PUSL3190 Computing Individual Project

PID Submission

Chemistry Lab Website for AL Students

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01. Introduction

The G.C.E. A-Level Chemistry syllabus has been considered one of the most challenging academic programs at a pre-university level, with topics ranging from reaction mechanisms, identification of catalysts, and properties of countless organic and inorganic compounds that students must grasp. Much of the challenge is abstract in nature; these are issues that are often invisible and, if material is given solely by the traditional learning method, difficult to retain. Traditional teaching techniques, while foundational, often lack the interactive and practical elements needed to fully engage students and enhance their comprehension (Brown et al., 2018). Research indicates that integrating technology into education significantly improves learning results by providing students with engaging, interactive environments (Silberberg, 2019).

This project aims to leverage these findings by developing an interactive e-learning platform specifically designed for G.C.E. A-Level Chemistry students. This system works to overcome the drawbacks of traditional modes of learning through incorporating simulative visual and hands-on virtual tools, along with systematic resources. For example, embedding tools like interactive periodic tables and lamp test simulators will help students explore and deduce properties, structures, and reactions concerning chemistry in a way that develops comprehension and retention (Housecroft & Sharpe, 2020). The principal features of this platform include the ability to simulate organic transformations and inorganic qualitative tests through virtual laboratories. Virtual labs fill the gap between theoretical knowledge and application; thus, students can safely have as many tries as possible in conducting experiments. That is according to Atkins & de Paula, 2022.

Further, the inclusions of chemistry calculators and formula tools support the analytical aspects of the curriculum through calculation of molar masses, concentrations, and gas laws. These tools have often assisted students in understanding even the most complicated scientific concepts (Bruice, 2017). The platform also addresses the need for additional study aids, such as tutorials, past papers, and quizzes. These resources provide structured guidance and encourage active learning, which has been demonstrated to improve long-term retention and exam performance (Chang, 2019). Additionally, the inclusion of features like color visualization for anions, cations, and compounds enhances the learning of inorganic chemistry, a subfield where color often plays a critical role in understanding chemical properties and reactions. By acting as a supplementary resource to traditional classroom instruction, this project aims to create an interactive, engaging, and efficient way for students to learn chemistry. Its emphasis on visual learning and virtual experimentation aligns with modern pedagogical trends that advocate for technology-integrated education to better prepare students for higher education and careers in the sciences (Silberberg, 2019).

Above all, this platform aims to make students like the subject of chemistry, which usually appears to be frightening for them, approachable and easy.

In the greater perspective, the project contributes to reforming education with the use of technology. Indeed, these days interactive e-learning tools increasingly win popularity in STEM education, since they meet different types of learning styles and provide an individual approach to each student (Brown et al., 2018). This not only caters to the immediate needs of A-Level Chemistry students but also upholds the potential for technology to shape the way in which challenging subjects are taught and learned.

02.Business Case

01.Business Need

This is the gap that the project would want to fill by developing an interactive mobile application that shall enhance the learning of organic and inorganic chemistry among G.C.E A-Level students and bring solutions to the challenges they have been facing. Traditional studying materials, such as textbooks and notes, usually do not get students involved or even allow the students to perceive reactions, catalysts, and compounds for what they truly are. In addition, it is very cumbersome for most students to memorize organic transformations and recall which catalysts have been used in every reaction-a vital component of academic success.

This would entail designing an online learning tool for A-level chemistry, complete with interactive tools that make chemistry interesting and memorable. Examples include interactive simulations, colorful compound visualizations that students can play with, and calculators that apply important formulas. Research has documented that using interactive and visual learning materials increases comprehension and retention by up to 80%. Therefore, this is the reason why this novel educational tool will be highly indispensable.

02.Business Objectives

The following are the key objectives targeted in this project –

1. Improve Learning Outcomes in Students

- Objective - Improve student engagement in, and retention of complex chemical concepts with the help of interactive tools.
- Explanation - Active participation by students and better learning outcomes will result from the engaging features of the platform.

2. Increase Accessibility to Chemistry Resources

- Objective - Comprehensive study material in chemistry and interactive resources.
- Explanation - More than 100 sets of reactions, compounds, and practice questions will be included to ensure that students have a great deal of material available.

3. Encourage Active Learning and Application

- Objective - Provide reaction simulators, periodic tables, and color finders for further learning.
- Explanation - These interactive tools will support students in visualizing and applying theoretical knowledge in practice.

4. Improve Exam and Coursework Preparation

- Objective - Provide practice questions and past papers to enhance revision and self-assessment.
- Explanation - The platform will enhance revision for exams by better focusing practice resources.

5. Address Education Technology Trends

- Objective - Ensure mobile-responsive design and ease of use across devices.
- Explanation - Modern usability standards will improve learning both on the mobile and desktop platforms.

03. Project Objectives

- Identify Organic Transformations and Compounds - Allow students to identify the organic transformation, catalysts, and product produced in an interactive visualization format for better understanding.
- Simulate Chemical Tests and Identifications - Allow the student to apply their knowledge by virtually performing lamp tests and identifying colors of anions, cations, and compounds.
- Interactive Study Resources - Allow students to memorize important chemical reactions, catalysts, and properties by providing them with a periodic table and summary of reactions.
- Calculating Chemical Properties - Provide calculators and interactive visual tools that allow students to further analyze chemical properties and their reactions for deeper understanding.
- Reflection and Self-Assessment - Encourage students to build up the habit of self-assessment of their knowledge through regular quizzes, questions, and assessment included in the course to measure progress.
- Support Personalized Learning Paths - Allow students to develop individual study schedules and to choose content for study according to their needs to enhance retention and mastery.

04.Literature Review

1. Overview

1.1. What is Chemistry?

Chemistry is the science that deals with the composition, structure, properties, and reactions of matter. It is usually viewed as a fundamental science since it provides the basis for understanding many natural phenomena and offers solutions to practical problems in medicine, engineering, and the environment. Chemistry can be further divided into several disciplines: inorganic chemistry, organic chemistry, physical chemistry, analytical chemistry, and biochemistry. When it comes to G.C.E. Advanced Level studies, students deal chiefly with inorganic and organic chemistry.

Inorganic Chemistry deals with inorganic compounds, which mostly contain metals and minerals. When it comes to inorganic chemistry, students should be aware of flame tests, color tests, and prediction of reactions. On the other hand, Organic Chemistry deals with carbon-containing compounds; hence, one should be aware of reaction mechanisms and about catalysts and their participation in chemical processes.

1.2. Fundamental Chemistry Concepts

- The fundamental concepts of inorganic chemistry are:
    - Element Identification - Certain methods involve the use of color-reference charts, such as flame tests, for element identification.
    - Reaction Prediction - The reaction patterns based on the periodic table and chemical principles.
    - Complex Ion Formation - A detailed study is devoted to finding out the mode of interaction between ligands and metals for complex formation.
    - Acid-Base Reactions - Basic processes that guide chemical reactions both in a laboratory and in nature.
- Organic Chemistry entails the following central concepts
    - Reaction Mechanisms - an investigation of how and in what manner molecules interact with each other in chemical transformations.
    - Catalysis - in such a context, catalysis is understood as the transient alteration of reaction pathways through which catalysts accelerate chemical transformations.
    - Functional Group Analysis - under this heading comes the study of organic compound transformations according to the nature of functional group variations.

2. Introduction to Educational Platforms in Chemistry

Given the increasing role of technology in education, a wide range of interactive chemistry tools have been developed to enable students to learn more effectively. Reaction simulators, interactive periodic tables, and calculators that simplify complex concepts are just a few of those tools that were given (Hassani & Jafari, 2021). However, most of these suffer from a serious drawback-the lack of integration among the platforms-

strongly forces students to switch between different platforms in search of what they need (Berthet et al., 2020).

3. Importance of Educational Applications in Chemistry

It has also been proved that educational applications improve students' participation and understanding, especially for subjects requiring abstraction, such as chemistry. As Hwang et al. (2018) note, technology-enhanced learning environments can further facilitate motivation and conceptual understanding through immediate feedback and opportunities to meet individual learning needs. In addition, such applications provide a suitable avenue to present abstractions in chemical concepts and improve overall performance. Several key features and target areas have been suggested for this application.

The proposed educational application is targeted at supporting G.C.E. Advanced Level students in science, targeting a few specific learning challenges of the subject chemistry. Its salient features are as follows:

1. Color Identification for Elements and Compounds - Learning is far more enriched with visual aids, as it is often found that students can retain more when something has been interpreted visually. This feature will help students recognize and understand the colors that differentiate various chemical elements and compounds.

2. Catalyst Information for Organic Chemistry - This section will be used to go into detail about the catalysts and their applications in organic reactions to assist the reaction mechanisms.

3. Interactive Periodic Table - An interactive tool displaying element properties and their relationships, including real-life applications, will further enhance student understanding of chemical interactions and trends.

4. Calculator for Chemistry-Based Problems - The inbuilt calculator will enable students to calculate problems concerning molarity, stoichiometry, and other related chemistry areas, hence making learning easier.

5. Ease of Use - Ensure the interface is well-designed to be easy to navigate; this will enhance navigation and, consequently, improve student engagement in learning.

4. Technological Systems and LMS Integration

There are a lot of benefits due to the integration of LMS into an educational application. For example, it gives a systematic approach toward the management and distribution of education resources via the LMS platform. Through such integration, the ability has been given to educational applications to provide seamless access to learning material, follow student progress, and offer real-time feedback.

- Integration with LMS - LMS integration allows for easy and smooth access to educational resources and provides instructors an opportunity to keep track of student progress.
- Data Analytics - LMSs will record data on student interactions that can inform teaching strategies and could provide actionable analytics to make sure extra support, or interventions reach the right students at the right time.
- Support for Mobile Learning - This is all about responsive design, considering that for most students, the usage of mobile devices is becoming an increasingly important part of their learning environment and daily routines.

5. The Use of Educational Games for Interactive Chemistry Learning

Educational games have emerged as useful pedagogical tools and methods for making learning fun and interactive. For example, Bayir (2014) designed three chemistry games-Elemental Periodica, Compoundica, and Groupica-to provide high school students with knowledge about elements, compounds, and the periodic table. These games highlight some fundamental conceptions in chemistry, such as atomic number, properties of elements, and structure of periodic table arrangement. In this, the study undertaken at a Chemistry Games Days event was attended by 250 students in grades 9-12 and 30 teachers; it showed that the participants enjoyed games, which positively reinforced chemistry concepts and helped with exam preparation in an amusing manner. The study by Bayir, 2014, underlines the capacity of gamification to lighten hard subject matters and make learning more appealing.

6. Virtual Laboratories in Learning Enhancement

The integration of virtual labs into chemistry education has increased engagement and improved learning.

Alhashem and Alfailakawi (2023) studied the effect of virtual labs on pre-service chemistry teachers by comparing a group exposed to traditional methods with one that also used virtual labs. They found that virtual labs significantly enhanced participants' perceptions of chemistry studies and their interest in conducting labs, but with no significant change in their technical performance in the lab. Alhashem & Alfailakawi, 2023, emphasized that virtual labs played an important role in supplementing conventional teaching techniques and encouraging the use of technology in learning institutions.

7. Context-Based Learning in Organic Chemistry

Context-based learning allows for improved insight and application of organic chemistry concepts. Hanson (2023) investigated this approach, including real-life experiences in teaching organic topics such as addition reactions and molecular structures, by finding out that students exposed to CBL clearly improved their reasoning and problem-solving activities, thus pointing out the efficiency of this approach in making intricate subjects relevant.

8. Simulation-Based Teaching Methods for Pre-Service Chemistry Teachers

Various simulation-based teaching methods have been used to develop the acquisition of skills by pre-service teachers; for instance, Situational Simulation Teaching (SST) has been widely implemented. It involves educators in role-playing activities that simulate classrooms and laboratory settings. According to Hanson (2023), SST enhances learning and develops professional competencies in teaching, communication, and classroom management. This approach focuses on practical exposure that equips prospective teachers with the capacity to apply the acquired knowledge in real situations.

9. Improving Engagement through Creative Chemistry Resources

Innovative resources such as online tutorials, activity books, and chemistry-themed coloring books have gained traction for engaging diverse learners. Caspi et al. advocate for these tools, which bridge theoretical knowledge with real-world applications, making chemistry relatable and inclusive. By targeting various audiences, including children and the public, these resources enhance critical thinking while broadening the accessibility of chemistry education (Caspi et al., 2023).

10. Comprehensive Integration of Interactive and Technology-Enhanced Tools

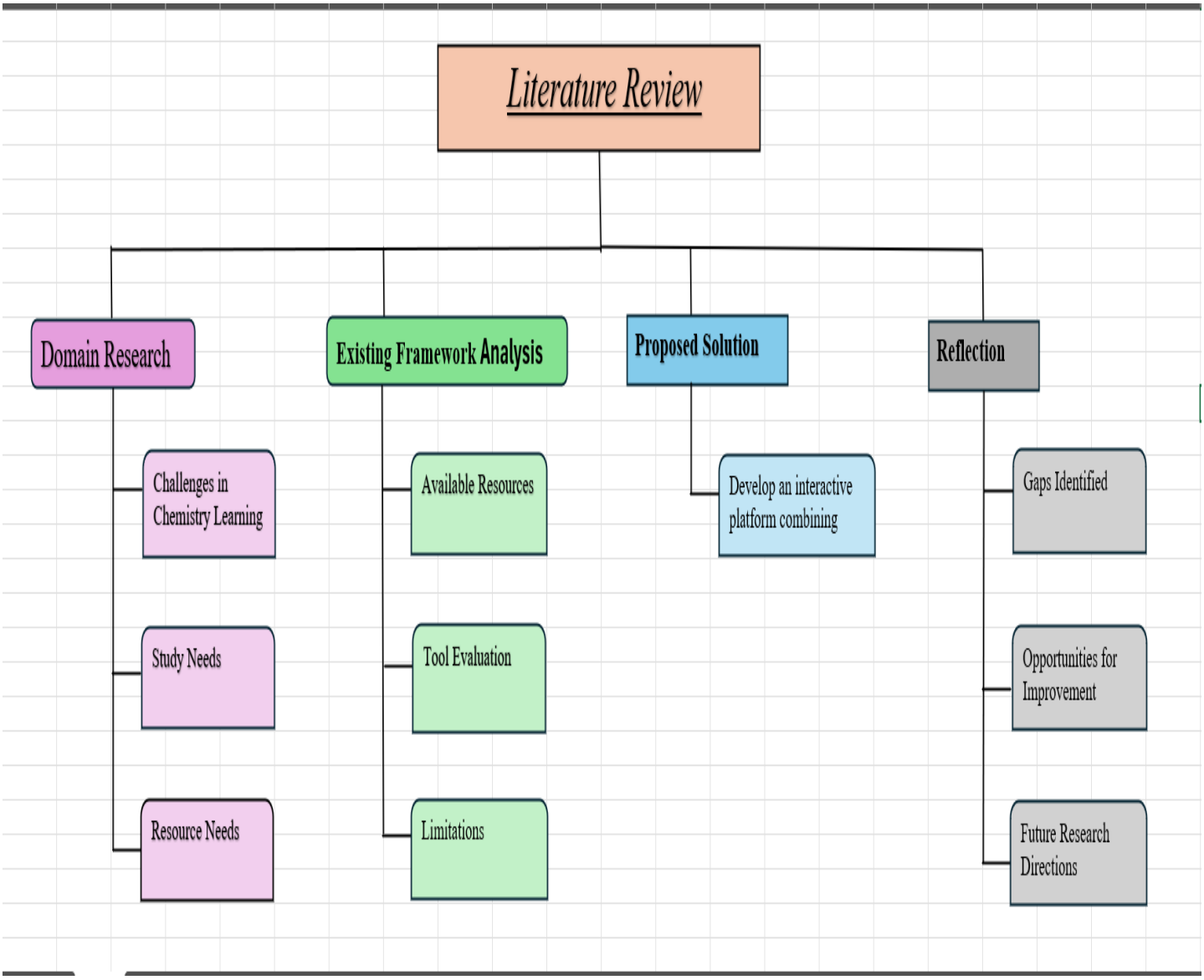
The collective findings suggest that incorporating interactive and technology-enhanced tools creates a more engaging chemistry learning environment. Educational games, virtual laboratories, and simulation-based methods improve engagement, conceptual understanding, and accessibility. These approaches align with the goals of enhancing scientific literacy and preparing students for practical applications of chemistry.

Literature reviewed identifies interactive tools and technology to have a transformative effect on chemistry education.

Gamified learning-as proposed by Bayir (2014)-virtual laboratories by Alhashem & Alfailakawi (2023), and context-based approaches by Hanson (2023) all contribute to enhancing engagement and understanding in unique ways.

Simulation-based teaching methods help in professional skills development among the pre-service educators, while creative resources widen the appeal and access of chemistry education. Collectively, these methodologies give a wide-based approach towards education that focuses on innovation and inclusiveness.

11.Conceptual Map



05. Method of Approach

1. Project Management Methodology - Agile

1. Creation of Product Backlog

- Objective - Enumerate all key features. Examples include organic chemistry transformations, lamp tests, quizzes, and periodic table.
- Tools - Manage these tasks using Trello or Jira.
- Outcome - Features defined for development.

2. Sprint Planning

- Objective - Divide the project into sprints - 2-4 weeks - with a specific feature delivery in focus.
- Example - Sprint 1 could be about the periodic table and design of the homepage; Sprint 2 could be about the lamp test simulation.
- Outcome - Clearly defined deliverables for each sprint.

3. Daily Standup

- Objective - Hold daily meetings to track progress, identify obstacles, and align.
- Tools - Utilize Slack or Microsoft Teams to provide quick status updates.
- Outcome - Ongoing team collaboration and resolution of issues.

4. Development Iterations (Sprints)

- Objective - Develop features in short cycles delivering working increments at the end of each sprint.
- Example - Sprint 1 delivers the functional periodic table. Sprint 2 delivers a working lamp test simulation.
- Outcome - Progressively functional components of the website.

5. Sprint Review & Demonstration

Objective - At the end of each sprint, demonstrate the developed features and take feedback.

Example - Provide feedback on the usability by showcasing the lamp test simulation.

Outcome - Stakeholder feedback that will inform further development.

6. Sprint Retrospective

- Objective - Reflect on the sprint with the purpose of deciding on improvements for the next cycle.
- Example - Discuss unclear requirement handling or improvement on sprint planning.
- Output - Continuous process improvement.

7. Iterative Feedback & Updates

- Objective - Gather feedback in the aftermath of every sprint to refine the product further.
- Example - Refine the color identifier tool with the help of user feedback.
- Output - Continuous refinement of features as required by the users.

8. Adaptation to Changing Requirements

- Objective - To be open to new requirements and adapt them whenever necessary.
- Example - Add a conversion calculator only if students request one.
- Outcome - Product adaptive and constantly improving, meeting user expectations.

9. Tools for Agile Implementation

- Project Management - Use Trello or Jira for managing tasks.
- Team Communication - Slack or Microsoft Teams will provide collaboration opportunities.
- Version Control - Keep your code managed with GitHub or GitLab.
- Outcome - The workflow will be smooth and very well coordinated within the team.

2. Tools and Technologies

a. Development Stack

Frontend Development -

- HTML, CSS, and JavaScript - These will constitute the core web technologies that will be employed for building the platform's UI, which shall be responsive and intuitive. Further integrations can include other CSS frameworks like Bootstrap to make things easier with responsive design.
- JavaScript Libraries: Much of the interactivity will involve things like simulations and color identifications that could be done through jQuery or similar custom JavaScript functions.

Backend Development -

- PHP - PHP will be used to create the backend for maintaining the server-side logic, handling user authentication, and managing data regarding quizzes, interactives, and student progress.
- Java Alternate Backend - In case the platform needs very high scalability and/or integration with external services, one good alternative can be Java, using frameworks like Spring.

Database -

- MySQL - This will handle the storage of data about the users, quizzes, study resources, and progress tracking. Providing a relational structure to data, MySQL assures stability and ease of management. Table relationships will be established to connect user information with study records and assessment results.

b. Design and User Experience

- UI/UX Design - Figma will be used in prototyping and creating wireframes to map the flow of interactions and get early feedback.
- Interactive Elements - Features requiring interactive functionality will be created using JavaScript plugins or libraries that allow this, for example, 3D models or simulations.

c. Collaboration and Version Control

- Git and GitHub - In terms of version control, this team collaboration will rely on Git to maintain code in order and as a backup.
- Project Management Tools - Trello or Jira will be used to organize and track Agile sprint tasks and progress to communicate priorities and timelines.

d. Testing and Quality Assurance

- Manual Testing - Manual testing during each sprint to ensure functionality, usability, and any bugs.
- User Testing - Sessions with students and teachers periodically for feedback on ease of use regarding achieving the educational goals of the platform.

3. Key Development Phases

i. Requirements Gathering & Sprint Planning - This will establish the key features, user stories, and outline the goals of the sprint.
ii. Prototype and Design Phase - Create initial wireframes and prototypes in HTML, CSS, and JavaScript; test the design with actual users.
iii. Frontend & Backend Development –
    - Frontend - Develop user interface components and interactions in HTML, CSS, and JavaScript.
    - Backend - Perform server-side processing using PHP and integrate with MySQL for user database management, resource, and quiz management.
iv. Database Integration - Use MySQL for structuring data into tables and defining the relationships between users, study material, quizzes, and progress tracking.
v. Testing and Continuous Improvement - Plan continuous testing cycles, at the end of each sprint, to ensure that each increment is functional and meets user needs.
vi. Release and Feedback Collection - Release the platform and gather insights for further development phases.

4. Technologies and Platforms

• Frontend: HTML, CSS, JavaScript (with jQuery or Bootstrap if necessary)

• Backend: PHP

• Database: MySQL

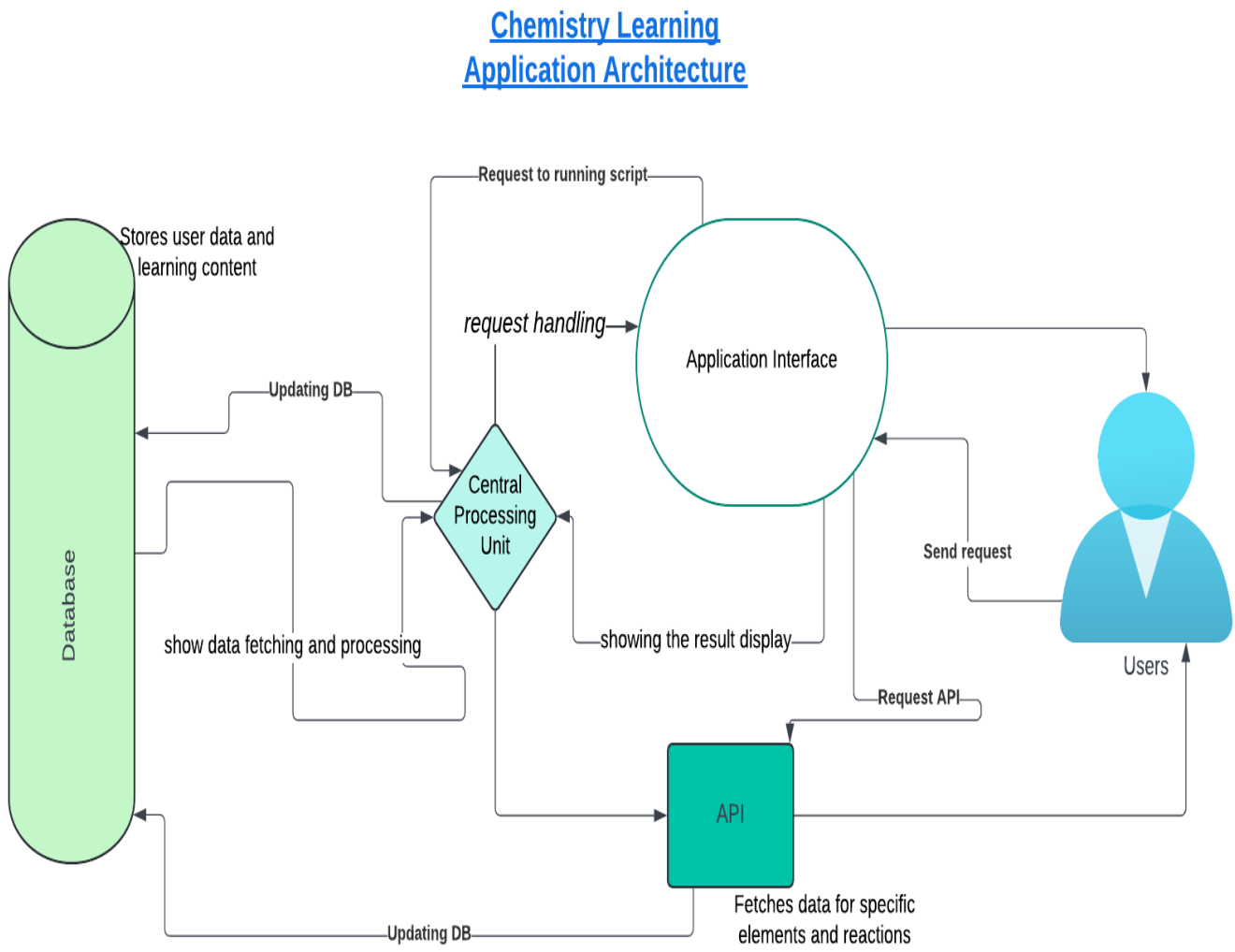
• Design Tool: Figma for UI/UX design

• Version Control: Git and GitHub

• Project Management: Trello or Jira

By using this platform with Agile, it will help the team deliver an early iteration for feedback and continuous improvement based on user input. The frontend will be done in HTML/CSS/JS, the backend in PHP/Java, and MySQL for data management; this will ensure a reliable, friendly-to-use, and adaptable chemistry learning platform.

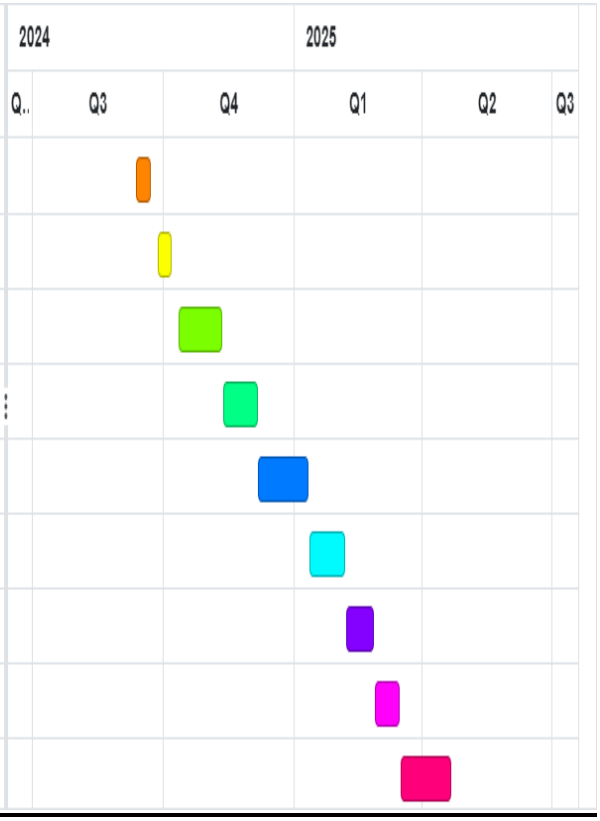
5.High Level Diagram



06.Initial Project Plan

Gantt chart

ID	Task Name	Start	End	Duration
1	Project Planning & Requirements Gathering	2024-09-11	2024-09-21	11 days
2	Wireframing & Design Planning	2024-09-26	2024-10-06	11 days
3	Frontend Development (Phase 1)	2024-10-11	2024-11-10	31 days
4	Backend Development Setup	2024-11-11	2024-12-05	25 days
5	Frontend Development (Phase 2)	2024-12-06	2025-01-10	36 days
6	Testing & Bug Fixing (Phase 1)	2025-01-11	2025-02-05	26 days
7	Content Population & Final Touches	2025-02-06	2025-02-25	20 days
8	Final Testing & Bug Fixing (Phase 2)	2025-02-26	2025-03-15	18 days
9	Project Completion & Documentation	2025-03-16	2025-04-20	36 days



07.Risk Analysis

Category	Risk	Description	Likelihood	Impact	Mitigation Strategy
Technical Risk	Performance and Load Issues	High traffic or complex interactive features may lead to slow load times or crashes that will impact user experience	Medium	High	Performance testing regularly, code optimization, and implementing caching techniques. Where applicable, database queries should be optimized and CDNs implemented to manage increased traffic
	Data Security and Privacy	Inaccurate tracking of user information, including progress and personal information, due to unauthorized access or data breach	Medium	High	To mitigate this, follow the best practices in data storage and encrypt sensitive data. Implement strong password policies and good session management. Periodic security audits should be conducted, and software should be kept updated with security patches
	Incompatibility Across Devices and Browsers	The platform might not perform or render appropriately on all devices and browsers, hence giving inconsistent user experiences	Medium	Medium	Responsive design will be implemented with cross-browser testing. Usage of features which are widely supported in HTML, CSS, and JavaScript
Project Management Risks	Scope Creep	Additional features or changes requested by stakeholders may inflate the project's scope and thus increase timelines and budgets	High	Medium	Clearly define the scope of the project with stakeholders in the planning phase. Leverage Agile's sprint framework to manage feature changes in a structured manner. Periodically revisit the scope of the work and adjust priorities as needed

	Timeline Overrun	Delays that were unforeseen during development or testing may result in the project running behind schedule beyond the due date	Medium	High	Make use of Agile sprint reviews to closely track progress. Mention the milestones, including buffer times in case of delay in any of them. Allow efficient task allocation and monitor the team's productivity from time to time
Operational Risks	Data Loss	Data can be lost due to system crashes, malfunctioning hardware, or may be deleted accidentally	Low	High	Automate user data and platform configuration backups daily. Regular testing of the backup and restore processes should be done to restore data in case of a failure
	Third-Party Library Dependency	The usage of third-party libraries may introduce compatibility issues or security vulnerabilities when these libraries reach their end-of-life or are not frequently updated	Medium	Medium	Making use of well-maintained libraries. Regularly check updates to see if a library is deprecated and needs replacement. Audits of dependencies for the assessment of possible library vulnerabilities
Risks to User Experience and Adoption	Poor User Engagement	students or teachers may find the platform not user-friendly or engaging enough or would not be able to adopt it fully, reducing the effectiveness of the project	Medium	High	Conduct user feedback sessions while the development is in process. This will help in including preferences and expectations. Provide an easy-to-use, intuitive interface with guides or tutorials for first-time users
	Content Accuracy and Quality	Inaccurate or ill-structured educational content would eventually mislead the learner and affect the credibility of the platform	Low	High	Set creation and review of content by subject matter experts. Give a quality review process for new content and allow frequent updates about new educational standards

Resource Risks	Team Availability and Skill Gaps	Lack of availability of team members or skill gaps in them may affect the timeline of the project	Medium	Medium	Role assignments to be done based on Individual capabilities, trainings needed in case gaps in skill sets are identified. Extra recruitment if required and flexible project timeline
	Budget Constraints	Additional resources or tools, extended timelines required may stress the project budget	Medium	Medium	Perform budget reviews on a periodic basis through the prioritization of features in terms of importance; where feasible, find economical solutions and select open-source alternatives
Legal and Compliance Risks	Non-compliance with Data Protection Regulations	Failure to comply with Data privacy regulations (such as GDPR) could lead to some serious legal consequences and erode users' trust in us	Low	High	Ensure data collection, storage, and usage policies are in line with relevant privacy standards; display a clear privacy policy and get user consent while collecting personal data. how to get this in a table

08.Stakeholders Analysis

- Purpose - Identify key stakeholders involved in the project and outline their interests, influence, and involvement.
- Key Stakeholders
    - Advanced Chemistry Students - Primary users of the website who will benefit from learning resources and tools.
    - Chemistry Professors and Educators - Experts in developing the content and validating the accuracy of the information provided.
    - IT and Development Team - These are the builders, testers, and maintainers of the website.
    - University Administrators - Those who may fund or back the project with resources and approvals.
    - Future Contributors - Those who will potentially add quizzes, tutorials and other learning resources in the future.
- Stakeholder Matrix - You may want to build out a matrix highlighting each stakeholder by title, level of influence, and frequency of communication.

09.Communication Plan

- Purpose - Offer a concentrated communication plan to keep all parties as informed and up to date as possible on the project.
- Communications
    - Weekly Status Meetings - This would involve regular meetings with the development and creation teams.
    - Bi-Weekly Progress Reports - This would be in the form of progress and update distribution to professors, administrators, and other key stakeholders.
    - Feedback Sessions - Periodic sessions with advanced students for feedback about usability and content.
    - Documentation Repository - A single-point platform like Google Drive or SharePoint where all the project documentation, requirements, and design documents are kept.
- Communication Schedule - Provide a timeline for when the various communications shall take place and list who is responsible for each type of communication.

10. Risk Management Plan

- Purpose - To identify risks that could potentially occur, determine the extent of damage, and develop ways to avoid them.
- Key Risks
    - Content Accuracy - Chemistry content erroneous; mitigated by thorough review and validation by experts.
    - Project Delays - It is possible that development phases may get delayed. Mitigation: Provide a buffer in the timeline and progress checks.
    - Technical Issues – Buggs or incompatibility of simulations and calculators. Mitigation: Rigorous testing during every stage.
- Risk Matrix - One may consider providing a matrix showing the probability, impact, and mitigation strategy for each risk.

11. Future Enhancement Plan

- Purpose - To include a set of actions for further enhancements that are beyond the scope of this current project.
- Possible Future Features
    - Quizzes and Interactive Tutorials - Students can interactively test their knowledge.
    - Resource Repository - Increase access to tutes, past papers, and video tutorials.
    - Community Forum - Provide students an opportunity to discuss and share knowledge with each other through a community section.
- How to Implement
    - After launching the beta version, gather feedback from users to identify which features should be further implemented.
    - Consider providing resources for further updates and creating more content.

The inclusion of such parts into a project plan will not only support a more systematic and reflective development but also work out several problems that might arise in the working group, which would go hand in glove with educational goals and ethical standards.

12. References

https://pubs.acs.org/doi/abs/10.1021/acs.jchemed.1c00678

https://www.rsc.org/teaching-and-learning/

https://www.researchgate.net/publication/263020242_Developing_and_Playing_Chemistry_Games_To_Learn_about_Elements_Compounds_and_the_Periodic_Table_Elemental_Periodica_Compoundica_and_Groupica

https://files.eric.ed.gov/fulltext/EJ1357304.pdf

https://pubs.rsc.org/en/content/articlepdf/2022/sc/d2sc01881k

https://pubs.rsc.org/en/content/articlelanding/2022/sc/d2sc01881k

https://www.idpublications.org/wp-content/uploads/2017/11/Full-Paper-ENHANCING-STUDENTS'-PERFORMANCE-IN-ORGANIC-CHEMISTRY.pdf

https://www.mdpi.com/2227-7102/14/5/476

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjhi-KL4tmJAxVc-jgGHVCGDOoQFnoECCwQAQ&url=https%3A%2F%2Fwww.sciepub.com%2Fportal%2Fdownloads%3Fdoi%3D10.12691%2Fwjce-12-4-1%26filename%3Dwjce-12-4-1.pdf&usg=AOvVaw0Z53JjxXWcJhPQeq6XrfUZ&opi=89978449

https://www.cedtech.net/download/technology-enhanced-learning-through-virtual-laboratories-in-chemistry-education-13739.pdf

https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2023.1197296/full

https://journal.uny.ac.id/index.php/cp/article/view/28335

https://chemguide.co.uk/

https://global.oup.com/ukhe/product/atkins-physical-chemistry-9780198847816?cc=gb&lang=en&

https://www.pearson.com/en-us/subject-catalog/p/chemistry-the-central-science/P200000006971/9780136873891

https://www.amazon.com/Chemistry-Central-Science-Theodore-Brown/dp/0134414233

https://chemistry.com.pk/free-organic-chemistry-books/

https://www.goodreads.com/book/show/17412.Chemistry

https://www.pearson.com/nl/en_NL/higher-education/subject-catalogue/chemistry/bruice-organic-chemistry-8e-ge.html

https://archive.org/details/paula-yurkanis-bruice-organic-chemistry-pearson-2017/OC%204e%20Bruice%201392p%202014/page/404/mode/2up

https://www.amazon.com/Inorganic-Chemistry-4th-Catherine-Housecroft/dp/0273742752

https://www.pearson.com/en-us/subject-catalog/p/inorganic-chemistry/P200000004498/9781292134147

https://chemistrydocs.com/chemical-distributors/

https://ibtlumhs.weebly.com/uploads/1/1/5/6/11564445/silberberg_principles_of_general_chemistry_2nd_txtbk.pdf

https://www.researchgate.net/publication/335191878_A_new_classification_scheme_for_teaching_reaction_types_in_general_chemistry