TRIBHUVAN UNIVERSITY

FACULTY OF HUMANITIES AND SOCIAL SCIENCES

LALITPUR ENGINEERING COLLEGE

LABXPLORERX: INTERACTIVE LEARNING ENVIRONMENT

BY

SUSHANT BRAMHACHARYA (LEC077BCA08)

A FINAL PROJECT REPORT

SUBMITTED TO THE DEPARTMENT OF COMPUTER APPLICATION

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR

THE DEGREE OF BACHELORS IN COMPUTER APPLICATION

DEPARTMENT OF COMPUTER APPLICATION

LALITPUR, NEPAL

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Tribhuvan University

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Submitted to

Department of Computer Application

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In partial fulfillment of the requirement for the degree of Bachelors in Computer Application

Submitted by

Sushant Bramhacharya (LEC077BCA08)

SEPTEMBER, 2024

Under the Supervision of

Er. Bibat Thokar

DECLARATION

I declare that the work hereby submitted for Bachelors in Computer Application at the Department of Computer Application , Lalitpur Engineering College entitled "**LabXplorerX: Interactive Learning Environment**" is my own work and has not been previously submitted by me at any university for any academic award. I authorize the Department of Computer Application , Lalitpur Engineering College to lend this project work to other institutions or individuals for the purpose of scholarly research.

Sushant Bramhacharya (LEC077BCA08)

September, 2024

SUPERVISOR'S RECOMMENDATION

The undersigned certify that he have read and recommend to the Department of Computer Application for acceptance, a project work entitled "**LabXplorerX: Interactive Learning Environment**", submitted by **Sushant Bramhacharya (LEC077BCA08)** in partial fulfillment of the requirement for the award of the degree of "**Bachelors in Computer Application**".

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September, 2024

Tribhuvan University

Faculty of Humanities and Social Sciences

Lalitpur Engineering College

LETTER OF APPROVAL

This is to certify that this project prepared by Sushant Bramhacharya entitled "**LabXplorerX: Interactive Learning Environment**" in partial fulfillment of the requirements for the degree of Bachelor in Computer Application has been evaluated. In our opinion it is satisfactory in the scope and quality as a project for the required degree.

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DEPARTMENTAL ACCEPTANCE

The project work entitled "**LabXplorerX: Interactive Learning Environment**", submitted by **Sushant Bramhacharya (LEC077BCA08)** in partial fulfillment of the requirement for the award of the degree of "**Bachelors of Computer Application**" has been accepted as a genuine record of work independently carried out by the student in the department.

Er. Bibat Thokar
BCA Coordinator
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September, 2024

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I am also grateful to my classmates and friends for offering me advice and moral support. To my family, thank you for encouraging me in all of my pursuits and inspiring me to follow my dreams. I am especially grateful to my parents, who supported me emotionally, believed in me and wanted the best for me.

Sushant Bramhacharya (LEC077BCA08)

September, 2024

ABSTRACT

LabXplorerX is an innovative web application that will be developed using React, Express, and Postgres, designed to provide interactive learning community . This platform offers a user-friendly interface where students can conduct various simulation, read science related content, perform quizes, track their progress. By leveraging real-time, visually engaging simulations powered by Phaser.js and Unity 3D, LabXplorerX enhances students' understanding of scientific concepts through hands-on learning. The platform also supports collaboration and knowledge sharing via integrated discussions and quizes, fostering a community of inquisitive learners. Comprehensive feasibility studies, addressing technical, operational, and economic aspects, along with detailed system design diagrams, ensure the platform's robustness and scalability. Utilizing the latest web-platform development technologies, LabXplorerX delivers a responsive and efficient user experience. Rigorous unit testing, particularly on the authentication module, ensures security and reliability, making LabXplorerX a dynamic, effective, and engaging tool for modern science education.

Keywords: *Interactive, Collaboration, Simulation*

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LIST OF ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
ACID	Atomicity, Consistency, Isolation, Durability
API	Application Programming Interface
CSS	Cascading Style Sheet
DFD	Data Flow Diagram
DOM	Document Object Model
ER	Entity-Relationship
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
I/O	Input Output
IT	Information Technology
JS	JavaScript
JSON	JavaScript Object Notation
JSX	JavaScript XML
JWT	JSON Web Token
OS	Operating System
RAD	Rapid Application Development
REST	Representational State Transfer
SQL	Structured Query Language
STEM	Science Technology Engineering Mathematics
UI	User Interface
UX	User Experience
WebGL	Web Graphics Library
XML	Extensible Markup Language

1 INTRODUCTION

1.1 Introduction

LabXplorerX is revolutionizing science education by providing an innovative interactive learning platform designed to transcend traditional learning methods. Specifically tailored for students and educators in STEM fields, LabXplorerX aims to bridge gaps in practical science education by offering interactive simulations across diverse disciplines. This cutting-edge platform serves as a dedicated arena where scientific concepts can be engaged with deeply, virtual simulations can be conducted, can be visualized, and seamless collaboration can be achieved within the academic commLabXplorerX addresses critical gaps in science education by providing a dedicated platform specifically designed for simulations tailored to students in grades 7, 8, and 9. Unlike general educational platforms that lack interactive simulation components, LabXplorerX offers specialized modules such as Basic Electronics Simulations, Basic Chemistry Simulations, Basic Astronomy Simulations, and a Basic Online Coding Environment with animations. This targeted approach allows students to gain hands-on experience and apply theoretical knowledge in practical settings, thereby enhancing their understanding and retention of scientific concepts.

For educators, LabXplorerX provides tools to conduct simulations, create study capsules, assign quizzes to capsules, and facilitate collaborative learning through discussions.unity.

1.2 Problem Statement

LabXplorerX addresses critical gaps in science education by providing a dedicated platform specifically designed for virtual laboratory simulations for students of grades 7, 8, and 9. Unlike general educational platforms that lack interactive simulation components, LabXplorerX offers tailored modules such as Basic Electronics Simulations, Basic Chemistry Simulations, Basic Astronomy Simulations, and a Basic Online Coding Environment with animations. This specialized approach enables students to gain hands-on experience and apply theoretical knowledge in practical settings, enhancing their understanding and retention of scientific concepts.

For educators, LabXplorerX provides tools to perform simulations, create studying capsules, assign quizes to capsules, and facilitate collaborative learning through a discussion.

1.3 Objectives

- Create an interactive learning platform for students from Grade 7,8,9 that enhances STEM education through inter-active simulations aweb various disciplines.

1.4 Scope

- The platform should provide a virtual space for students and educators to conduct interactive simulations and promote simulating learning.
- LabXplorerX facilitates collaborative learning through comments, enabling students to share insights and ask questions.
- The platform should be user-friendly and accessible, making it easy for students to engage in.
- LabXplorerX includes learning capsules where students can gain in-depth knowledge and understanding of various scientific concepts.

1.5 Limitation

- The creation of simulations is restricted to developers, as users and super users do not have the capability to create new simulations.
- The platform lacks mobile responsiveness for simulations, which limits accessibility and usability of simulations on mobile devices.

1.6 Development methodology

FFor the development of LabXplorerX, the Rapid Application Development (RAD) methodology is employed. This approach emphasizes iterative development and continuous user feedback rather than rigid planning. By engaging a diverse range of stakeholders, including friends, family, and esteemed faculty members from the Department of Computer Application, valuable insights on usability and functionality are gathered. This engagement allows for practical feedback from potential end-users and expert advice on educational and technological standards. As a result, LabXplorerX evolves in response to real user needs and academic requirements, ensuring the development of a more effective and user-centric platform for science education.

This iterative process ensures that LabXplorerX evolves in response to real user needs and academic requirements, resulting in a more effective and user-centric platform for science education.

1.7 Report Organisation

The material in this project report is organised into Six chapters. After this introductory chapter introduces the problem topic this project tries to address, chapter 2 contains the literature review of vital and relevant publications, pointing toward a notable project related infromations. Chapter 3 describes the Designs and Analysis of the System for the implementation of this project and models and methods. Chapter 4 provides an overview of Implementation tools, modules used and testing performed in certain unit. Chapter 5 Lesson Learn with outcomes including future recommendations. After Main Report contains have Appendix A that contains Gantt Chart and Supervisor Consultation form. Last one contains Referneces.

2 BACKGROUND AND LITERATURE REVIEW

2.1 Background Study

Traditional science education, dependent on textbooks, lectures, and physical labs, often faces limitations due to resource constraints, high costs, and safety issues. These challenges are especially evident in under-resourced schools, where practical scientific experiences are limited. LabXplorerX addresses these issues by offering an innovative platform with interactive simulations in chemistry, physics, electronics, and astronomy. It provides a virtual space for conducting experiments, visualizing data, and engaging with scientific concepts, aiming to enhance traditional learning methods.

Additionally, LabXplorerX includes learning capsules, which function like blogs where users can access quizzes, share PDFs, and resources. This feature supports a more comprehensive and interactive learning experience, bridging gaps in practical science education and setting a new standard for STEM learning.

2.2 Literature Review

Teacher perception of Olabs pedagogy

OLabs, as name says, offers a robust web-based platform encompassing simulations, animations, tutorials, and assessments, designed to enhance interactive and accessible learning experiences outside traditional laboratory settings. Emphasizing student-centered learning, inquiry-based approaches foster essential skills such as scientific thinking, evidence-based reasoning, and creative problem-solving, which are fundamental for knowledge creation and retention.[1]

How Khan Academy is changing the rules of education

This paper briefly describes how can an online learning platfrom change the way our education system worka and improve on it.

- Khan Academy offers free, online instructional videos covering various subjects, allowing students to learn at their own pace and revisit concepts.
- The platform uses analytics to provide real-time feedback, enhancing personalized

learning experiences for both teachers and students.

- Khan Academy promotes a flipped classroom model where students watch videos at home and engage in problem-solving and discussions in class, fostering deeper understanding and collaboration.
- It democratizes education by providing high-quality instruction globally, irrespective of geographic location or socioeconomic status.
- The platform challenges traditional educational paradigms and suggests new possibilities for delivering effective education in the digital era.

Khan Acadamy being one of the main motivation for onile learning and educating. [2]

PhET: Interactive simulations for teaching and learning physics

Perkins et al. (2006) introduce PhET, a collection of interactive simulations designed to enhance the teaching and learning of physics. These simulations aim to make abstract concepts more accessible and understandable through dynamic visualizations and interactive models. The authors emphasize the effectiveness of PhET in promoting conceptual understanding by allowing students to manipulate variables and observe real-time outcomes, thereby bridging the gap between theoretical concepts and practical application. They discuss the development process, which involves collaboration between physicists, educators, and software developers to ensure accuracy and educational efficacy. The article highlights PhET's versatility in catering to diverse learning styles and educational settings, promoting active learning and engagement. [3]

An Introduction to HTML5 Game Development with Phaser.js

It provides a comprehensive guide to creating 2D games using the Phaser.js framework. It covers setting up a development environment, understanding fundamental game concepts, and managing game states and assets. The book teaches how to implement physics and collision detection, create animations and visual effects, design user interfaces, and integrate audio. It emphasizes practical, project-based learning, guiding readers through real game

development scenarios. Additionally, it offers debugging, optimization techniques, and deployment strategies for various platforms, making it an essential resource for both beginners and experienced developers looking to master HTML5 game development with Phaser.js.[4]

3 SYSTEM ANALYSIS AND DESIGN

3.1 System Analysis

The project is following a structured approach that utilizes the Rapid Application Development (RAD) methodology. This approach segments the project into smaller, manageable components, allowing for incremental progress through iterative development. Individual modules are developed and integrated progressively, focusing on delivering and refining smaller segments. This method ensures continuous improvement and alignment with the overall goals while effectively managing the project through ongoing feedback and adjustments.

3.1.1 Requirement Analysis

Requirement analysis is a critical phase in the software development lifecycle that focuses on understanding and documenting the needs and expectations of stakeholders. This process involves gathering detailed information about what users require from a system, which includes identifying functional requirements (what the system should do), non-functional requirements (how the system should perform), and constraints (limitations or restrictions). The goal is to create a comprehensive and clear specification that guides the development team in designing and implementing the system. Effective requirement analysis ensures that the final product aligns with user needs and business objectives, reduces the risk of project failure, and facilitates efficient communication among stakeholders. By thoroughly analyzing requirements, teams can address potential issues early, prioritize features, and ensure a smoother development process.

3.1.1.1 Functional Requirements

The functional requirements of LabXplorerX are mentioned below:

- **User Profiles and Progress Tracking:** LabXplorerX enables children and teachers to create personalized profiles for tracking their learning progress and achievements. Users can log in with unique credentials, update their profiles with educational interests and avatars, and monitor their completion of simulations and quizzes. The

progress tracking feature records tasks completed, concepts learned, and achievements unlocked, offering a comprehensive view of individual learning journeys and performance over time.

- **Interactive Virtual Simulations:** LabXplorerX offers a range of interactive virtual simulations, including Basic Electronics, Basic Chemistry, Basic Astronomy, and an Online Coding Environment. These simulations provide immersive experiences where users can engage in hands-on activities, such as manipulating virtual equipment and conducting experiments. By integrating interactive animations and real-world scenarios, LabXplorerX facilitates experiential learning, allowing users to explore scientific principles and phenomena in a dynamic digital environment.

- **Capsule Tools:** Creators are equipped with specialized tools to create and manage educational capsules and assign tasks to students. They can design experiment capsules with sequential steps, interactive quizzes, and checkpoints to assess student progress. Teachers review completed assignments, provide feedback, and evaluate learning outcomes, ensuring that learning experiences are tailored to individual needs. Learning capsules, similar to capsules or blog entries, provide focused content and insights on specific topics, allowing for an organized and structured approach to content delivery and knowledge reinforcement.

- **Discussion section for Learning Capsules:** LabXplorerX includes a discussion section that promotes collaborative learning and knowledge sharing. Both students and teachers can start discussions, ask questions, share insights, and respond to others' posts. The section supports threaded discussions, tagging, and search functionalities, fostering meaningful interactions and peer engagement within the learning community.

- **Quizzes and Learning Capsules:** LabXplorerX integrates quizzes and learning capsules to reinforce knowledge and assess comprehension. Quizzes are designed to evaluate understanding of concepts covered in simulations, while learning capsules provide bite-sized, focused content on specific topics. These features help consolidate learning and provide instant feedback.

- **Admin Dashboard:** The admin dashboard in LabXplorerX offers a centralized interface for managing user accounts, monitoring platform usage, and overseeing

system performance. Administrators can access detailed analytics, configure system settings, and manage content to ensure smooth operation and address any issues that arise.

3.1.1.2 Nonfunctional Requirements

The nonfunctional requirements of LabXplorerX are mentioned below:

- **Performance Enhancement:** The focus on performance involves optimizing the platform to handle high user loads and complex simulations efficiently. This includes minimizing reliance on external frameworks and ensuring smooth and responsive interactions.
- **Authentication Security:** Security is a paramount concern. To enhance the platform's security, advanced authentication algorithms, particularly focusing on hashing techniques within the backend environment, have been implemented. This ensures that user authentication data is stored and managed in a highly secure manner.
- **Better UX Design:** User experience is central to the project's success. The emphasis on better UX design means that every aspect of the platform's interface, from navigation to interaction, will be meticulously crafted to ensure a seamless and intuitive experience. This design approach caters not only to experienced users but also to newcomers, ensuring that all users can effortlessly navigate and engage with the platform.
- **Responsive Design:** Recognizing the diverse range of devices and browsers that users utilize, the creation of a responsive design is important for this project. This means that the platform's design and functionality will adapt flawlessly to various screen sizes, ensuring that users can access and interact with the platform effectively, whether they are using a desktop computer, tablet, or smartphone. This responsiveness guarantees a consistent and satisfying experience aweb different devices and platforms, promoting accessibility and usability.

3.2 Feasibility Analysis

A feasibility study is a systematic and structured analysis conducted to determine the viability and practicality of a proposed project plan. It serves as an evaluation tool to assess whether the project can be successfully implemented and if it aligns with the organization's goals and objectives. It involves gathering and analyzing relevant information to determine if the project is technically feasible, operationally feasible, economically feasible, and scheduling feasible.

3.2.1 Economical Feasibility

The development of the web application will utilize a range of free and open-source software development tools. For the frontend, React, a popular JavaScript library for building dynamic and interactive user interfaces, will be used. On the backend, Express, a minimal and flexible Node.js web application framework, will handle server-side logic and HTTP requests. PostgreSQL, an open-source relational database management system known for its reliability and performance, will be employed for database management. Interactive simulations will be created using Phaser, a robust HTML5 game framework, while Unity, a powerful cross-platform game engine, will be used for more complex simulations and 3D elements. Additionally, funds will be allocated for economical server hosting to ensure the application remains accessible to users while managing costs effectively.

3.2.2 Operational Feasibility

LabXplorerX prioritizes operational feasibility through a user-centric design approach, emphasizing simplicity and ease of use. The system is highly interactive, enabling both students and educators to navigate effortlessly without requiring extensive technical knowledge. The user interface (UI) features a clean layout and intuitive controls, ensuring a seamless experience when accessing virtual environments and educational resources. By minimizing the need for extensive training and reducing potential barriers to adoption, LabXplorerX enhances user acceptance and engagement. The straightforward design promotes effective use of the app's features, supports educational activities, and fosters a positive user experience.

3.2.3 Technical Feasibility

Combining Express.js with React and PostgreSQL offers a robust and scalable solution for developing modern applications. Express.js, built on Node.js, provides an efficient backend framework for creating RESTful APIs and managing server-side logic. PostgreSQL, known for its reliability and advanced data management features, serves as a solid foundation for secure and efficient data storage and querying. On the frontend, React facilitates the creation of responsive and visually appealing applications across multiple platforms using a single codebase. This stack leverages the strengths of each technology: Express.js for backend scalability and API development, PostgreSQL for comprehensive data handling, and React for seamless and dynamic UI development. Supported by active communities and extensive documentation, this combination ensures ample technical support, resources, and flexibility for both deployment and maintenance, making it an ideal choice for delivering modern, interactive applications.

3.3 Structured System Modelling

Structured system modeling is a methodical approach used to design complex systems by decomposing them into manageable components and utilizing formal diagrams and tools. This approach aids in clearly defining system requirements, workflows, and interactions. By breaking down a system into its constituent parts, structured system modeling facilitates a thorough understanding of its structure and behavior. The use of formal diagrams and tools ensures that all aspects of the system are documented and analyzed systematically, which enhances clarity, communication, and accuracy throughout the design process. This methodical approach supports the creation of well-organized and efficient systems, improving overall design quality and project outcomes.

3.3.1 Process Modeling: DFD

Processing Modeling Data Flow Diagrams (DFDs) visually represent the flow of data within a system, showing how inputs are processed into outputs. They help in understanding the system's functionality and data movement, aiding in the design and analysis of processes.

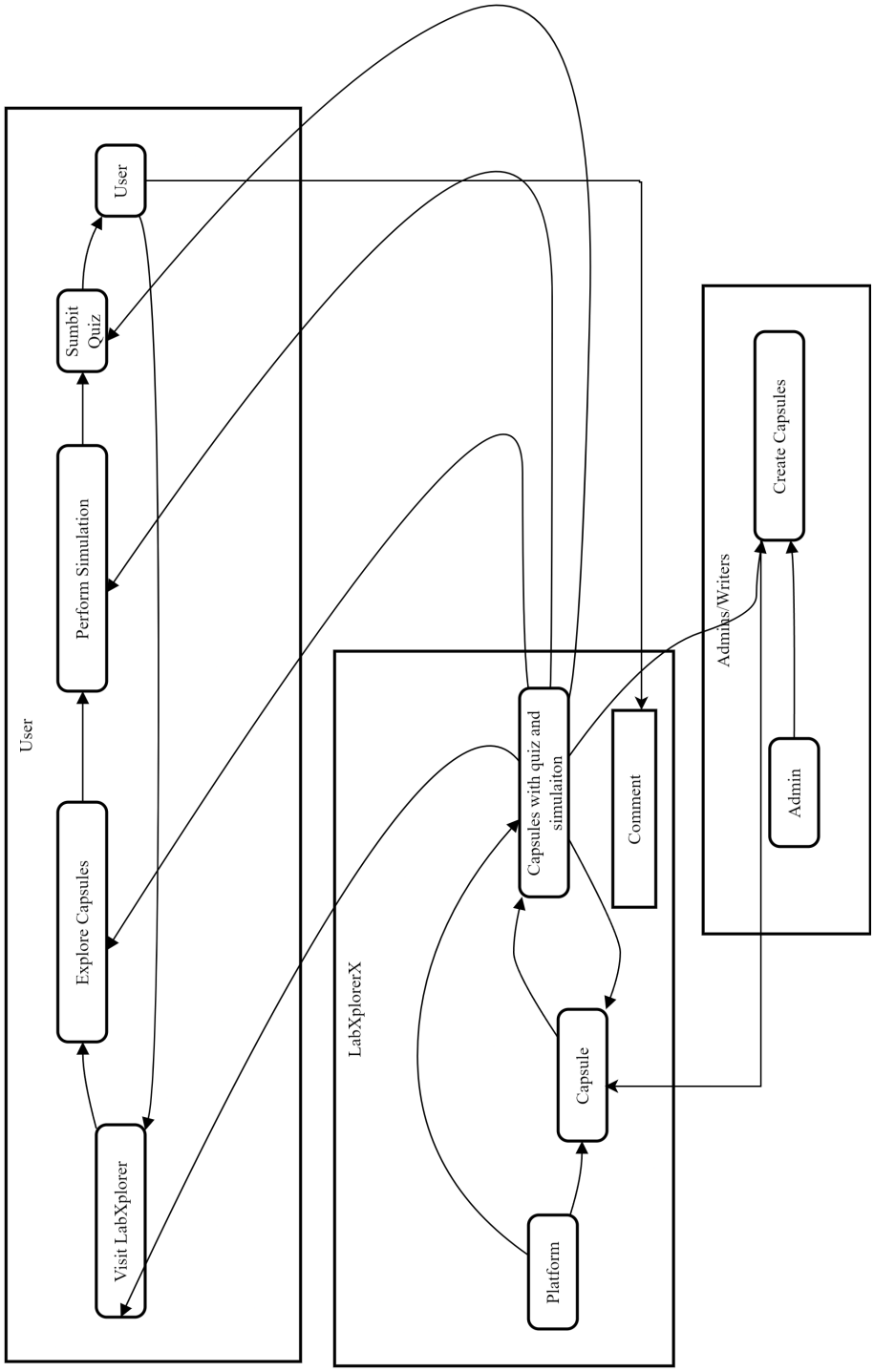


Figure 3.1: Process Model: Logical DFD

3.3.2 Data Modelling(ER-Diagram)

The Entity-Relationship (ER) Diagram is primarily used to design a database schema. The ER diagram provided below facilitates the creation of a database in SQL by clearly illustrating the entities, their attributes, and the relationships between them. This visual representation helps in structuring the database effectively, ensuring that all necessary data elements and their interconnections are accounted for.

Entities and Attributes

- **Users**
  - `id`: Unique identifier for the user.
  - `username`: The name of the user.
  - `email`: Email of the user.
  - `password`: Password for user authentication.
  - `email_verification_token`: Token to verify the email.
  - `email_verified`: Status indicating whether the user's email is verified.
- **Capsules**
  - `id`: Unique identifier for the capsule.
  - `title`: Title of the capsule.
  - `description`: Description of the capsule.
  - `thumbnail`: Image representing the capsule.
  - `images`: Additional images related to the capsule.
  - `pdf`: PDF documents associated with the capsule.
  - `category`: The category to which the capsule belongs.
  - `author_id`: Reference to the user who created the capsule.
- **Simulations**
  - `id`: Unique identifier for the simulation.
  - `title`: Title of the simulation.

  - `description`: Description of the simulation.
  - `link`: URL or reference to the simulation.
  - `category`: The category of the simulation.

- **Comments**
  - `comment_id`: Unique identifier for the comment.
  - `comment_text`: The text of the comment.
  - `user_id`: Reference to the user who made the comment.
  - `capsule_id`: Reference to the capsule that was commented on.

- **Quiz**
  - `quiz_id`: Unique identifier for the quiz.
  - `title`: Title of the quiz.
  - `category`: The category of the quiz.
  - `capsule_id`: Reference to the capsule related to the quiz.

- **Options**
  - `option_id`: Unique identifier for the option.
  - `option_text`: Text of the quiz option.
  - `is_correct`: Boolean indicating if the option is correct.
  - `quiz_id`: Reference to the quiz.

- **Favorites**
  - `user_id`: Reference to the user.
  - `capsule_id`: Reference to the capsule marked as a favorite.

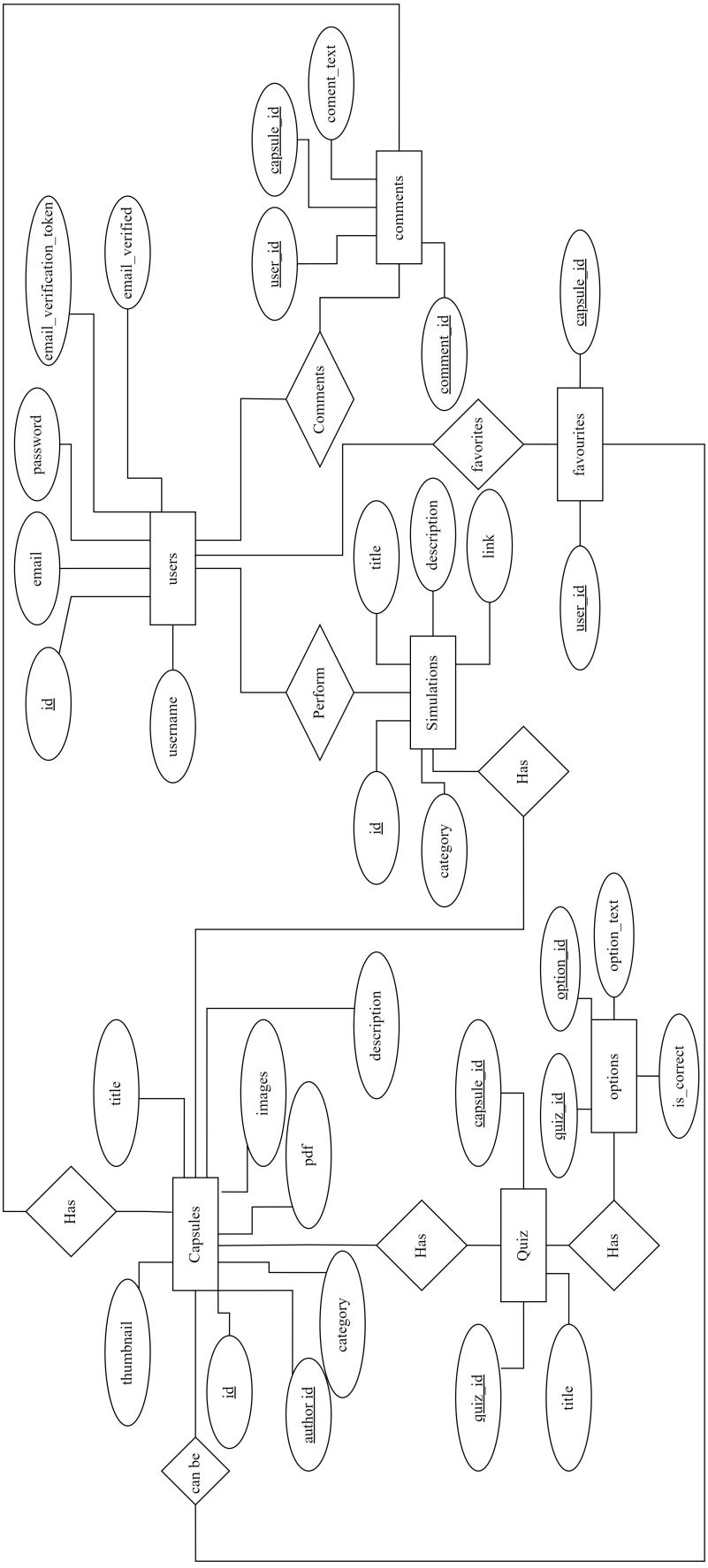


Figure 3.2: ER Diagram of System Data

3.4 Structured System Design

3.4.1 Architecture Design

The following diagram illustrates the architecture of our application. The application is structured using a three-tier architecture to ensure a clear separation of concerns and efficient functionality. The Presentation Layer, built with React.js, manages the user interface and user interactions. The Business Logic Layer, developed with Node.js and Express, handles core operations through middleware, routes, models, controllers, and utilities. Finally, the Data Management Layer uses PostgreSQL for relational database management and local server storage for handling files.

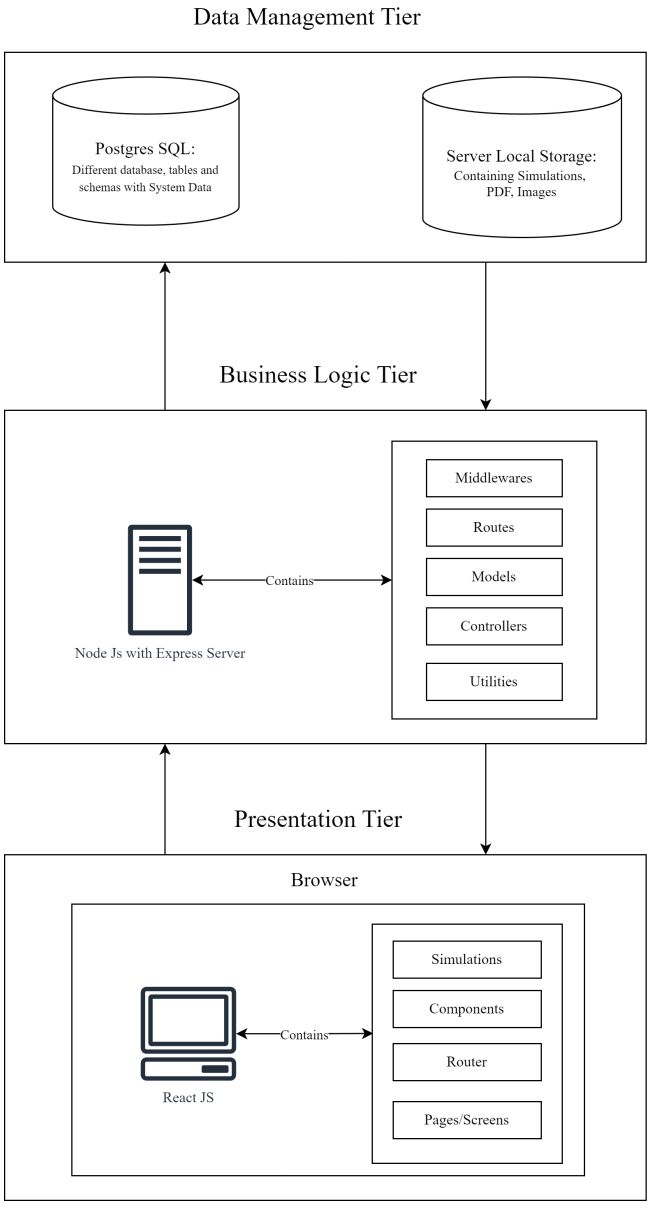


Figure 3.3: Three Tier Architecture of System

3.4.2 Database Schema Design

The schema design details the tables, their attributes, and the relationships between them, ensuring that data is stored efficiently and consistently. This design includes defining primary keys to uniquely identify records, foreign keys to establish relationships between tables, and constraints to maintain data integrity. The schema design provides a clear blueprint for creating and managing the database, supporting effective data organization and retrieval as per the application's requirements.

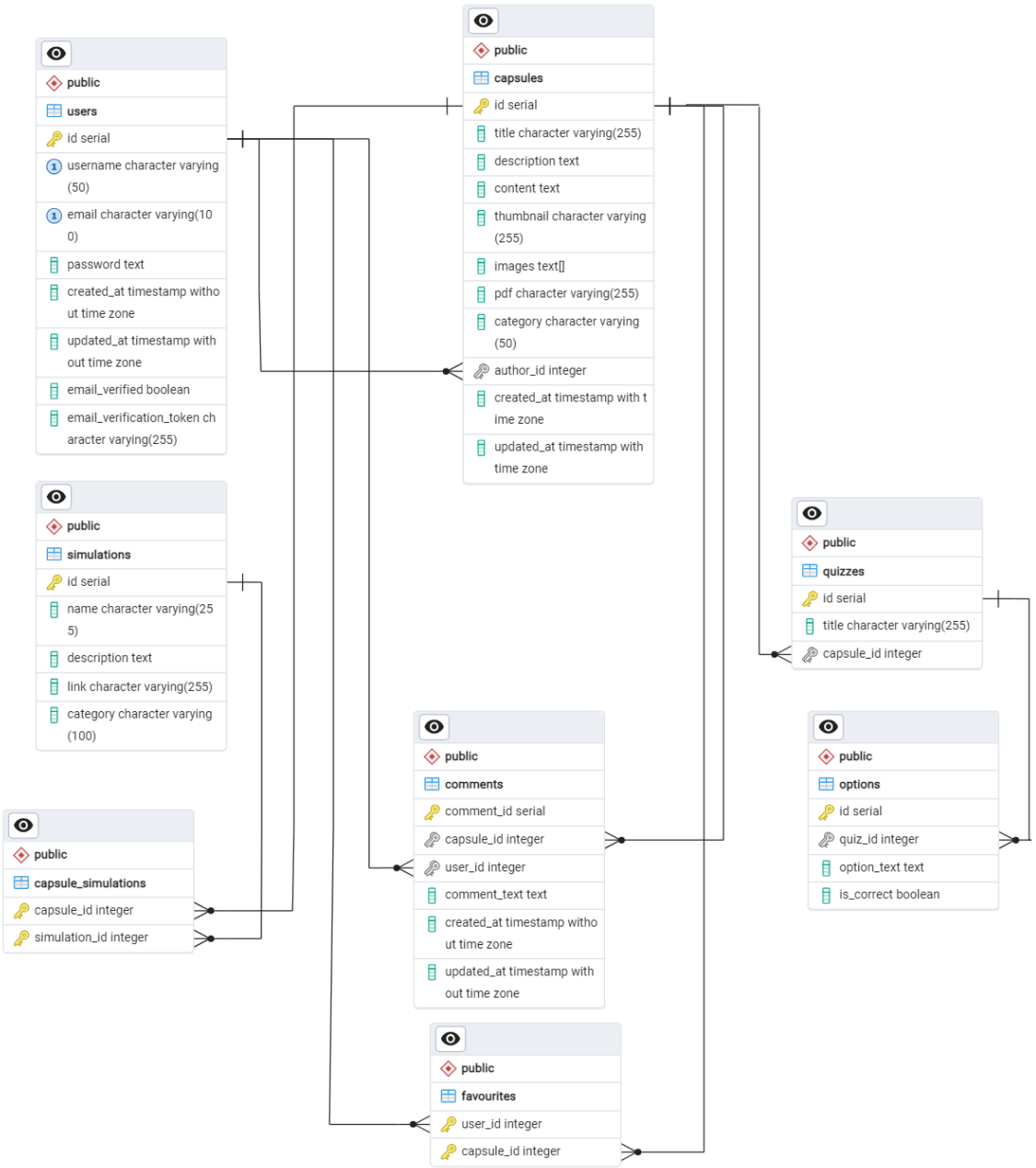


Figure 3.4: Schema Design

3.4.3 Interface Design

Here are the UI/UX Designs created for this project:

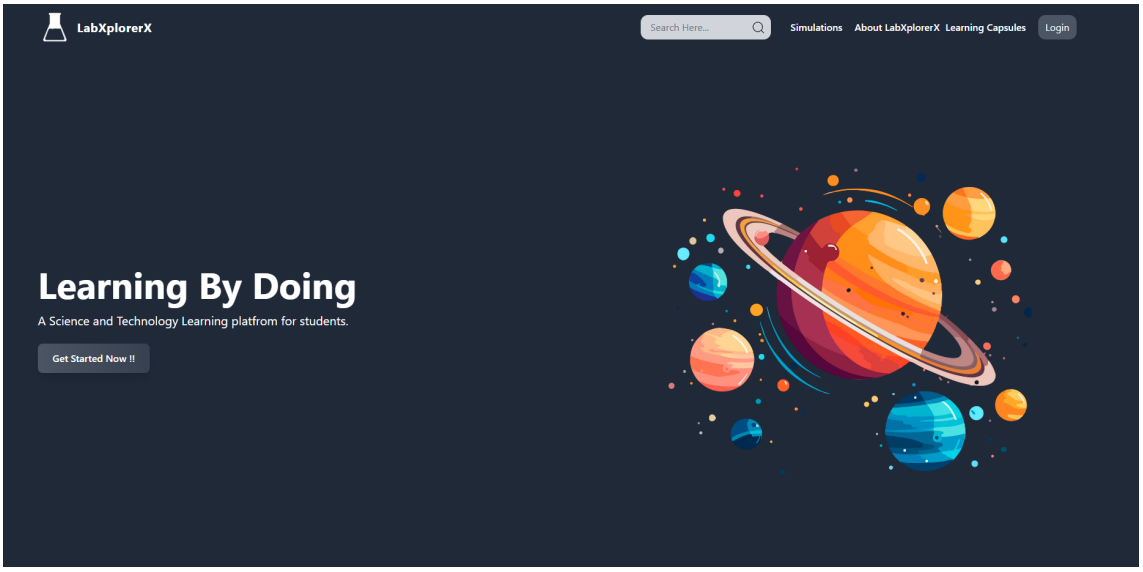


Figure 3.5: Home Screen UI Design

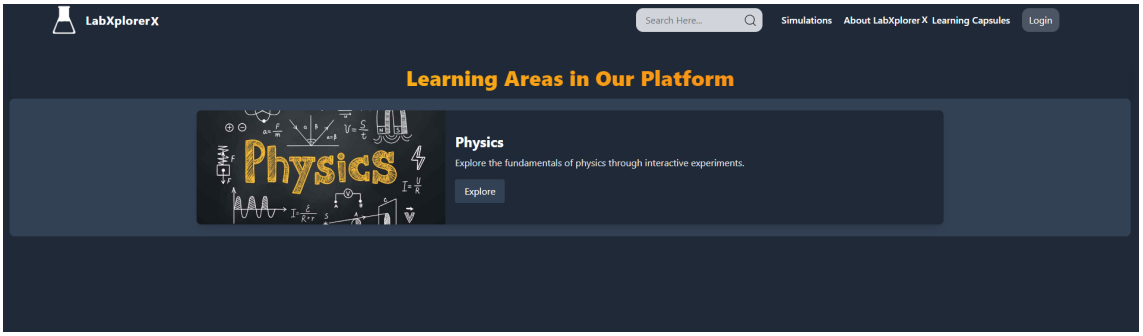


Figure 3.6: Capsule Category UI Design

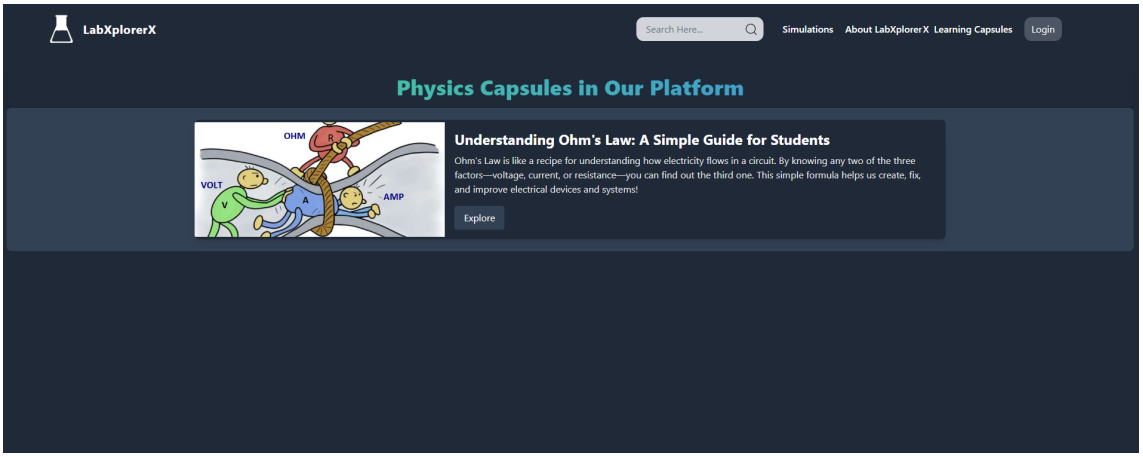


Figure 3.7: Capsules Menu Design

3.4.4 Physical DFD

This Physical Data Flow Diagram (DFD) outlines the architecture of a web application with a clear separation of frontend and backend components. On the backend, Express (Node.js) handles the server-side logic, with middleware for authentication and error handling, routes for user, admin, and capsules, asynchronous controllers for managing requests, and a PostgreSQL database for storing data. Static files, including Unity simulations, are served from the backend. The frontend is built with React.js, utilizing React Router for navigation and RTK slices and APIs for state management. Screens and UI components, along with Phaser simulations, allow users to interact with backend data and display both static and dynamic simulations. The central store handles state management locally across components.

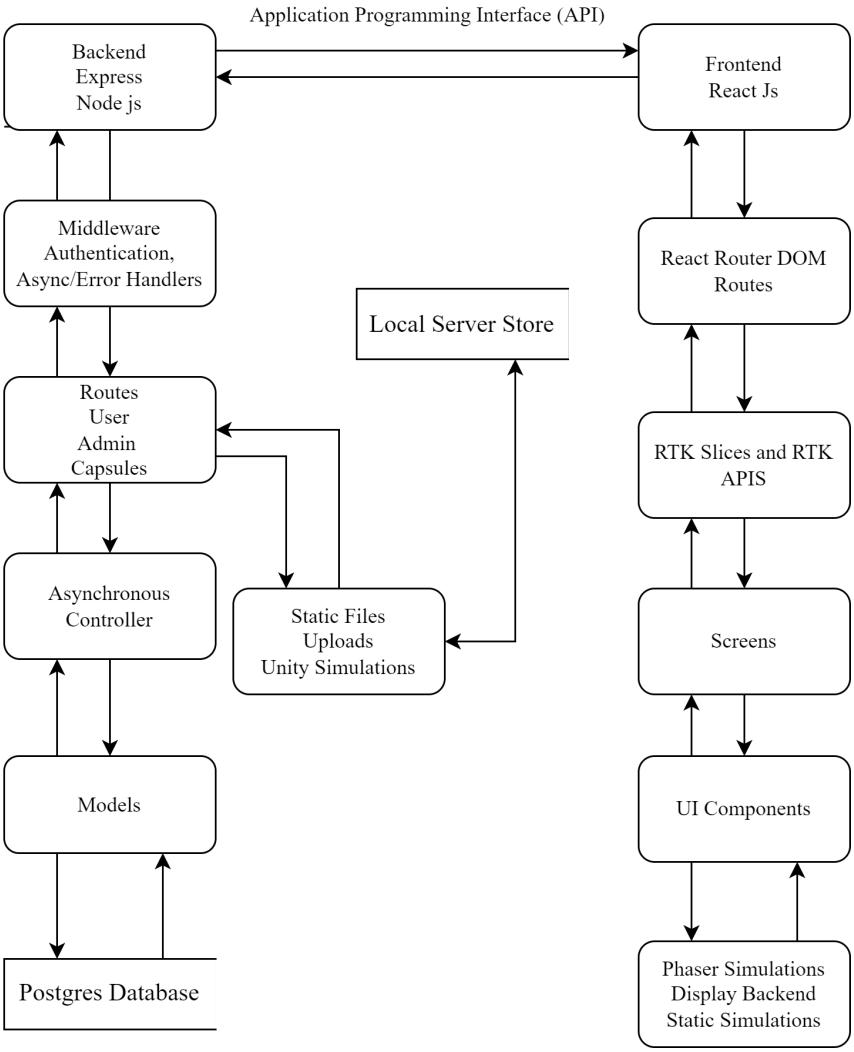


Figure 3.8: Process Modelling

4 IMPLEMENTATION

4.1 Tools Used

Figma

Figma is a cloud-based design and prototyping tool that empowers teams to collaborate on UI/UX design projects in real-time. It offers a user-friendly interface and powerful features that make it a popular choice among designers. With Figma, designers can create and share interactive prototypes, design components, and design systems. Its cloud-based nature allows for seamless collaboration, enabling multiple team members to work on the same design simultaneously. Figma supports version control, ensuring that design iterations can be easily tracked and managed.

React

React is a widely-used open-source JavaScript library developed by Facebook for building user interfaces, particularly single-page applications where data changes frequently. It emphasizes a component-based architecture, allowing developers to create reusable UI components that encapsulate their own structure, logic, and styling. React's use of a virtual DOM enhances performance by minimizing direct updates to the real DOM, ensuring efficient rendering. With its declarative approach, developers specify what the UI should look like based on different states, making the code more predictable and easier to debug. Additionally, React introduces JSX, a syntax extension that combines JavaScript and HTML, making it straightforward to write and understand UI components.

Postgres

PostgreSQL, often referred to simply as Postgres, is a powerful open-source relational database management system known for its reliability, robustness, and extensibility. Developed over decades and maintained by a global community of contributors, PostgreSQL offers a comprehensive set of features for managing structured data. It supports complex queries, transactions with ACID (Atomicity, Consistency, Isolation, Durability) properties, and a wide range of data types including JSON, XML, and spatial data. PostgreSQL's commitment to standards compliance and continuous improvement ensures compatibility with various programming languages and frameworks. With capabilities for scalability, data integrity, and advanced indexing, PostgreSQL is a preferred choice for applications requiring robust data management and high availability, contributing to its widespread adoption aweb industries from small startups to large enterprises.

Git/Github

Git is a distributed version control system that is both free and open-source, designed to handle projects of all sizes efficiently and swiftly. It simplifies collaboration by enabling multiple individuals to contribute changes that can be seamlessly merged into a single source. When using Git, the software runs locally on your computer, storing your files and their complete history. Alternatively, you can utilize online hosts like GitHub to store a copy of your files and their revision history. This central repository allows you to easily upload your changes and download updates from other developers, promoting seamless collaboration. Git facilitates automatic merging of changes, allowing multiple individuals to work on different sections of the same file and later merge their modifications without losing any work.

Node Js with Express

Node.js with Express.js is a powerful combination for building scalable and efficient web applications. Node.js provides a runtime environment that allows JavaScript to be executed server-side, leveraging its event-driven, non-blocking I/O model to handle multiple concurrent connections efficiently. Express.js, as a minimalist web framework for Node.js, simplifies the creation of APIs and routes, offering robust features such as middleware support, routing, and template engines. Together, Node.js and Express.js enable rapid development of RESTful APIs and web servers, making them well-suited for creating real-time applications, microservices, and backend systems. With a vibrant ecosystem of libraries and active community support, Node.js with Express.js remains a popular choice for developers seeking flexibility, performance, and scalability in web application development.

JavaScript

JavaScript is a programming language that is used to create interactive web pages and backend server. It is a powerful and versatile language that can be used to do a wide variety of things, including adding animation and interactivity to web pages, validating form data, processing user input, making Ajax requests to the server, and creating games and other interactive applications.

Phaser

Phaser is a powerful and popular open-source HTML5 game framework designed for creating 2D games that can run in both web browsers and mobile environments. Developed by Photon Storm, Phaser is known for its versatility and ease of use, making it a favorite among both beginner and experienced game developers. The framework supports Canvas and

WebGL rendering, automatically selecting the best option based on the device's capabilities. Phaser offers a robust set of features including physics engines (Arcade Physics, P2 Physics, and Matter.js), input handling, asset management, animations, and audio integration. Its component-based architecture allows developers to build complex games by combining reusable pieces of code, enhancing modularity and maintainability. With an active community, extensive documentation, and numerous tutorials, Phaser provides ample resources for learning and development, empowering creators to bring their game ideas to life efficiently.

Postman

Postman is a widely-used collaboration platform for API development, enabling developers to design, test, document, and monitor APIs with ease. Originally starting as a simple Chrome extension, Postman has evolved into a comprehensive tool that supports the entire API lifecycle. Its intuitive interface allows developers to construct and send HTTP requests to interact with APIs, receiving detailed responses to inspect and debug.

Unity 3D

Unity 3D is a leading game development platform renowned for its ability to create both 2D and 3D interactive experiences across a wide range of platforms, including consoles, mobile devices, and VR/AR environments. Developed by Unity Technologies, the engine offers a comprehensive suite of tools that cater to every aspect of game development, from design and prototyping to final deployment. Unity's real-time rendering capabilities, coupled with its powerful physics engine, allow developers to create highly immersive and visually stunning games. The engine's support for WebGL enables developers to deploy their games directly to the web, providing browser-based experiences without the need for plugins. WebGL in Unity leverages the engine's advanced rendering capabilities, allowing developers to create complex 3D environments that run smoothly in any modern browser. This makes Unity a versatile tool not only for traditional game development but also for creating interactive web applications.

4.1.1 Implementation Details of Modules

This subsection outlines the implementation specifics for each module, detailing the core functionalities and algorithms utilized. It covers the programming languages, frameworks,

and tools used in development, along with the interaction and communication between modules. Key design patterns, data management strategies, and error-handling mechanisms are discussed to ensure optimal performance. Additionally, security measures and optimizations applied during implementation are highlighted.

User Registration Module

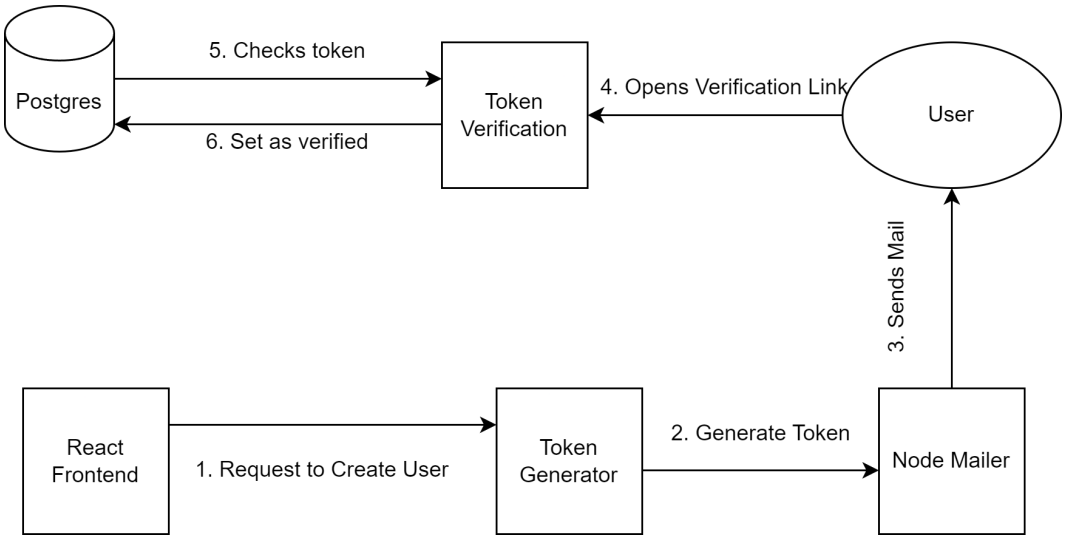


Figure 4.1: Registration Module

Authentication Module

The Authentication Module utilizes JSON Web Tokens (JWT) for secure user authentication. JWTs are compact, URL-safe tokens that encode user information, including a signature to verify the token's integrity. After a successful login, a JWT is generated and stored in an HTTP-only cookie, preventing unauthorized access via client-side scripts. The module also includes bcrypt hashing for securely storing user credentials and authentication middleware that checks the validity of the JWT on each request, ensuring only authenticated users can access protected resources.

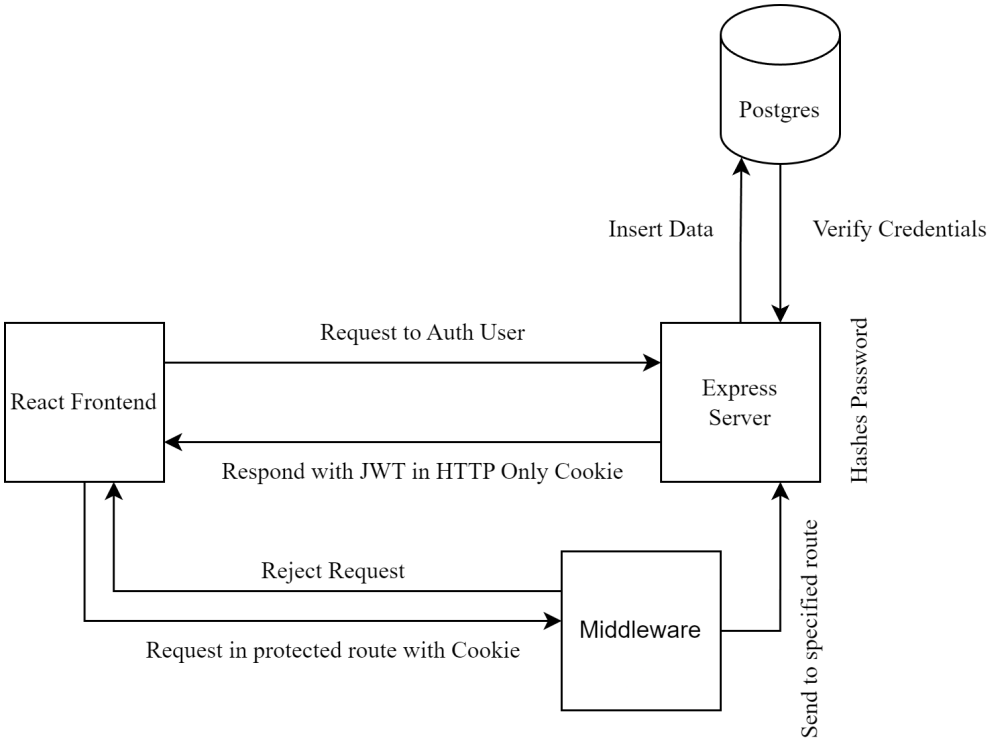


Figure 4.2: Authentication Module

4.1.2 Unit Testing Test Cases

Theses API unit testing are performed using Postman. API unit testing using Postman involves creating and sending requests to API endpoints to ensure they function correctly. You can write test scripts in Postman to validate responses against expected outcomes, such as status codes and response content. Postman also allows for automating tests using the Collection Runner and Newman for continuous integration and delivery.

Table 4.1: Express Endpoint Testing: Capsules GET Methods

Test No.	**Test Case**	**Endpoint**	**Output**
1	Getting Capsules By Category	`/api/capsule/category?category =physics`	Returns JSON response with Array of Objects with specific category
2	Getting Capsules By Id	`/api/capsule/?capsuleId=1`	Returns JSON response with Object of Capsules with specific id
3	Getting All Capsules	`/api/capsule/all`	Returns JSON response with Array of Objects of Capsules

Table 4.2: Express Endpoint Testing: Capsules GET Methods

Test No.	**Test Case**	**Endpoint**	**Output**
1	Login user/admin endpoint	`/api/user/login` `body: Username and Password`	Creates JWT token and sets an HTTP Only Cookie to the client side
2	api/user/register	`/api/capsule/category?category =physics`	Returns JSON response with Array of Objects with id

Table 4.3: Express Endpoint Testing: User Methods

Test No.	**Test Case**	**Endpoint**	**Output**
1	Admin add capsule endpoint	`api/admin/add` `body:capsule informations and images`	Sucessfully adds images in uploads folder and corresponding capsule into database

4.1.3 Test Cases for System Testing

The objective of System Testing is to conduct a comprehensive evaluation of the entire PERN application, encompassing both frontend and backend components. This testing phase aims to validate the correct and cohesive functioning of all integrated parts of the system.

Table 4.4: System/Application Testing: Capsules GET Methods

Test No.	**Test Case**	**Input**	**Output**
1	Acessing Specific Capsules By Id	`/capsule/8`	Shows whole capsule its images, pdf and all its meta information with quiz
2	Acessing Capsules Menu By Category	`/capsules/physics`	Shows cards, thumbnail, title, description and buttons about related category capsules
3	Getting All Capsules	`/learning-area`	Shows Learning Capsules with categories of each capsules

Table 4.5: System/Application Testing: Login

Test No.	**Test Case**	**Input**	**Output**
1	Login User	`/login` `Input: Username 'test' and Password 'test'`	Creates JWT token and sets an HTTP Only Cookie to the client side and redirects user into profile page
1	Login Admin	`/login` `Input: Username 'Admin' and Password 'admin'`	Creates JWT token and sets an HTTP Only Cookie to the client side and redirects user into profile page also shows Admin Button for Admin Panel

Table 4.6: System/Application Testing: User Methods

Test No.	**Test Case**	**Input**	**Output**
1	Admin add capsule	`/admin/add`	Shows Form to add capsules and adds capsules when submitted

5 CONCLUSION AND ANALYSIS

5.1 Conclusion

LabXplorerX is an innovative virtual laboratory platform tailored for enhancing science education through interactive simulations and experiments. It aims to revolutionize how students and educators engage with scientific concepts by offering a diverse range of features. LabXplorerX facilitates seamless exploration, collaboration, and learning aweb various scientific disciplines. This platform empowers users to conduct experiments, share insights, and leverage sophisticated algorithms to deepen their understanding. Additionally, LabXplorerX integrates advanced reporting capabilities and decision-making tools, enriching the educational experience beyond traditional classroom settings.

5.2 Work Completed

In the LabXplorerX project, significant strides have been made in creating an engaging and educational platform for students. Five interactive simulations have been successfully developed, offering hands-on learning experiences across various subjects. Additionally, learning capsules have been crafted to provide structured, multimedia-rich content that enhances student understanding. A robust authentication system has been implemented, ensuring secure access for students and teachers. The development of an admin panel enables efficient management of users, content, and simulations, while integrated quizzes allow students to assess their knowledge with immediate feedback.

- **Creation of Simulations:** Successfully developed 5 simulations, each tailored to provide interactive and educational experiences for students in various subject areas.
- **Learning Capsules:** Created comprehensive learning capsules that include structured content, interactive elements, and visual aids to enhance the learning experience.
- **Authentication:** Implemented a robust authentication system to manage user access, including secure login, registration, and account management features for both students and teachers.
- **Admin Panel:** Developed an admin panel that allows administrators to manage users, simulations, and content. The panel includes tools for monitoring user progress, updating content, and overseeing the overall platform.

- **Quizzes:** Integrated quizzes into the learning modules, enabling students to assess their understanding of the material. The quizzes are designed to be interactive and provide immediate feedback to the learners.

5.2.1 Screenshots of Outcomes

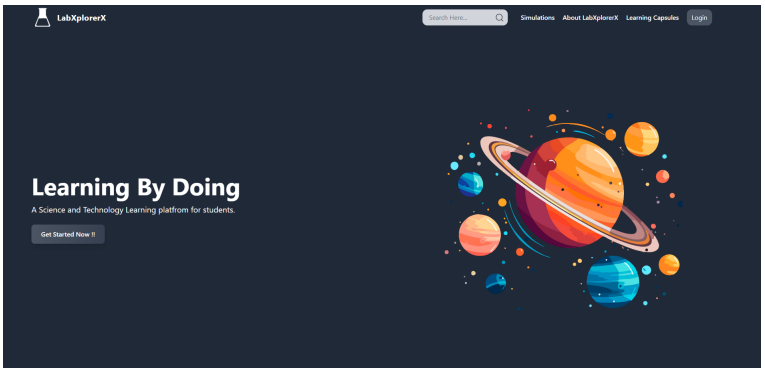


Figure 5.1: Home Screen

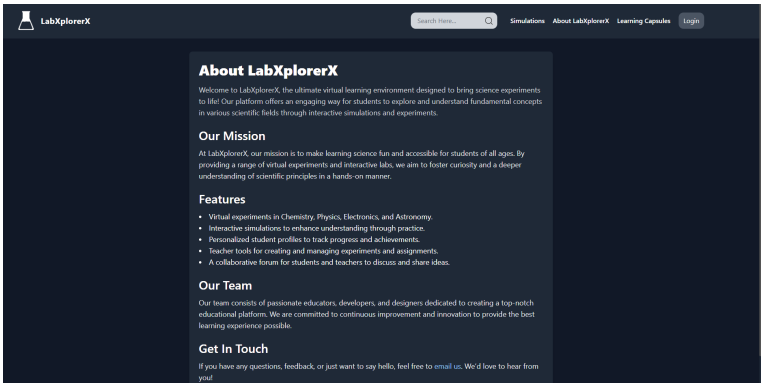


Figure 5.2: About Page

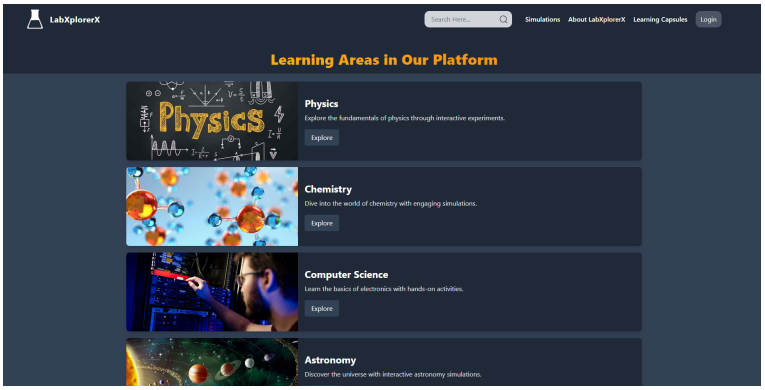


Figure 5.3: Learning Areas

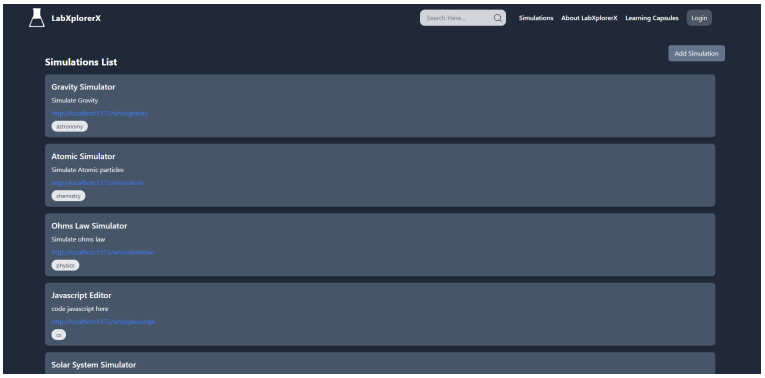


Figure 5.4: Simulations

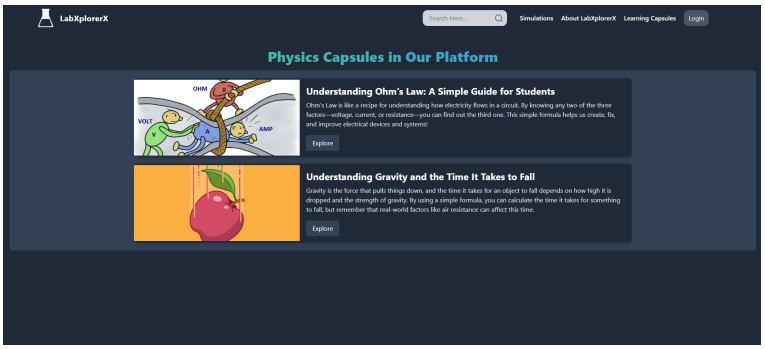


Figure 5.5: Capsules

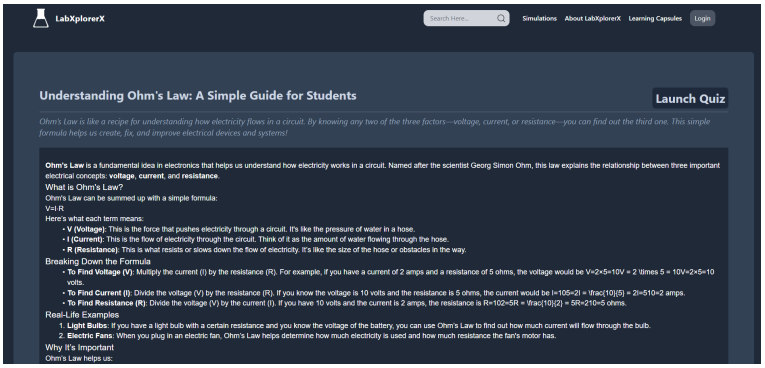


Figure 5.6: Single Capsule

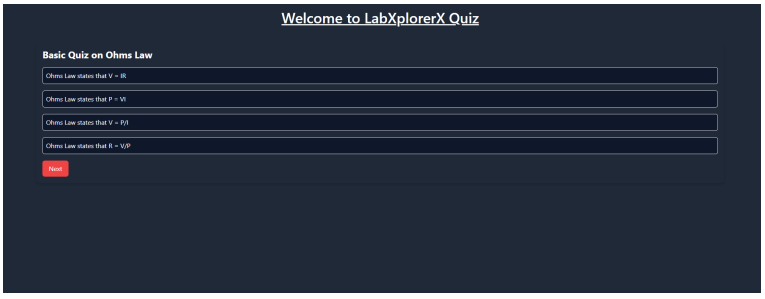


Figure 5.7: Quizzes

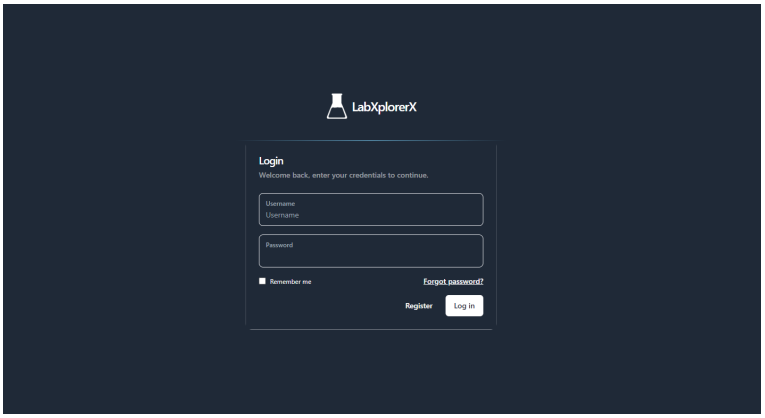


Figure 5.8: Login

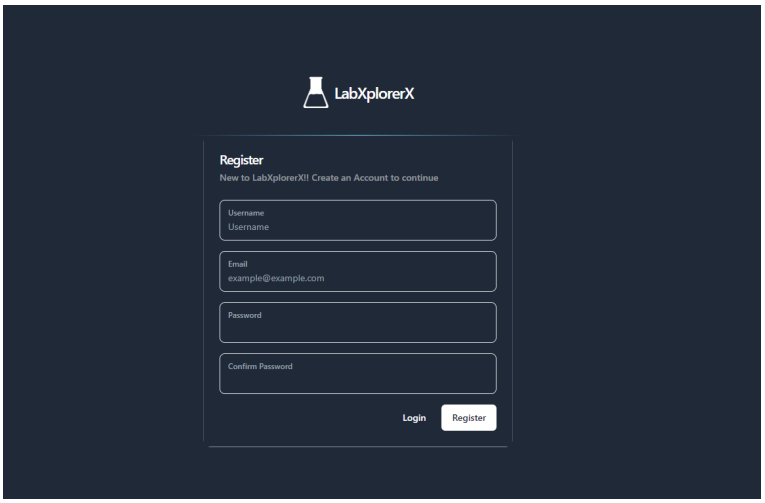


Figure 5.9: Register

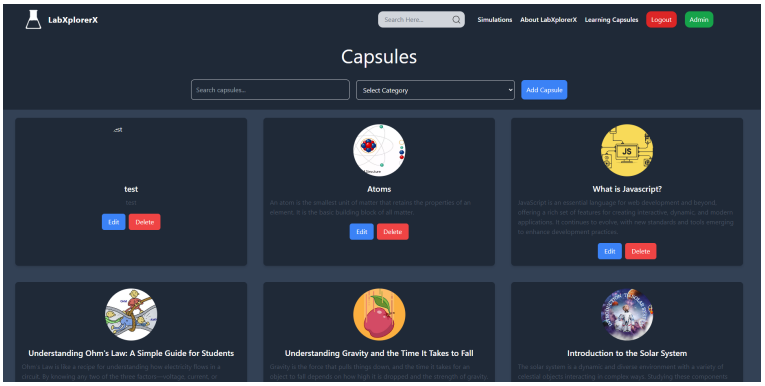


Figure 5.10: Admin Panel

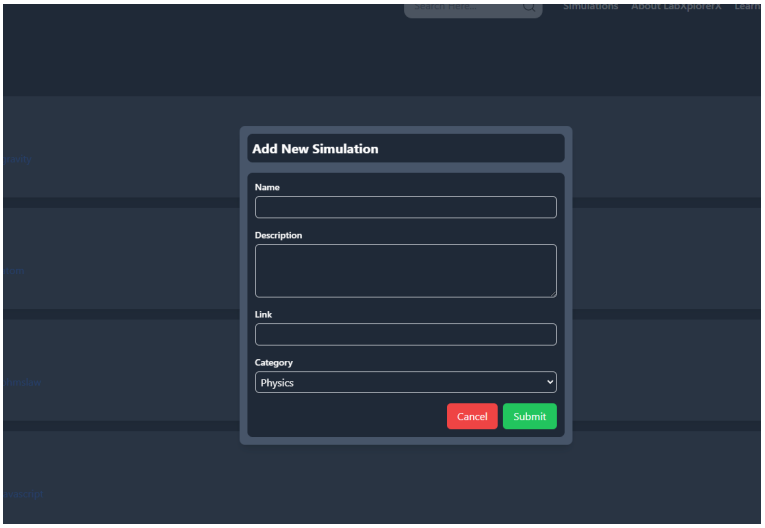


Figure 5.11: Add Simulations

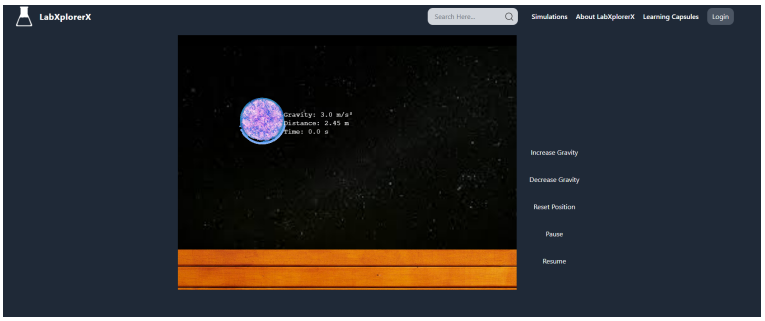


Figure 5.12: Gravity Simulator

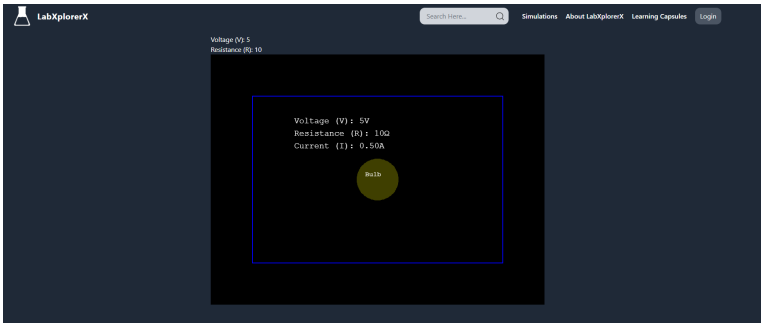


Figure 5.13: Ohms Law Simulator

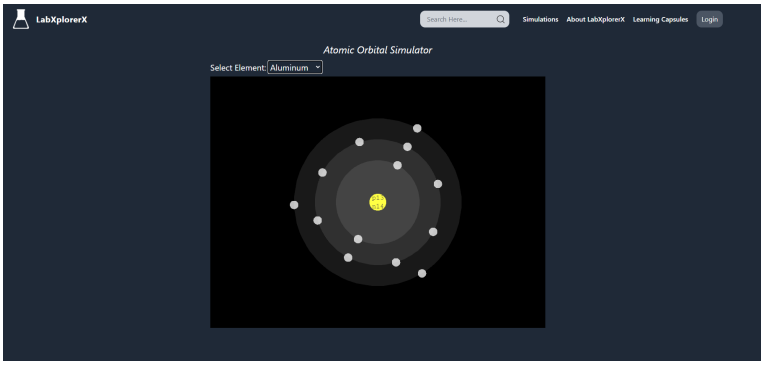


Figure 5.14: Atom Simulator

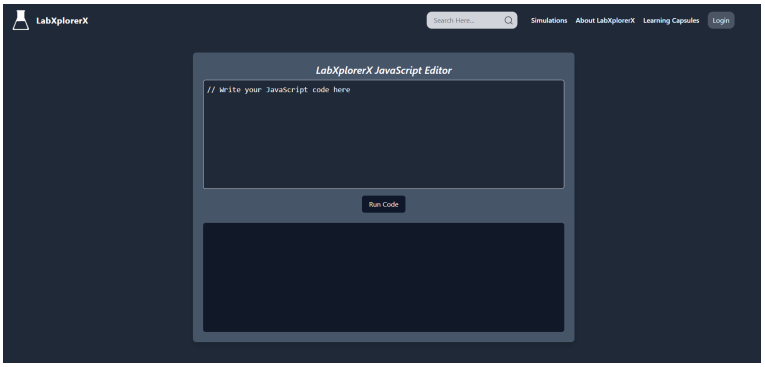


Figure 5.15: JavaScript Editor

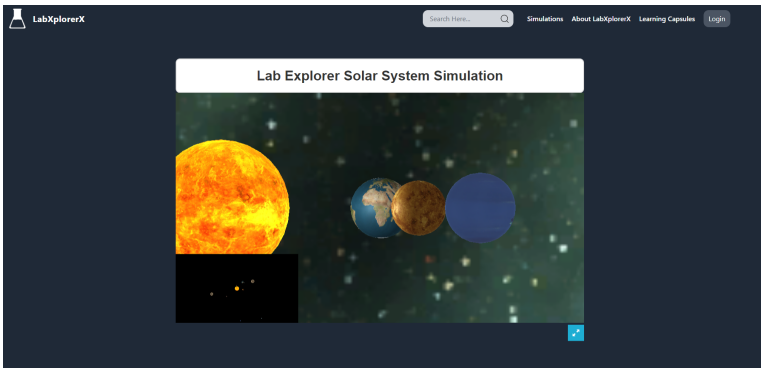


Figure 5.16: Solar System Simulator

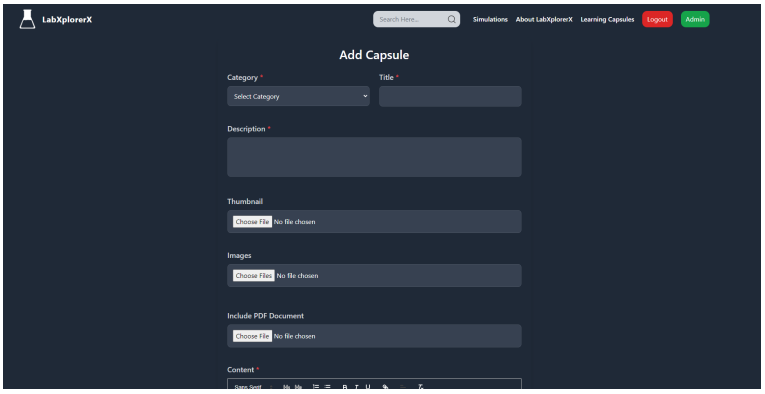


Figure 5.17: Add Capsule

5.3 Work Remaining

As the LabXplorerX project progresses, several key tasks remain to be completed. The development team will focus on creating additional simulations to further expand the interactive learning opportunities available to students. The implementation of user profiles is also pending, which will enable students to personalize their learning experience, track progress, and manage their accounts. Additionally, a discussion forum needs to be integrated into the platform, allowing students and teachers to engage in meaningful conversations, share ideas, and collaborate on learning activities.

- **More Simulations:** Continue creating additional simulations to broaden the range of interactive learning experiences available to students.
- **User Profiles:** Implement personalized user profiles, enabling students to track their progress, manage their accounts, and enhance their learning experience.
- **Discussion Forum:** Develop and integrate a discussion forum, facilitating communication and collaboration between students and teachers within the platform.

APPENDIX A

A.1 Project Schedule

Below is the Gantt chart for the project schedule. Specific tasks are planned to be performed within the designated time frames as illustrated. This chart provides a visual representation of the project's timeline, highlighting the start and end dates for each task, as well as their dependencies. By following this schedule, the project team can effectively manage resources, track progress, and ensure timely completion of each phase.

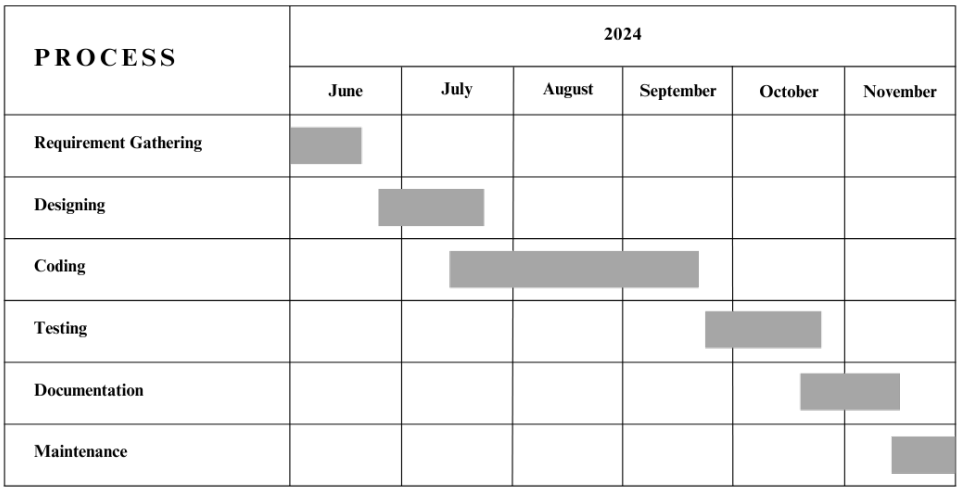
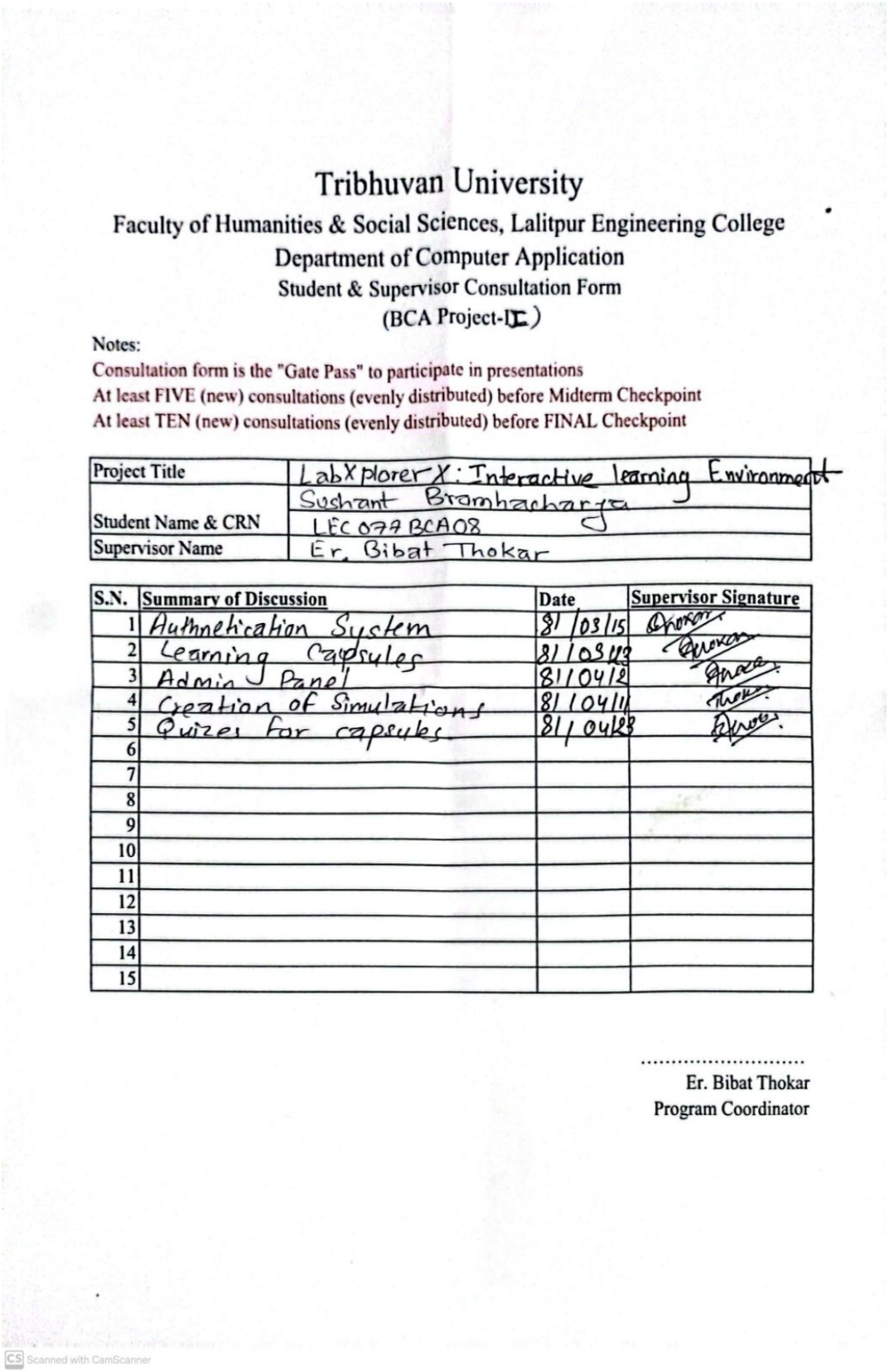


Figure A.18: Gantt Chart of Schedule

A.2 Supervisor Consultation Form



Tribhuvan University

Faculty of Humanities & Social Sciences, Lalitpur Engineering College

Department of Computer Application

Student & Supervisor Consultation Form

(BCA Project-II)

Notes:

Consultation form is the "Gate Pass" to participate in presentations

At least FIVE (new) consultations (evenly distributed) before Midterm Checkpoint

At least TEN (new) consultations (evenly distributed) before FINAL Checkpoint

Project Title	LabXplorerX: Interactive learning Environment
Student Name & CRN	Sushant Bramhacharya
	LEC 077 BCA 08
Supervisor Name	Er. Bibat Thokar

S.N.	Summary of Discussion	Date	Supervisor Signature
1	Authentication System	81/03/15	
2	Learning Capsules	81/03/23	
3	Admin Panel	81/04/2	
4	Creation of Simulations	81/04/11	
5	Quizes for capsules	81/04/23	
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.....

Er. Bibat Thokar

Program Coordinator

Figure A.19: Supervisor Consultation Form

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