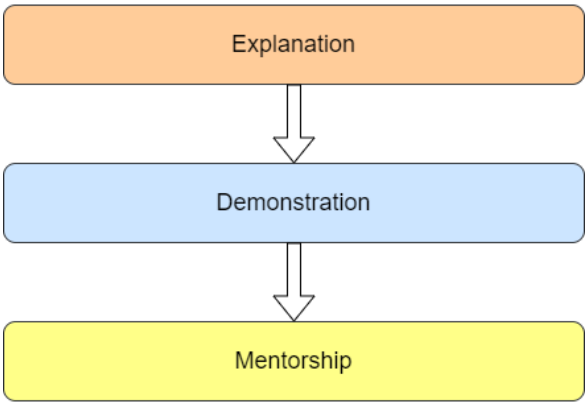


Figure 3: Diagram of approach in implementation

### *Result and Discussion*

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

Table 7: Functionality Test Result

| 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: Learning Slides | Users can control slides using a button and listen to the narrator. | Pass |
| 6 | Task 2: Tick Tablet | After completing the slides, the user will mark each subtopic as learned on the tablet. | Pass |
| 7 | Task 3: Watching Video | The user needs to watch a 3-minute, 6-second video in the room to complete the task. | Pass |
| 8 | Task 4: Making Experiments. | The user will perform three experiments and complete each experiment by following the steps. | Pass |
| 9 | Task 5: Put the results of the experiment into the recycle box. | The user must place the reaction results in the recycle bin before proceeding to the next experiment. | Pass |
| 10 | Task 6: Answer Quiz | Users must select the correct answer for each of the 10 questions by pressing the button on the table. | Pass |
| **11** | Task 7: Quiz Score | The quiz results and the score and grade will be displayed on the screen. Users can retry or return to the main menu if they wish to quit. | Pass |

Based on the SUS questionnaire, the age range for participants in this VR application was limited to 16-year-olds. This is because the simulation is based on the chemistry syllabus for students of this age, as shown in the horizontal graph in Figure 4. Most users were female, with a frequency of 18 participants (60%). Male participants had a frequency of 12 (40%), as shown in a pie chart in Figure 5.

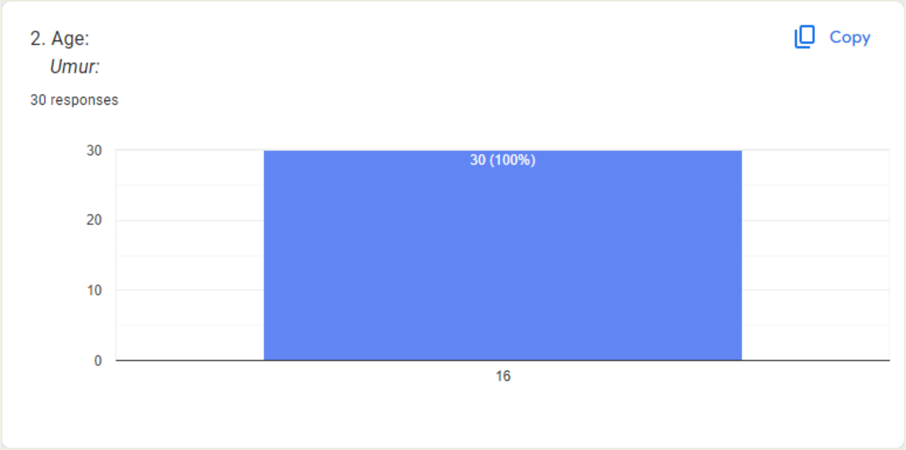


Figure 4: Horizontal bar graph of participants' age

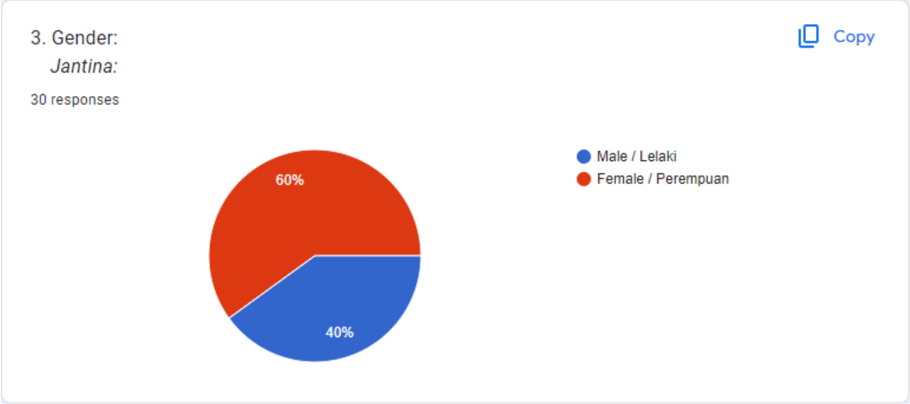
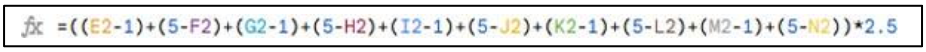


Figure 5: Pie chart of participants' gender

The System Usability Scale (SUS) questionnaire consists of ten items that can help determine the level of agreement on a statement. Each answer has a value ranging from 1 to 5. According to Guerci (2020), odd items such as 1, 3, 5, 7, and 9 should have 1 point subtracted from their SUS questionnaire score, while even items (2, 4, 6, 8, and 10) should have 5 points deducted from their score. To calculate the total score for each respondent, add up their item scores and multiply by 2.5. To get the average, add up the full scores for each respondent. Figure 6 demonstrate the spreadsheet formulas and calculations.



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fx =((E2-1)+(5-F2)+(G2-1)+(5-H2)+(I2-1)+(5-J2)+(K2-1)+(5-L2)+(M2-1)+(5-N2))*2.5
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Figure 6: Formula for SUS score

## *Conclusion*

The Virtual Reality (VR) Chemistry Learning application significantly enhances secondary school students' understanding of complex chemical concepts. The application is developed using the Unity game engine and seamlessly integrates three different environments - Main Menu, Lab, and Quiz - to provide an immersive and interactive learning experience. The VR application caters to the diverse learning styles of secondary school students through instructional strategies such as simulations and sequential content structuring. It also addresses traditional laboratory challenges such as accessibility and safety concerns. Continuous evaluation and user feedback will be crucial in refining and improving the application to ensure its effectiveness and relevance in secondary school education. An iterative development approach will enable ongoing enhancements based on user experiences, ultimately advancing educational technology by providing a safe and engaging virtual environment for students to learn about the complexities of chemistry.

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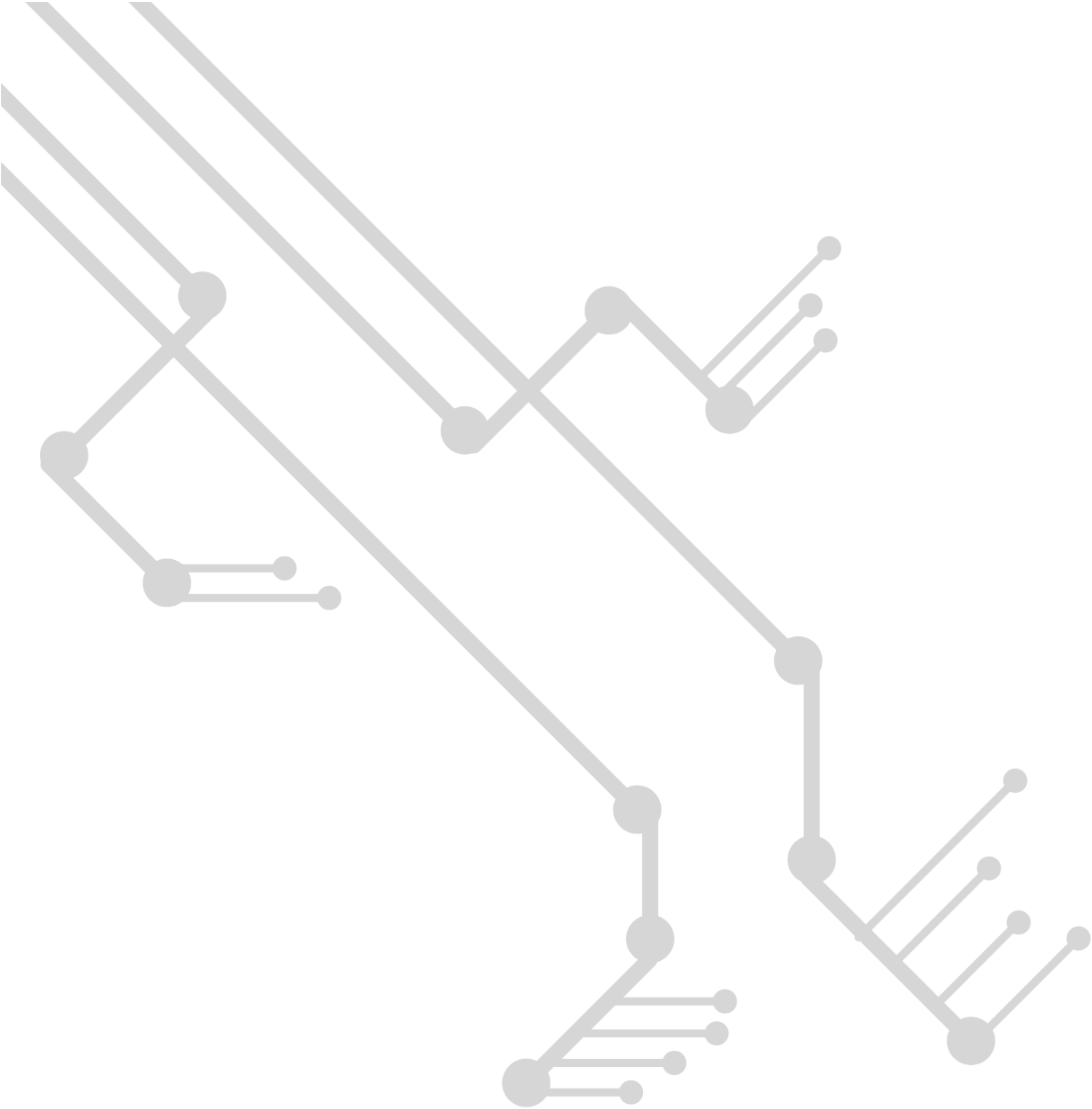

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