KEMENTERIAN PENGAJIAN TINGGI

DEPARTMENT OF INFORMATION TECHNOLOGY

DIPLOMA IN INFORMATION TECHNOLOGY
(DIGITAL TECHNOLOGY)

DFT50114: INTEGRATED PROJECT

CHEM LAB

DEVELOPMENT OF A VIRTUAL AND MIXED REALITY (VR/MR) APPLICATION FOR EXPERIENTIAL CHEMISTRY LEARNING

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1.0 INTRODUCTION

Virtual Chemistry Simulation is a Mixed Reality (MR) and Virtual Reality (VR) based application where an immersive virtual laboratory environment is presented to the users. Virtual Reality (VR) refers to the use of computer technology to create simulated environments that replicate real world settings. Instead of observing content on a flat screen, users are placed inside a fully interactive 3D environment. In recent years, VR has become an increasingly powerful tool in education, offering students the ability to practice and explore subject matter in dynamic, engaging ways that strengthen their conceptual understanding.

This project has been proposed to SMK Puchong Utama (1), a potential client that stands to benefit significantly from a virtual simulation platform, particularly for chemistry education. With the right equipment, such as a VR headset, students will be able to access realistic lab experiences without the limitations of physical laboratory setups.

The Virtual Chemistry Simulation is designed to allow students for simulating chemistry experiments by using hand gestures. The system will guide users through each experiment with virtual instructions and interactive interfaces that help them learn theoretical concepts in a more engaging and meaningful way.

Ultimately, this project will provide students at SMK Puchong Utama (1) with a new, innovative way to perform experiments and strengthen their learning without the concerns of cost, safety, or space limitations. By integrating MR and VR technology into the classroom, this simulation is expected to significantly enhance students academic outcomes and interest in chemistry.

2.0 PROBLEM STATEMENT

The traditional method of teaching chemistry relies on physical laboratory sessions, where students conduct hands on experiments. However, many schools that offer chemistry face significant limitations that hinder effective practical learning:

i. **Limited Lab Space** - Many schools have restricted laboratory areas, making it difficult to accommodate all students for practical sessions. This results in overcrowded labs or fewer opportunities for students to conduct experiments themselves.

ii. **Time Constraints** - Chemistry practical are often scheduled within a tight academic calendar, leaving students with minimal time to conduct and analyse experiments thoroughly. Rushed sessions reduce the effectiveness of hands on learning

iii. **Insufficient Materials** - Schools often face shortages of essential chemicals and lab equipment. Limited resources mean that some experiments may be skipped or demonstrated only by the teacher instead of allowing students to perform them.

iv. **Safety and Cost Issues** - Certain chemical reactions require expensive or hazardous materials, making it impractical for schools to conduct them frequently. As a result, students miss out on key learning opportunities.

3.0 OBJECTIVES

The objective of the project are as follows:

- **Enhance Experiential Learning** - To enable an engaging, hands on approach for students to perform virtual experiments.

- **Optimize Learning Opportunities** - To enable students to engage in experiments at their convenience, unrestricted by traditional lab schedules.

- **Mitigate Resource Limitations** - To decrease necessity on expensive and uncommon laboratory materials.

- **Boost Engagement and Comprehension -** To implement 3D visualizations to strengthen the understanding of theoretical principles.

- **Promote Safety** - To provide a secure setting for conducting experiments involving hazardous substances.

4.0 PROJECT SCOPE

User Scope:

- Students can interact using hand gestures to simulate lab work.
- Students can learn chemistry concepts through visual 3D simulation.
- Students can access the system on VR headsets, laptops, or smartphones.
- Students can review theory before and after experiments using embedded content.

System Scope:

- The system features common chemistry experiments like titration and reactions.
- The visual guidance will be provided.
- The system will include quizzes for learning reinforcement.
- The interface is designed to be simple, responsive, and multilingual ready.

5.0 PROJECT SIGNIFICANCE

- Virtual Chemistry Simulator offers an engaging alternative for schools lacking full lab resources.
- Virtual Chemistry Simulator provides safe access to hazardous experiments.
- Virtual Chemistry Simulator enhances student understanding with 3D visualization.
- Virtual Chemistry Simulator allows repeated practice without wasting materials.
- Virtual Chemistry Simulator boosts accessibility for schools with limited funds.

6.0 LITERATURE REVIEW

Table 2.0 Literature Review of Virtual Chemistry Simulator

Project	**MoleculARweb**	**ChemReaX**	**Labster**
Link Resources	https://molecularweb.epfl.ch/	https://www.sciencebysimulation.com/chemreax/Analyzer.aspx	https://www.labster.com/
Platform	Web / Mobile	Web	Web / VR
Description	Web based AR Chemistry learning	Chemical reaction simulator	Virtual science lab simulations
Advantages	Free, 3D interactive molecule simulations	Reaction based visuals, balance equations	Interactive and immersive lab environment
Disadvantages	Limited to molecular visuals	No VR support	Paid subscription required

Several existing platforms and tools were reviewed to inform the development of the Virtual Chemistry Simulation project. Among them:

- **MoleculARweb** provides free, web based augmented reality (AR) visualizations for molecular structures. It is interactive but limited to molecular level content without full VR lab simulations.
- **ChemReaX** offers a simulation based environment for chemical reactions and balancing equations, but it lacks immersive, hands on interaction and VR support.
- **Labster** delivers comprehensive VR science lab simulations with guided experiments and assessments, though it requires a paid subscription and is not always tailored to local syllabus.

These platforms highlight the benefits and limitations of current digital chemistry tools. Unlike these, the proposed Virtual Chemistry Simulation will integrate free, open source tools and hand gesture interaction for a more immersive, accessible, and syllabus aligned experience.

7.0 METHODOLOGY

The Visual Chemistry Simulator project adopts the Agile methodology, which is well suited for both small and large scale development projects. Agile allows the development team to focus more on building a functional and user friendly system, rather than being overly burdened by documentation and rigid processes. This methodology supports rapid development and flexibility, making it ideal for software projects where requirements may evolve during the development lifecycle.

Through incremental releases, Agile provides a flexible timeline that enables ongoing testing, feedback, and improvement. It also promotes continuous client engagement, which enhances user satisfaction and ensures the final product meets expectations.

Benefits of Agile Methodology:

- **Flexibility**: Agile allows for dynamic changes throughout the development cycle. This is especially useful in educational software projects where feedback from students and teachers may lead to frequent updates.
- **Improved Collaboration**: Agile encourages strong collaboration among team members and continuous interaction with clients. This results in better understanding of user needs and clearer communication of project goals.
- **Higher Team Morale**: Agile empowers team members to take ownership of their tasks, which increases motivation and fosters teamwork.
- **Continuous Feedback**: Agile incorporates regular reviews and client feedback, allowing early detection of issues and opportunities for continuous enhancement of the system.

Table 3.0 Phase Agile Methodology

No.	Phase	Activities
1	Meet & Plan	i. Brainstorm project ideas. ii. Meet with SMK Puchong Utama (1) staff for requirement gathering. iii. Conduct initial research. iv. Analyze gathered data.
2	Design	i. Design overall architecture and interface for the Virtual Chemistry Simulation. ii. Create UML diagrams, Data Flow Diagrams (DFD), and a Gantt Chart. iii. Sketch and prototype user interface in Figma based on client feedback.
3	Code & Test	i. Develop and test interactive VR/MR chemistry simulations using Unity and Blender.
4	Release	i. Deploy the system to be tested in the SMK Puchong Utama (1) school environment.
5	Feedback	i. Gather feedback from teachers and students. ii. Perform necessary improvements and fix any identified issues.

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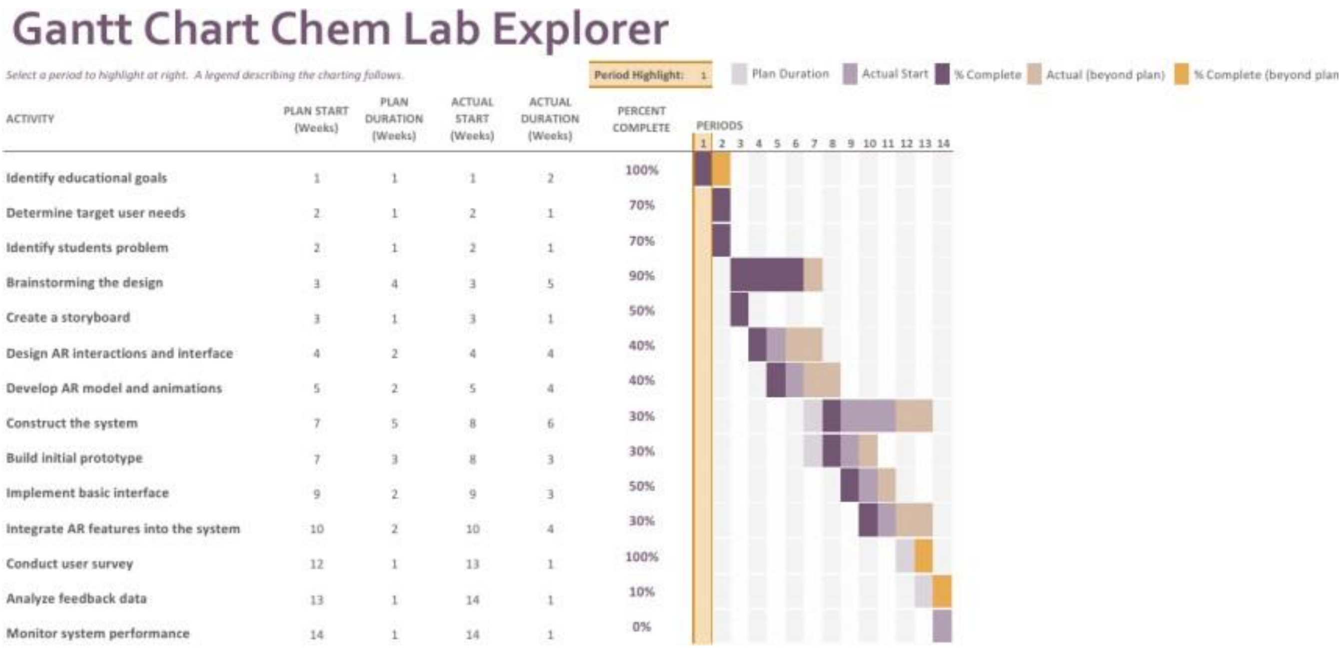
9.0 GANTT CHART



ACTIVITY	PLAN START (Weeks)	PLAN DURATION (Weeks)	ACTUAL START (Weeks)	ACTUAL DURATION (Weeks)	PERCENT COMPLETE
Identify educational goals	1	1	1	2	100%
Determine target user needs	2	1	2	1	70%
Identify students problem	2	1	2	1	70%
Brainstorming the design	3	4	3	5	90%
Create a storyboard	3	1	3	1	50%
Design AR interactions and interface	4	2	4	4	40%
Develop AR model and animations	5	2	5	4	40%
Construct the system	7	5	8	6	30%
Build initial prototype	7	3	8	3	30%
Implement basic interface	9	2	9	3	50%
Integrate AR features into the system	10	2	10	4	30%
Conduct user survey	12	1	13	1	100%
Analyze feedback data	13	1	14	1	10%
Monitor system performance	14	1	14	1	0%

10.0 COST PLANNING

Hardware:

NO	HARDWARE	PRICE	AMOUNT OF UNIT	TOTAL (RM)
1	Laptop	3000	3	9000
2	VR headset	2000	1	2000
3	Smartphone	1000	2	2000
4	VR box	50	1	50
Total estimation (RM)				13050

Software:

NO	SOFTWARE	PRICE	AMOUNT OF UNIT	TOTAL (RM)
1	Unity	Free	1	0
2	Blender	Free	1	0
3	MoleculARweb	Free	1	0
4	Avogadro	Free	1	0
5	Canva	Free	1	0
Total estimation (RM)				0

11.0 CONCLUSION

The Virtual Chemistry Simulation project has the potential to deliver a unique and immersive learning experience for students who may not always have access to fully equipped chemistry laboratories. By leveraging VR and MR technologies, students can engage in realistic and interactive simulations of chemistry experiments, allowing them to better understand core scientific principles and lab procedures in a safe, accessible environment.

Throughout the project, team members explored the capabilities of virtual reality hardware and free software tools such as Unity, Blender, and MoleculARweb. Additionally, by examining the educational environment at SMK Puchong Utama (1) and engaging with end users, the project team was able to identify real world challenges in traditional chemistry instruction. These insights guided the design of a virtual system that addresses resource shortages, space limitations, and safety concerns commonly faced by schools.

While a virtual laboratory cannot entirely replicate the tactile experience of handling real chemicals and equipment, this simulation serves as a powerful supplement to physical labs. It offers students a chance to practice, repeat, and explore experiments at their own pace without the limitations of time, materials, or lab scheduling. With the integration of hand gesture based interaction, students can perform virtual tasks such as mixing and manipulating chemistry stuff, closely mimicking real lab experiences.

In conclusion, this project bridges the gap between theoretical learning and hands on practice, making chemistry more engaging, equitable, and effective for students in Malaysia and beyond.