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Interactive Educational Application in Odontogenic Oral Pathology

In partial fulfilment of the requirements for the degree of

Bachelor of Science in Computer Science

Supervisor: Iram Noreen

Department of Computer Sciences

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Certificate

We accept the work contained in the report titled

"Interactive Educational Application in Odontogenic Oral Pathology"

written by

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as a confirmation to the required standard for the partial fulfilment of the degree of Bachelor of Science in Computer Science.

Approved by:

Supervisor: Dr. Iram Noreen

_____

December 24, 2024

DECLARATION

We hereby declare that this project report is based on our original work except for citations and quotations which have been duly acknowledged. We also declare that it has not been previously and concurrently submitted for any other degree or award at Bahria University or other institutions.

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Date : December 24, 2024

Specially dedicated to
my beloved grandmother, mother and father
(Murtaza Anwaar Ul Haq Hashmi)
my beloved grandmother, mother and father
(Sheheryar Sohail)

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We would like to express our gratitude to our research supervisor, Dr. Iram Noreen, for her invaluable advice, guidance and her enormous patience throughout the development of the research. We would also like to express our gratitude to our co-supervisor & project collaborator, Dr. Asifa Iqbal, for her invaluable advice, guidance, and her enormous patience throughout the development of the research.

In addition, we would also like to express our gratitude to our loving parent and friends who had helped and given me encouragement.

Murtaza Anwaar Ul Haq Hashmi
Sheheryar Sohail

Interactive Educational Application in Odontogenic Oral Pathology

ABSTRACT

Dental education has evolved significantly, yet challenges persist in effectively teaching complex subjects like Oral Pathology. Students often struggle to understand the intricate details of oral diseases due to limited access to clinical cases, traditional teaching methods, and a lack of interactive resources. These limitations hinder their ability to comprehend anatomical structures, develop diagnostic skills, and retain critical knowledge, ultimately impacting their preparedness for professional practice. To address these challenges, this project introduces an Interactive Educational Application in Odontogenic Oral Pathology, leveraging advanced 3D modelling technology to provide detailed, interactive visualizations of dental structures and pathological conditions. The application reimagines textbook content as dynamic, interactive modules, featuring 3D models for exploring anatomical structures, quizzes to test comprehension, and cross-platform accessibility for seamless learning. Optional functionalities such as bookmarking and note-taking further enhance usability. Preliminary feedback suggests the application improves students' understanding, retention, and confidence in diagnosing oral diseases, offering a comprehensive solution that bridges the gap between theoretical learning and clinical practice.

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CHAPTER 1

INTRODUCTION

1.1 Background

There has been overall great improvement in teaching and learning oral pathology with advancement in modern technology, however teaching of oral pathology – one of the most complicated subjects – has not been easy. Even when biology of cells, microbiology, and the science of materials are imparted, conventional teaching methods dominated by the use of pictures and books still leave students needing practical exposure and active participation to fully appreciate the subject.

Oral Pathology is regarded as connective tissue linking basic medical sciences with clinical dentistry. General dentists must be familiar with pathogenesis and sequelae of the most frequent lesions of the teeth and the mouth in order to meet the needs of the patients properly. Nevertheless, it is evident that many dental students experience difficulty in understanding these topics due to the complicated nature of the focal area and inadequate resources in some dental faculties.

This report presents the results of the work undertaken in the scope of development of the Interactive Educational Application in Odontogenic Oral Pathology, directed on coping with the learning problems through use of 3D modelling technologies. This particular application incorporates presentations of the forms of the anatomical parts and different pathological processes helping students to understand the subject better.

1.2 Problem Statements

Oral Pathology is a vast and complex course which dental students regularly struggle with. The almost complete lack of practical training coupled with the requirement to visualise and understand complex anatomical structures makes it difficult for students to develop the diagnostic skills needed for clinical practice. The lack of practical exposure, particularly in dental institutes with low patient turn over leads to knowledge gaps affecting the overall quality and the output of future dental graduates.

1.3 Aims and Objectives

The project aimed mainly at developing an interactive 3D dental educational application that would be easy for dental students to understand and improve the knowledge of Odontogenic Oral Pathology. The key objectives were:

1. To design and develop detailed 3D models of dental structures and pathological conditions for learning through 3D interactive experience.
2. To develop quiz modules that dynamically test medical students on the subject matter.
3. To provide dental educational application on multiple platforms, including desktop and mobile, creating a more accessible experience for students and educators.

1.4 Scope of Project

This developed work included the creation of an interactive application consisting of 3D models of teeth and pathological conditions. The application also includes quizzes to help people recall. Note taking and bookmarking optional features were also being considered to further increase the user experience as secondary scope.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Technology-Assisted Learning in Dentistry

Over the last two decades, a shift has taken place in dental education: the acceptance of digital applications that aim at improving the learning experience. Since it's a combination of two words; traditional, it suggests that their were two words that were traditional and descriptive of ways that one carried on an education. The different platforms include 3D models, virtual simulations, augmented reality (AR), gamification elements. These tools have shown to increase student engagement, understanding and retention not only of Oral Pathology, but also complex topics such as this [1].

Recent studies show that such interactive tools enable the students to explore the detailed representation of the anatomical structures and to improve their memory retention and spatial awareness. These technologies eliminate the gap between theoretical and practical by giving you a much tangible learning experience than traditional resources. In addition to interactive quizzes and simulations, they are used to help students assess how well they understand complex topics and apply their knowledge in real time.

2.2 Evolution of Dental Education and the Role of Technology

Classical dental education has widely used the didactic ways of knowledge transfer, such as lectures and clinical rotations. Unfortunately, these methods do not give students the depth of understanding needed to master hard subjects such as Oral Pathology. Education technology has led new ways of engaging students through flexible, interactive, more personal way of learning.

Technology alone is not the only role of technology in dental education. Virtual simulations provide students a controlled environment to practise clinical skill. Students are then able to simulate tasks that they otherwise would have in clinical settings, for example diagnosing an oral lesion or planning an appropriate treatment strategy. Technology continues to change and its potential to revolutionise further dental education [2].

2.3 Challenges in Teaching Oral Pathology

It is one of the most difficult subjects in dentistry education because there is just so much information that students need to learn, and that learning has to be related procedurally to real clinical cases. In this subject, students are required to develop an in-depth knowledge of many of the diseases that affect the oral cavity, including the aetiology, pathogenesis and treatment options.

Most traditional methods of teaching Oral Pathology (lectures and textbook readings) proved to be unsuccessful of transferring the complexity of dental anatomy and pathologic conditions, as well as to assist students in retention of large amounts of information, particularly if the content is theoretical and practically unimportant. This problem is made worse by the scant supplies of clinical cases in some schools of dental science because even the students find it difficult to acquire live experience in diagnosing oral disease or in their treatment [3].

Additionally, many dental schools do not have patient turnover, which means their students do not experience a range of conditions and miss exposure to the range of types of conditions and thus a range of diagnostic skills. Therefore, this problem has generated demand for educational tools with more concrete or hands on experiences, which can be supplied by digital platforms such like 3D models or virtual simulations. Existing Technology-Assisted Tools in Dentistry

Several tools have already been introduced to the field of dental education, including 3D models, virtual simulations, and gamified learning environments. These tools have proven to be highly effective in enhancing student learning, particularly in subjects that require a deep understanding of complex anatomical structure [4].

2.3.1 3D Models for Oral Pathology

3D models provide an inexpensive visual aid for explaining dental structures and pathological conditions. They are also very interactive, allowing the student to manipulate and interact with various structures of the oral environment. This is different from old fashioned textbooks and static images; 3D models permit students to rotate, zoom, and modify anatomical features, delivering a more whole knowledge of what is going on within their health. Students who had used 3D models when studying dental anatomy did significantly better in practical exams compared to those who did it with traditional methods.

2.3.2 Virtual Simulations for Clinical Practice

The advances of the past decades in computer science and digital imaging have created virtual simulations for dental students that are becoming important tools for preparing for clinical practice. Students are able to participate in virtual patient interactions and diagnostic procedures, giving them a trouble-free environment in which to practice necessary skills. Virtual simulations can aid students in developing their diagnostic skills and be confident while performing clinical tasks, particularly with limited real life patient exposure [5].

2.3.3 Gamification and Its Impact on Student Motivation

By using the gamification, we have introduced the game like element into the education like the points, levels and rewards have been proved to increase the student engagement and motivation. In a recent study, it was reported that students using gamified learning environments participated better and scored higher academically than those using traditional learning environments. Gamification fosters an atmosphere that is somewhat competitive, which makes it easier for students to participate and retain information about gamification [6].

2.4 Advantages of Interactive Learning in Medical and Dental Education

Interactive learning has given medical and dental education a real chance to evolve, making the learning experience much more engaging and immersive. Virtual simulations and augmented and in real life scenarios can provide an interactive level

in the sense of 3D models, and students can better visualize complex concepts and apply knowledge on practical scenarios. These tools can help students learn different oral disease studies in a more hands on way, bridging the gap of theory knowledge and what happens in clinical, and these interactive tools were found to increase the ability of students studying Oral Pathology with interactive tools to have higher retention patterns and had better practical exams done when compared to traditional resource. Additionally, these tools provide students with repeated practice of those skills, which contribute to reinforce learning the concept and helping clinic skills improve with time.

2.5 The Role of Augmented Reality (AR) in Dental Education

Augmented reality (AR) is an emerging technology for dental education. AR overlays digital information over real world environment thus students can interact with both physical and virtual objects at the same time. The use of AR in dental education enables overlaying of digital representations of anatomical structures onto physical models to allow students to gain a fuller picture of the complex interplay between anatomical systems.

AR has been shown in recent studies to dramatically help students develop a better handle of anatomy spatial relationships and build the skills to do complex procedures. For example, a study demonstrated that students felt more satisfied with the learning experience and believed they would be more competent with their skills if they used AR in dental education in comparison to those who didn't used such technologies [5].

2.6 Gap in Existing Literature

Although technology assisted learning tools have been pervasive in dental education, there currently exists a lack of the development of specialised tools directed at Odontogenic Oral Pathology. While there are several general-purpose tools for teaching dental anatomy and pathology, they are all customized products that do not address the specific issues of the odontogenic disease students face. This gap emphasizes the need for more focused educational tools like the Interactive Educational Application in odontogenic oral pathology, which feature in depth 3D models and interactive tests to really aid students in the understanding of these conditions.

CHAPTER 3

ANALYSIS

3.1 Functional Requirements

3.1.1 User Registration and Authentication

- Users should be able to register with their full name, email, password, and other details such as year of study, university name etc.
- Authentication should be handled using secure services such as Firebase Authentication.

3.1.2 Topic and Chapter Management (Faculty Side)

- Faculty members should be able to create, edit, and delete topics and chapters dynamically.
- Faculty members can upload chapter content, including images or 3D models along with the textual content.
- Chapters should have associated pre-tests and post-tests to gauge the effectiveness of the lecture content.

3.1.3 Progress Tracking (Student Side)

- Students should view their progress for each topic based on completed chapters.
- Progress bars should dynamically update based on completed chapters.
- Completed chapters should be marked with a tick on the UI.

3.1.4 Learning Content

- Students should be able to access chapters with images, descriptions, and interactive
- Moreover, a set of comprehensive learning modules should be developed under the supervision of the subject expert (Project Collaborator).

3.1.5 3D dental models

- Chapters should be scrollable and responsive across devices with interactive 3D models which would include hotspots/annotations for further details for the user.

3.1.6 Test Functionality

- Students can take pre-tests and post-tests for topics.
- Tests can include dynamic fields such as text, headings, MCQs, and images.
- Test results should be saved to Firestore.

3.1.7 User Profiles

- Users should be able to update their profiles and view their activity history, including test scores.

3.1.8 Verification

- After registration, users should receive a verification email, and without verification, the user wouldn’t be allowed to access their account.

3.2 Non-Functional Requirements

3.2.1 Scalability

- The system should handle multiple users simultaneously without performance degradation.

3.2.2 Security

- User data should be secured with Firebase Authentication and Firestore security rules.
- Passwords should comply with industry standards for complexity.

3.2.3 Performance

- The application should load content efficiently and ensure smooth navigation between pages.
- 3D models should render smoothly without significant lag.

3.2.4 Usability

- The UI should be intuitive, with clear navigation and accessible features.
- Dark mode and light mode should provide consistent visual appeal.

3.2.5 Cross-Platform Compatibility

- The application should work seamlessly on both Android and iOS devices.

3.2.6 Data Consistency

- All data updates, such as progress tracking and test submissions, should sync reliably with Firestore.

3.2.7 Maintainability

- The application codebase should follow best practices for maintainability and allow easy updates or feature additions.

3.2.8 Reliability

- The system should ensure high availability, minimizing downtime or disruptions.

3.2.9 Accessibility

- The application should be designed with accessibility in mind, providing support for diverse user needs.

3.2.10 Extensibility

- The system should allow easy integration of additional features such as new test types or gamification elements.
-

These functional and non-functional requirements provide the foundation for the development and evaluation of the e-learning application. They ensure the system meets user needs effectively while maintaining high standards for performance, security, and usability.

3.3 Functional Requirements Documents

3.3.1 Use-case Diagram

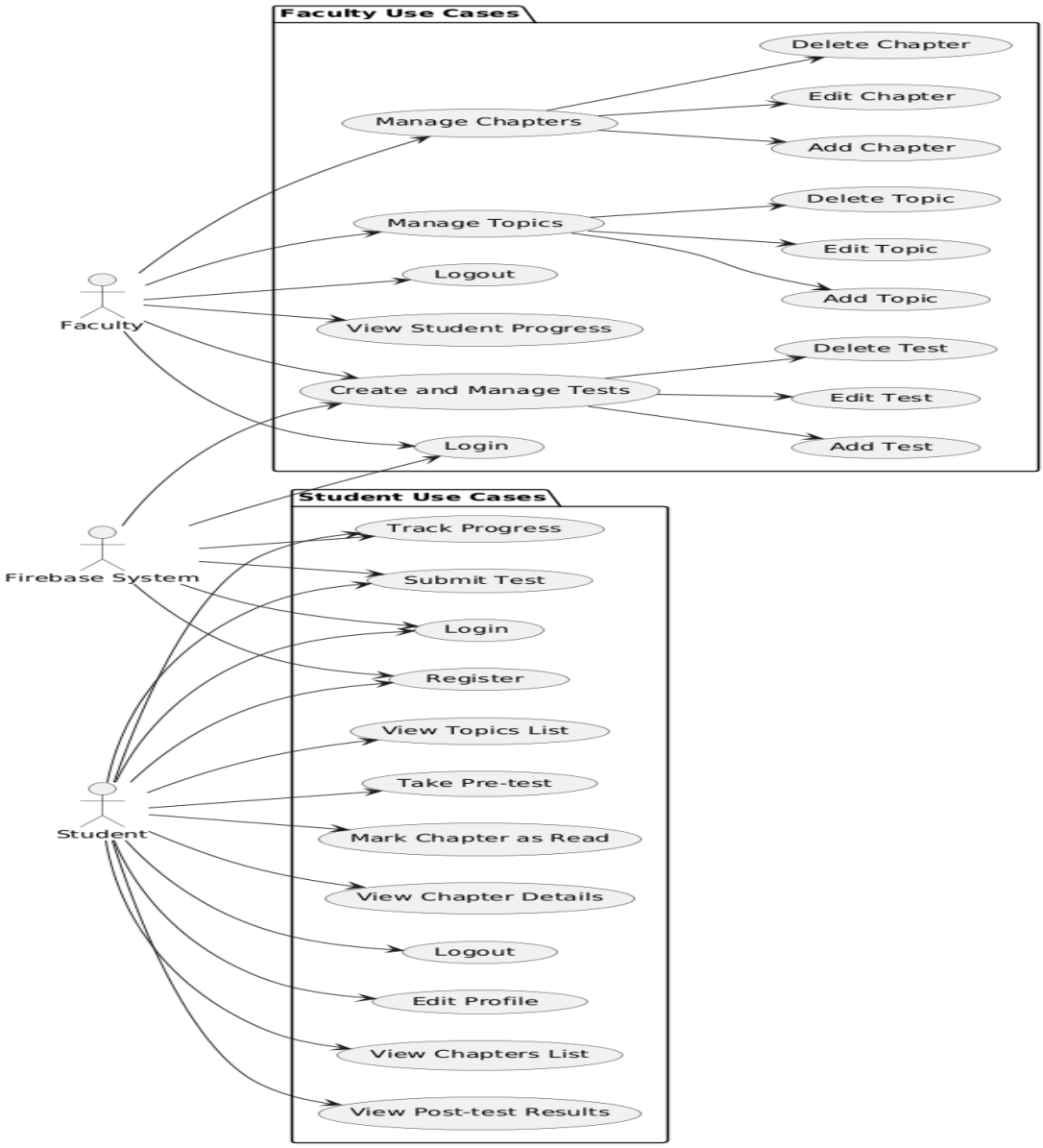

Figure 3.1: Use Case Diagram

3.3.2 Use-case Tables

3.3.2.1 User Registration

Table 3.1: Usecase Table – User Registration

Field	Details
Use Case ID	UC-01
Use Case Name	Register User
Actor(s)	Student, Faculty
Description	This use case allows a new user to register by providing personal details and creating an account.
Preconditions	User has access to the registration page.
Main Flow	1. User fills out the registration form (name, email, city, year of study, university). 2. User selects or enters university. 3. User enters a password and confirms it. 4. User submits the form. 5. The system sends a verification email. 6. User is redirected to the login screen.
Postconditions	User account is created, and the data is saved to Firestore. A verification email is sent.
Extensions	1. If the password does not meet the required criteria, show an error message. 2. If any field is missing, show a validation error.

3.3.2.2 User Login

Table 3.2: Usecase Table – User Login

Field	Details
Use Case ID	UC-02
Use Case Name	Login User
Actor(s)	Student, Faculty
Description	This use case allows the user to log into the system using their credentials.
Preconditions	User must have an active account.
Main Flow	1. User enters email and password. 2. User submits the login form. 3. The system authenticates the credentials. 4. If successful, the user is redirected to the home page. 5. If authentication fails, an error message is displayed.
Postconditions	User is authenticated and logged in.
Extensions	1. If the credentials are incorrect, show an error message.

3.3.2.3 View Topics List

Table 3.3: Usecase Table – View Topics List

Field	Details
Use Case ID	UC-03
Use Case Name	View Topics List (Student)
Actor(s)	Student
Description	This use case allows the student to view a list of topics along with their progress.
Preconditions	User must be logged in as a student.
Main Flow	1. Student accesses the "Topics List" page. 2. The system fetches a list of topics from Firestore. 3. The system displays each topic with a progression bar showing chapters completed. 4. The student selects a topic to explore.
Postconditions	The student sees a list of topics and their progress.
Extensions	1. If no topics are available, show a message indicating that.

3.3.2.4 View Chapter Details

Table 3.4: Usecase Table – View Chapter Details

Field	Details
Use Case ID	UC-04
Use Case Name	View Chapter Details (Student)
Actor(s)	Student
Description	This use case allows the student to view the details of a selected chapter, including text, images, or 3D models.
Preconditions	User must be logged in as a student and must have selected a topic.
Main Flow	1. Student selects a chapter from the topic. 2. The system displays the chapter's image, title, and description. 3. The student can mark the chapter as read. 4. The system updates the chapter's status in Firestore.
Postconditions	The chapter's status is updated in Firestore.
Extensions	1. If the chapter has no content, show an appropriate message.

3.3.2.5 Take Pre-Test

Table 3.5: Usecase Table – Take Pre-Test

Field	Details
Use Case ID	UC-05
Use Case Name	Take Pre-Test (Student)
Actor(s)	Student
Description	This use case allows the student to take the pre-test for a selected topic.
Preconditions	User must be logged in as a student and must have selected a topic.
Main Flow	1. Student selects "Start Pre-Test." 2. The system displays the pre-test questions (text, MCQs, etc.). 3. The student answers the questions and submits the test. 4. The system calculates the score and saves it to Firestore.
Postconditions	Pre-test score is saved in Firestore.
Extensions	1. If the student does not answer all questions, prompt them to complete the test.

3.3.2.6 Take Post-Test

Table 3.6: Usecase Table – Take Post-Test

Field	Details
Use Case ID	UC-06
Use Case Name	Take Post-Test (Student)
Actor(s)	Student
Description	This use case allows the student to take the post-test after completing a topic.
Preconditions	User must be logged in as a student and must have completed the related chapters.
Main Flow	1. Student selects "Start Post-Test." 2. The system displays the post-test questions. 3. The student answers the questions and submits the test. 4. The system calculates the score and saves it to Firestore.
Postconditions	Post-test score is saved in Firestore and compared with pre-test score.
Extensions	1. If the student doesn't complete the test, prompt them to finish it.

3.3.2.7 View Test Scores

Table 3.7: Usecase Table – View Test Scores

Field	Details
Use Case ID	UC-07
Use Case Name	View Test Scores (Student)
Actor(s)	Student
Description	This use case allows the student to view their pre-test and post-test scores.
Preconditions	User must be logged in as a student and must have taken both the pre-test and post-test.
Main Flow	1. Student accesses the "Test Scores" page. 2. The system retrieves the scores from Firestore. 3. The student views their pre-test and post-test scores, and the comparison is displayed.
Postconditions	The student sees the test scores and progress comparison.
Extensions	1. If no scores are available, show a message indicating that.

3.3.2.8 Manage Topics

Table 3.8: Usecase Table – Manage Topics

Field	Details
Use Case ID	UC-08
Use Case Name	Manage Topics (Faculty)
Actor(s)	Faculty
Description	This use case allows the faculty member to manage topics (add, edit, delete).
Preconditions	User must be logged in as a faculty member.
Main Flow	1. Faculty accesses the "Manage Topics" page. 2. The system displays a list of topics. 3. Faculty selects an option to add, edit, or delete a topic.
Postconditions	The system updates the topic list in Firestore based on the selected operation.
Extensions	1. If there are no topics, show a message indicating that.

CHAPTER 4

DESIGN & METHODOLOGY

4.1 Design of Scrum Methodology

In building this project with a doctor who is researching the effectiveness of e-learning technologies efficacy for dental studies, we adopted the **Scrum framework** to help manage and develop our app. The reason we chose Scrum is because it is so **flexible** and so able to incorporate feedback's quickly that the app can continue to align with the research needs and move from an **iterative improvement basis**. It was also selected because we had some **prior experience with Scrum**, but also because Scrum has a process that keeps the team on the path to the doctor's vision, yet **easily adapts to changing requirements**.

4.1.1 Scrum Team Structure

With the wide scope of the project, we had a small Scrum team of only two developers. However, the roles were clearly defined to ensure smooth workflow and accountability:

- **Product Owner:** The Product Owner was played by the collaborator (Dr. Asifa Iqbal) who oversaw the research. The vision of the app was defined by the PO, priorities were set, feedback was needed at the end of every sprint to tell the project where to go.
- **Scrum Master:** I accomplished this as I served as a Scrum Master for both my project partner and I, removing impediments the team faced, maintaining the process as a Scrum team was supposed to, and ensuring the values and events of Scrum are kept intact.

- **Development Team:** Just the two of us were on the development team, comprising of the coding, design and integration of the application in different features. Even though we consisted of a small team, our roles synergized along the lines of frontend development using Flutter, backend practices of integrating with Firebase, and 3D modelling with Blender.

4.1.2 Artifacts in Scrum

Scrum utilises various artifacts that ensure transparency and provide a clear picture of the progress of the project.

4.1.2.1 Product Backlog

The **Product Backlog** was created and managed using GitHub to track features, bug reports, and technical tasks. The backlog consisted of:

- Features like the test section, learning section, integration of 3D dental models.
- Requirements for UI/UX improvements and the creation of learning content.

The backlog was **continuously refined** based on feedback from the Product Owner (project collaborator) after each sprint.

4.1.2.2 Sprint Backlog

The **Sprint Backlog** was created at the start of each two-week sprint. In consultation with the Product Owner, we selected high-priority items from the Product Backlog to be worked on during the sprint. Each backlog item was broken down into smaller, manageable tasks that allowed us to incrementally build and integrate features into the app.

4.1.3 Increment

Following Sprint Increment review by the Product Owner for each Sprint, a working increment was delivered. Key increments delivered throughout the project include:

- **Base App:** The initial app structure with login, user profile, and mobile flow to go from one section to the other.
- **Test Section:** Fetching and storing test data in Firebase, quizzes and tests implementation.
- **Learning Section:** A place where users can look at educational content, complete with featured progress tracking and chapter lists.
- **Learning Content Creation and Integration:** Building the features that support the doctor uploading those learning materials, chapters and tests.
- **3D Models Creation and Integration:** Integrating the created dental models with Blender and the learning content in order to improve the interactive experience.

4.1.4 Scrum Events

We adhered to the standard Scrum events to ensure effective communication, regular feedback, and continuous improvement throughout the project lifecycle.

4.1.5 Sprint Planning

At the start of each two-week sprint, we conducted a **Sprint Planning** meeting with the Product Owner. During this meeting, we discussed the most important features to be developed based on the doctor's research needs. We also estimated the effort required for each feature and broke them down into tasks that could be completed within the sprint. For estimation, we used a combination of timeboxing and task prioritisation, considering our small team size and available time.

4.1.6 Daily Scrum

While we did not have a large team, we held **daily Scrum meetings** between the two of us to discuss the following:

- What was accomplished the previous day.
- What we planned to work on that day.
- Any blockers or challenges encountered.

These quick stand-up meetings helped us stay on track and address issues as they arose, ensuring continuous progress.

4.1.7 Sprint Review

At the end of each sprint, we held a **Sprint Review** with the Product Owner, presenting the working increment. The doctor provided **valuable feedback**, often suggesting improvements based on user needs or research requirements. This feedback was essential in guiding the development of the next sprint's backlog and ensuring the app remained aligned with the overarching goals.

4.1.8 Sprint Retrospective

Following each Sprint Review, we conducted a **Sprint Retrospective** to reflect on the sprint's successes and areas for improvement. In these retrospectives, we identified ways to optimise our workflow, such as refining our code review process or improving communication. For example, after noticing some delays in integrating 3D models, we adjusted our sprint planning to allow more time for 3D model testing and review.

4.1.9 Sprint Length and Workflow

We chose a **two-week sprint length** to ensure rapid development while allowing sufficient time to incorporate **feedback from the doctor**. This sprint length provided enough flexibility to develop features iteratively and adjust priorities as new research insights or user needs emerged. Each sprint followed a structured workflow:

1. Sprint Planning (with the Product Owner)
2. Development (coding, testing, and integrating features)
3. Daily Scrum meetings
4. Sprint Review (demonstrating the increment to the Product Owner)
5. Sprint Retrospective

4.1.10 User Story Breakdown

We structured our user stories such that the goals of the doctor were satisfied and designed around the functionality required to create e learning application. Example user stories included:

- “As a student, I want to take a pretest and post-test to see my learning progress.”
- "They key feature I would love as a researcher would be to upload 3D dental models to help students better enjoy the educational experience."

The User stories were estimated, broken down into tasks such as backend integration, UI design and testing.

4.1.11 Risk Management and Mitigation

Throughout the project, we identified several risks and mitigate them accordingly:

- **Technical risks:** One of the issues is the integration of the 3D models in Flutter, which didn’t take as long as expected, so we spent more time on it in the Sprint Backlog for testing and adjustments.
- **Scope creep:** We interacted with the doctor (Product Owner) closely to define the requirements clearly and by keeping the product backlog prioritised we did not get into the scope creep.
- **Limited team size:** However, with **two developers**, we were very efficient with communication and made certain that important features were delivered on time while not burning out ourselves.

4.1.12 Continuous Integration and Delivery (CI/CD)

We set up a **CI/CD pipeline** using GitHub Actions to ensure that code pushed to the repository was automatically tested and built. Regular testing was conducted to identify issues early, and we aimed for bi-weekly deployments to ensure the doctor could review the latest increments.

4.2 Design Documents

4.2.1 Sequence Diagrams

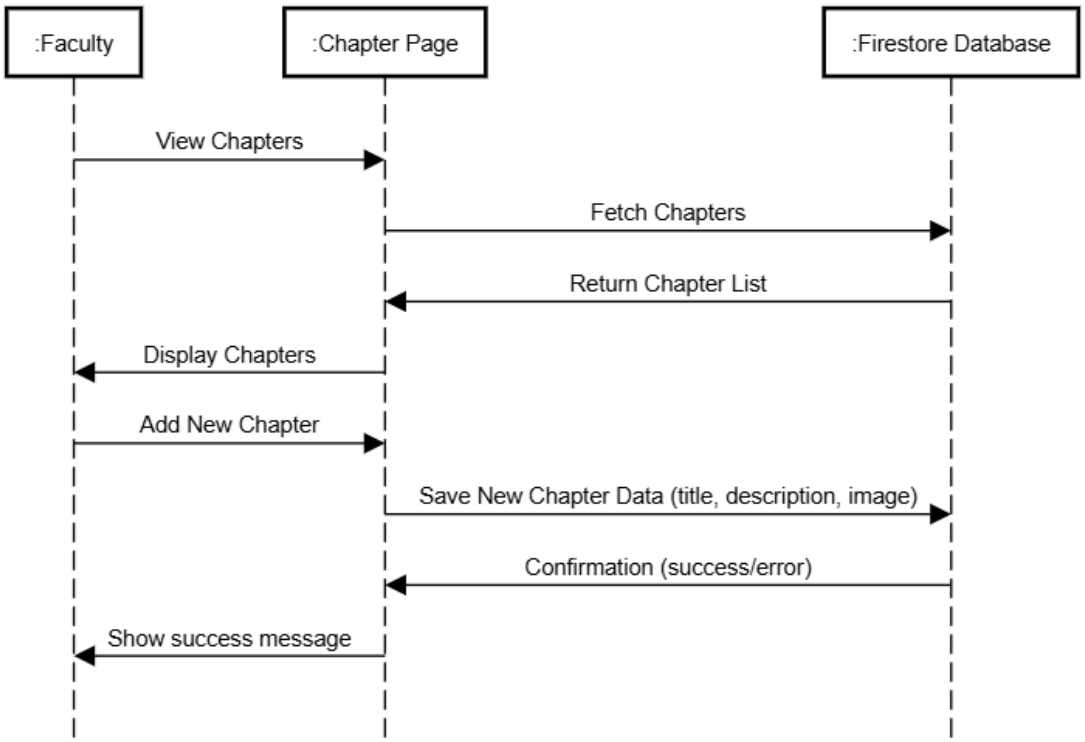

Figure 4.1: Sequence Diagram – Chapters Management

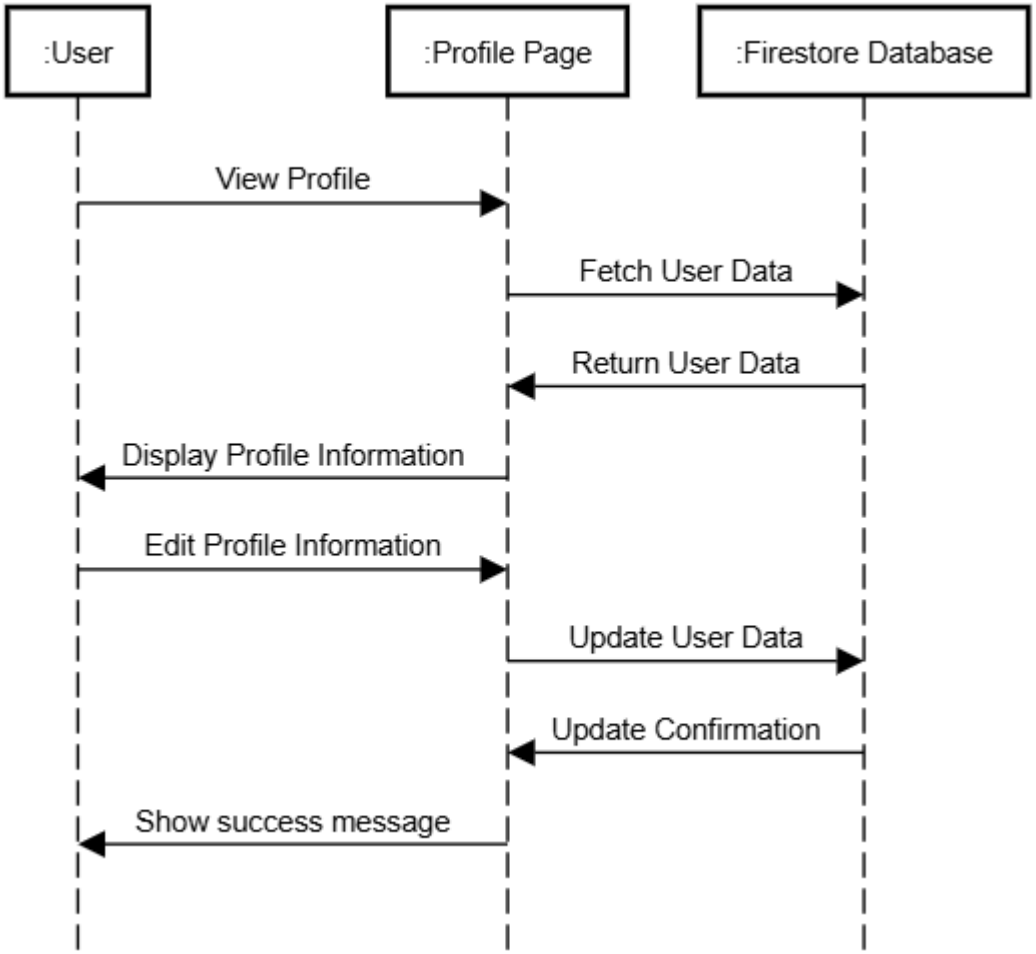

Figure 4.2: Sequence Diagram – User Profile Management

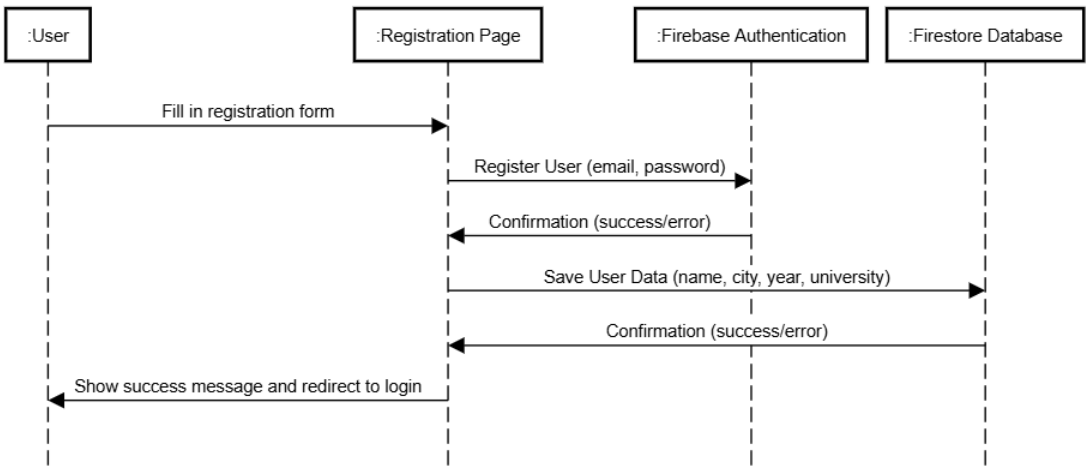

Figure 4.3: Sequence Diagram – Registration

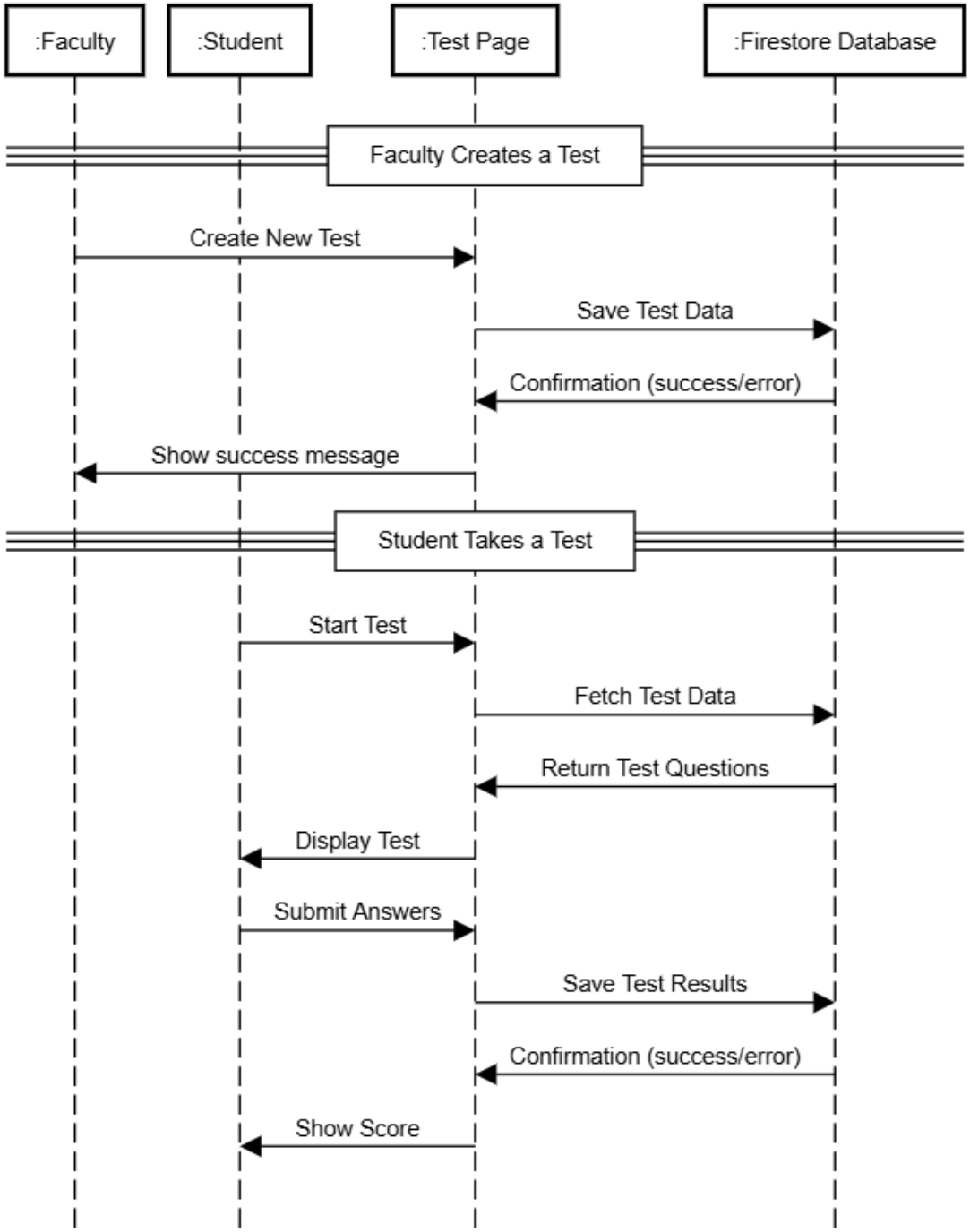

Figure 4.4: Sequence Diagram – Test Managment

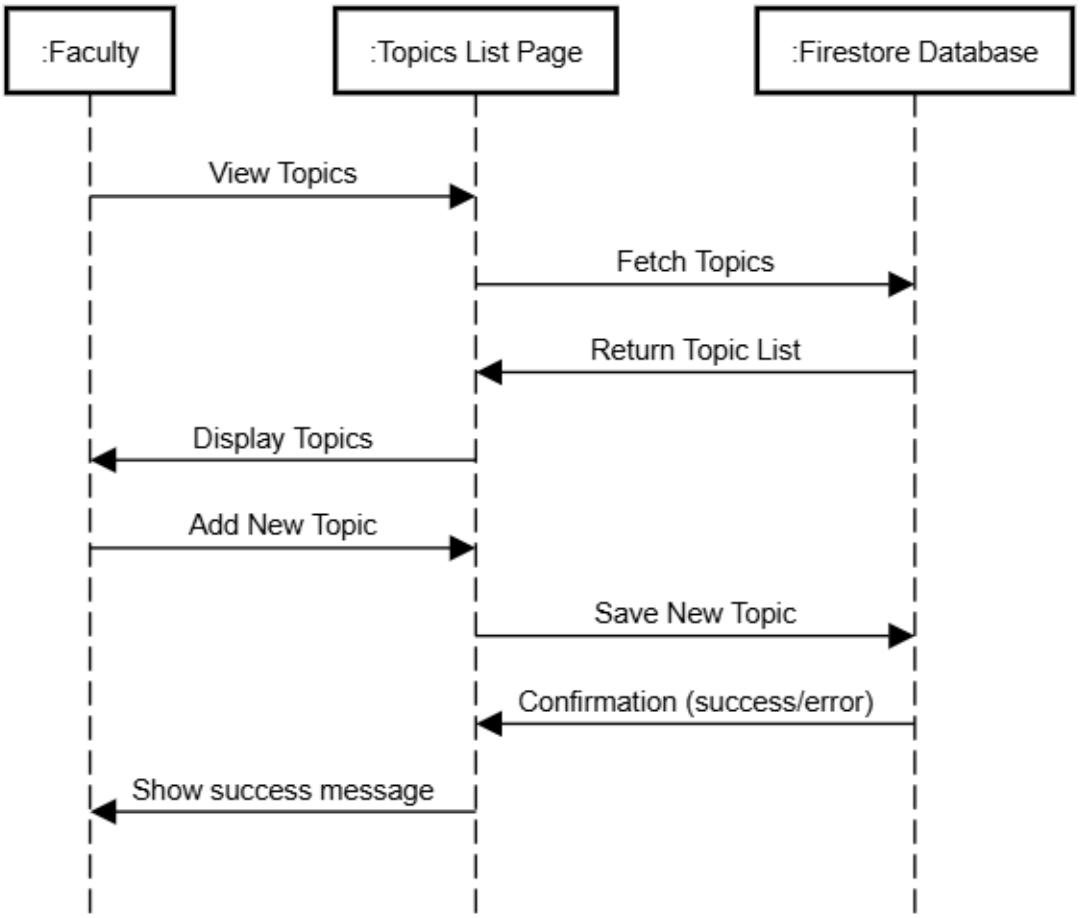

Figure 4.5: Sequence Diagram – Topics Management

4.2.2 UI Design Prototypes

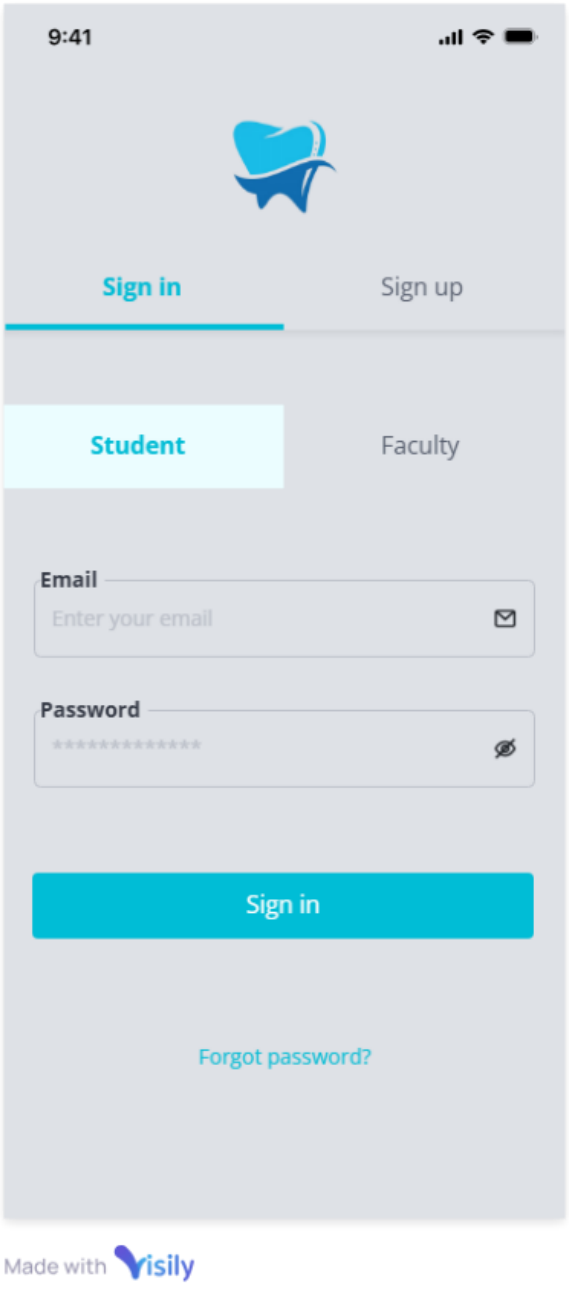

Figure 4.6: UI Prototype - 1

Figure 4.7: UI Prototype - 2

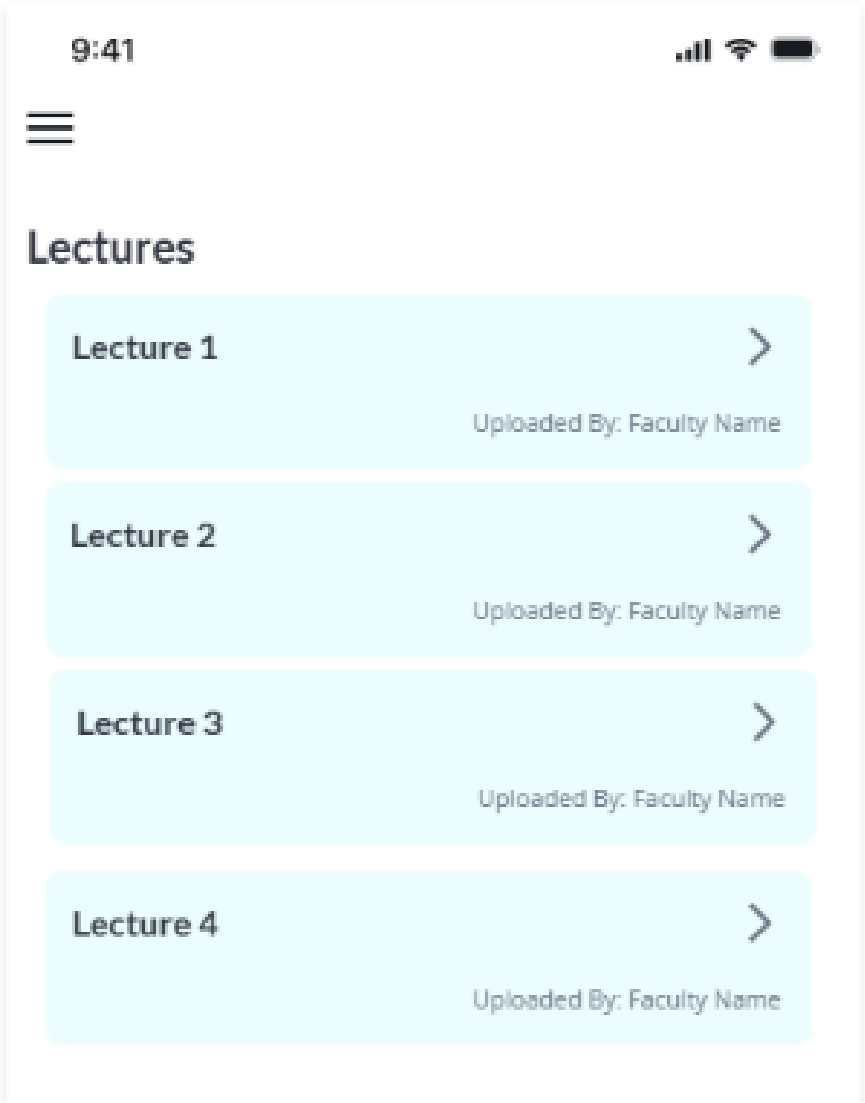

Figure 4.8: UI Prototype - 1

4.2.3 ERD

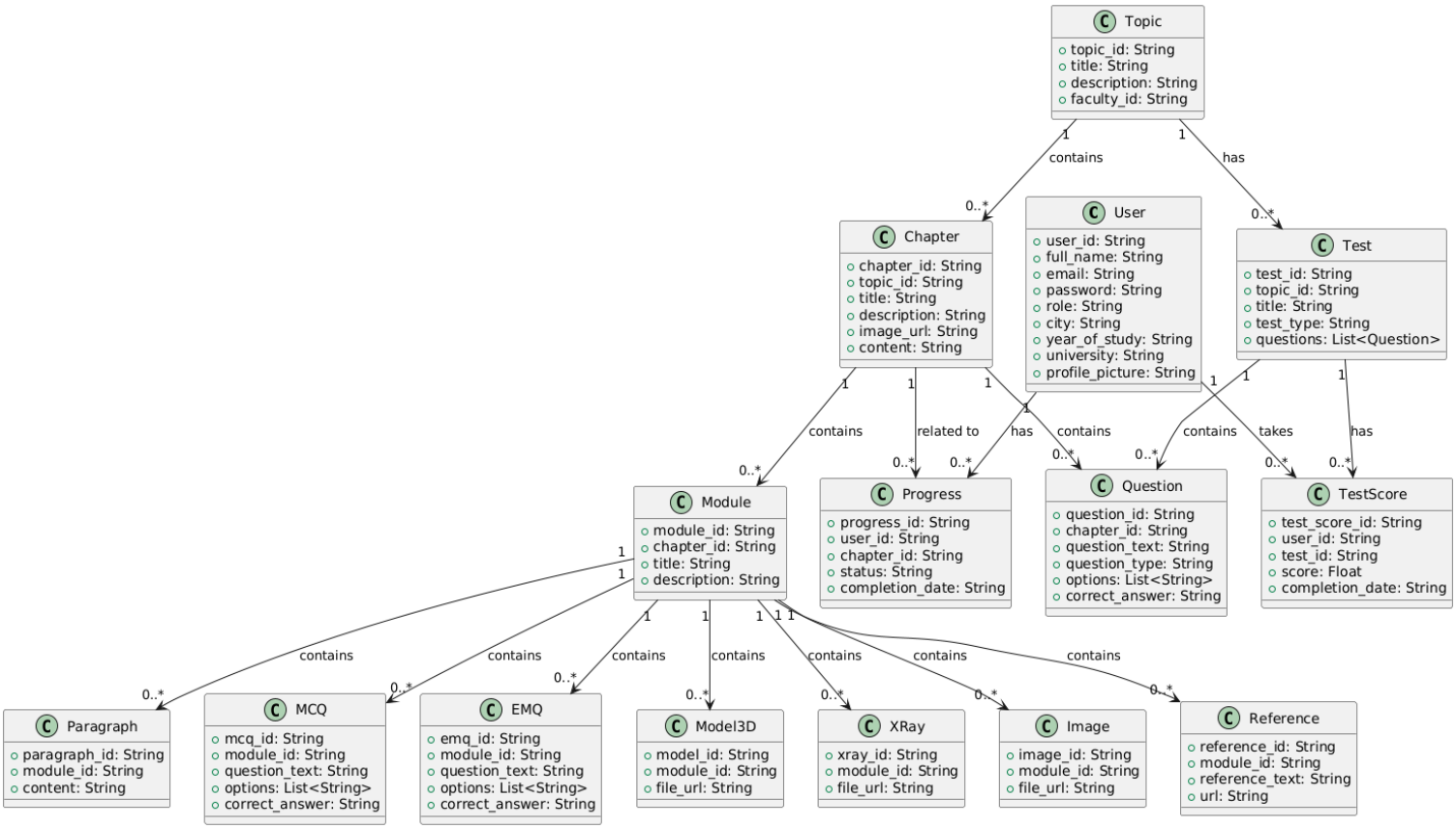

Figure 4.9: ERD

4.2.4 High Level Architecture Diagram

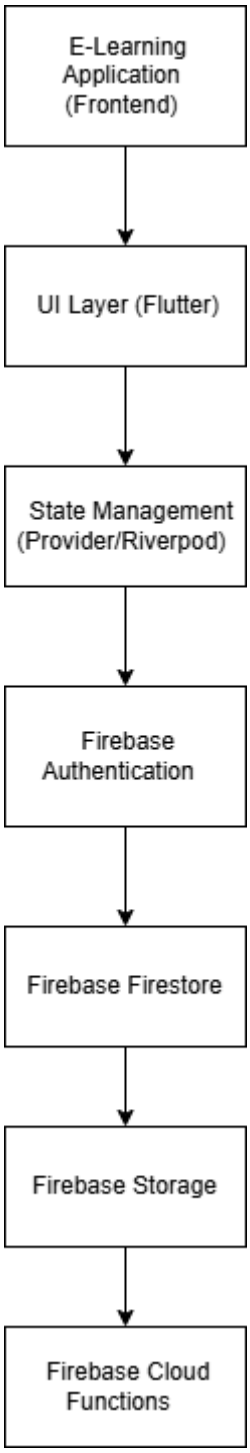

Figure 4.10: High Level System Architecture Diagram

CHAPTER 5

Implementation

The **Interactive Educational Application in Odontogenic Oral Pathology** was developed following the objectives and methodology outlined in the project. The implementation phase focused on creating a functional, user-friendly mobile application that integrates interactive 3D models, quizzes, and learning content for dental students. Below, the key components of the implementation are detailed:

5.1 Development Tools and Technologies

The application was built using the following tools and technologies:

5.1.1 Tools and Technologies

We utilised several tools and technologies that enabled smooth project management, development, and collaboration:

5.1.1.1 GitHub

Used for version control, collaboration, and issue tracking. We used GitHub Issues and Projects to manage our Product Backlog and Sprint Backlog, ensuring transparency and tracking progress.

5.1.1.2 Firebase

Integrated as the backend for user authentication, real-time database, and cloud storage for user data, test results, and 3D models.

5.1.1.3 Flutter

The primary framework used for building the mobile application. Flutter's cross-platform capabilities allowed us to develop for both Android and iOS efficiently.

5.1.1.4 Android Studio

The integrated development environment (IDE) used for Flutter development and debugging.

5.1.1.5 Blender

Used to create the 3D dental models, which were later integrated into the learning content within the app.

5.2 Architecture

The app follows a modular architecture to ensure scalability and maintainability. Key architectural components include:

- **Model-View-Controller (MVC) Pattern:** To separate the application’s data, user interface, and logic, allowing for easier updates and debugging.

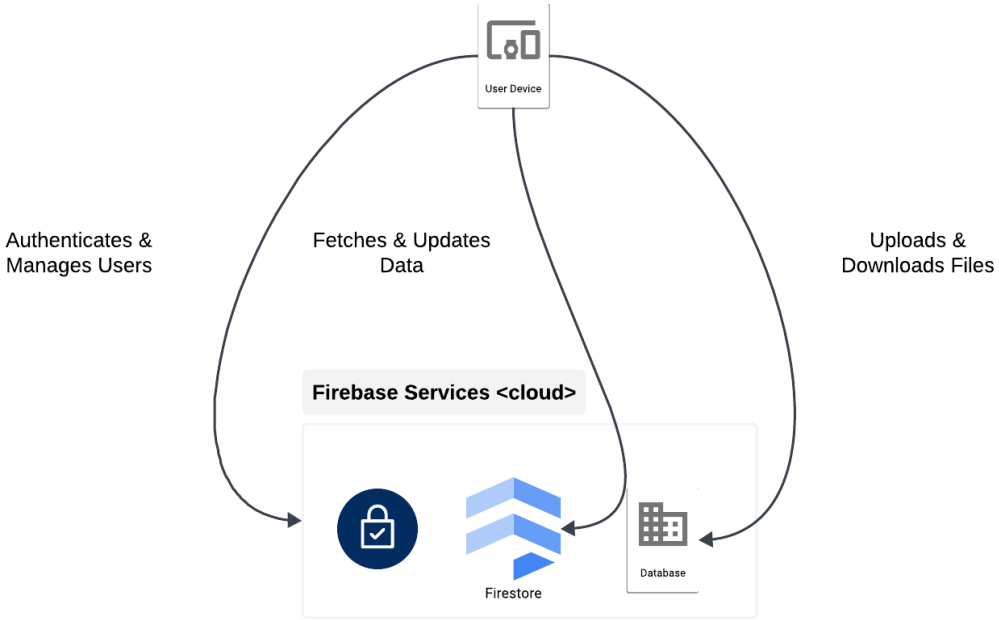

Figure 5.1: Top Level Architecture

- **Firebase Integration:** Cloud Firestore was used to store user data, chapter content, and test results. Firebase Storage was utilized for storing 3D model files and associated images.

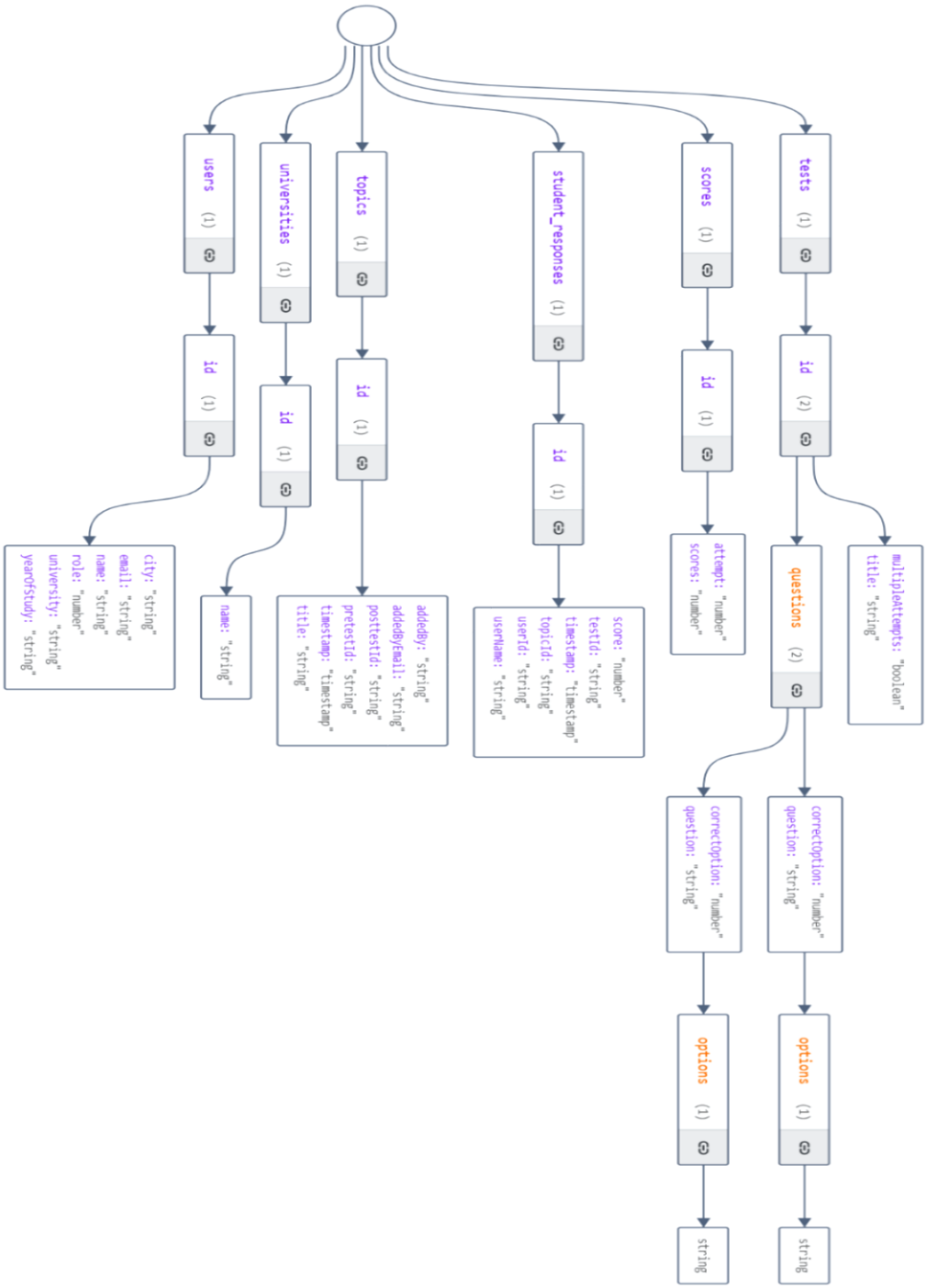

Figure 5.2: Database Structure

- **State Management:** Provider was used for efficient state management, ensuring seamless communication between widgets and data updates.

5.2.1 Key Features and Implementation

5.2.1.1 User Authentication

- Firebase Authentication: Implemented for secure login and registration using email and password.
- Users' data, such as progression and quiz scores, is linked to their accounts for personalized tracking.
- The registration form included validation for user inputs, such as email format and password strength.

5.2.1.2 Learning Section

5.2.1.2.1 3D Models

- Blender was used to design and render interactive 3D models of teeth and odontogenic lesions.
- The 3D models were exported to a compatible format and integrated into the Flutter app using **`flutter_3d_obj`** and **`model_viewer_plus`** packages.
- Students can manipulate the models (rotate, zoom, pan) to explore anatomical structures and pathological conditions.

5.2.1.2.2 Chapter Content

- Each chapter was created as a Firestore document with fields for title, description, and associated 3D model URLs.
- Chapters were displayed dynamically using Firestore queries and a ListView widget for seamless navigation.

- A progression tracker was implemented using a Firestore collection to record chapters completed by users.

5.2.2 Quizzes and Tests

- Quizzes were pre-designed and stored in Firestore with a fixed structure, including various question types such as MCQs (Multiple Choice Questions), image-based questions, scenarios, and EMQs (Extended Matching Questions).
- Each quiz was associated with a specific chapter and displayed using custom widgets tailored to the respective question types.

5.2.2.1 Real-Time Feedback

- After each quiz submission, the app calculated scores and provided instant feedback to the user.
- Test results were stored in Firestore, allowing users to review their scores and progress later.

5.2.3 Additional Features

5.2.3.1 Dark Mode and Accessibility Options

- A settings page was added to toggle between light and dark themes, enhancing usability for different lighting conditions.
- Font scaling options were included to improve readability.

5.2.4 3D Model Integration

5.2.4.1 Model Creation

- Detailed 3D models were designed using Blender, focusing on accuracy and aesthetics to aid in learning.
- Models included pathological variations, such as cysts and tumors, to demonstrate clinical conditions.

4.3.2.1 Model Optimization

- Models were optimized for mobile performance by reducing polygon counts without compromising detail.
- They were exported as `.glb` files, which support interactivity and efficient rendering.

5.2.4.2 Model Viewer Integration

- The `**model_viewer_plus**` package was used to embed 3D models in the Flutter app.
- Custom controls were implemented to allow users to manipulate the models intuitively.

5.3 Testing and Quality Assurance

5.3.1 Unit Testing

- Key application features, such as authentication, data retrieval, and progression tracking, were tested using Flutter's `test` package.

5.3.2 User Acceptance Testing (UAT)

- The app was tested by dental students and faculty to gather feedback on usability and educational effectiveness.
- Feedback was incorporated to refine features such as model interactivity and quiz difficulty levels.

5.3.3 Performance Testing

- The app was tested for performance on multiple devices to ensure smooth rendering of 3D models and efficient data fetching from Firestore.

5.4 Deployment

- **Firebase Hosting:** Used for deploying the web version of the app.
- **Version Control:** Continuous integration and deployment were managed through GitHub Actions, ensuring updates were seamlessly rolled out.

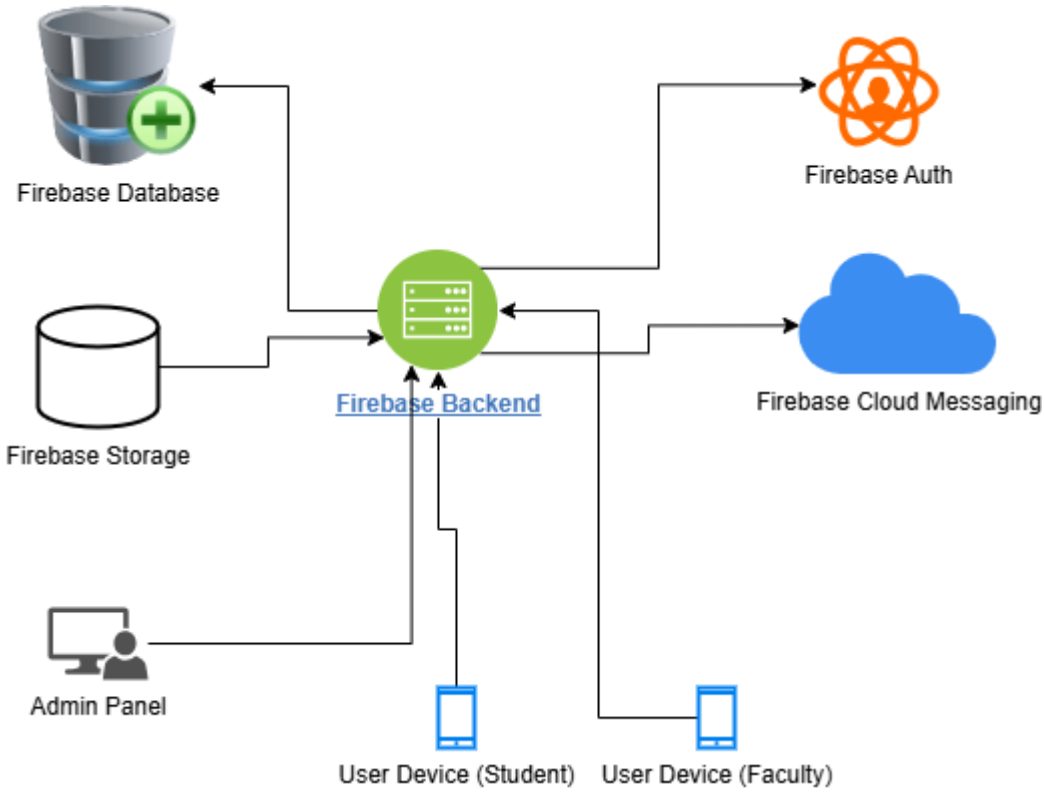

Figure 5.3: Deployment Model

5.5 Challenges and Solutions

5.5.1 Rendering Issues with 3D Models

- **Challenge:** Models with high polygon counts caused performance issues on lower-end devices.
- **Solution:** Simplified models using Blender's decimation tool and tested compatibility across devices.

5.5.2 Data Synchronization Delays

- **Challenge:** Real-time updates from Firestore occasionally lagged during peak loads.
- **Solution:** Implemented caching and optimized Firestore queries to reduce latency.

CHAPTER 6

User Manual for the E-Learning Application

6.1 Introduction

6.1.1 Purpose

Briefly describe the purpose of the application (e.g., "An e-learning application for dental students to study with interactive 3D models, quizzes, and progression tracking").

6.1.2 Target Users

Specify the intended audience (e.g., dental students, educators).
Overview Highlight the main features (e.g., 3D models, topic tests, progress tracking, and user-friendly design).

6.2 System Requirements

6.2.1 Device

Android or iOS device with Flutter-compatible specifications.

6.2.2 Operating System

Android 6.0+ or iOS 11.0+.

6.2.3 Network

Active internet connection for accessing content and syncing progress.

6.3 Installation Instructions

6.3.1 For Android

1. Download the APK from the provided link or store.
2. Allow installations from unknown sources if required.
3. Install and open the application.

6.3.2 For iOS

1. Install from the App Store (if available).
2. Open the application.

6.4 Getting Started

6.4.1 Registration

- Open the app and click **Register**.
- Fill in personal details like name, email, city, and university.
- Set a secure password (must meet specified criteria).
- Confirm registration by verifying your email.

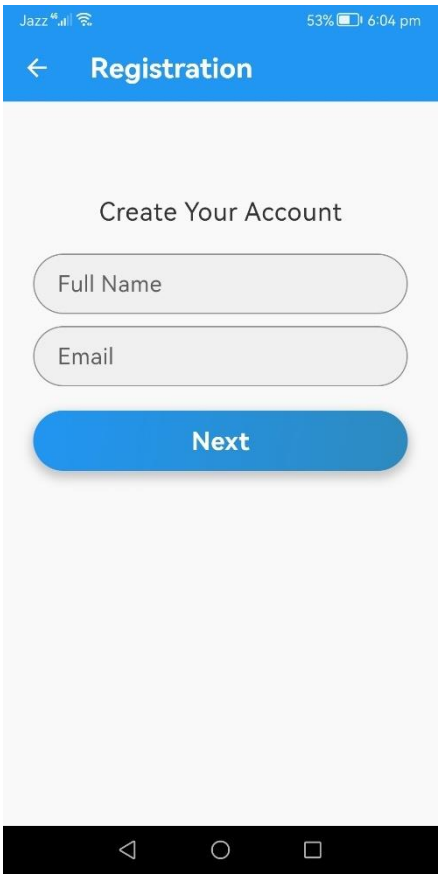

Figure 6.1: Registration Screen 1

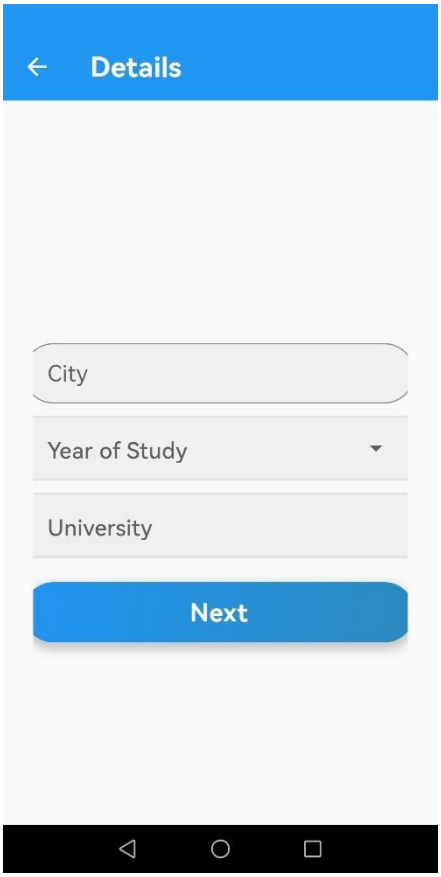

Figure 6.2: Registration Screen 2

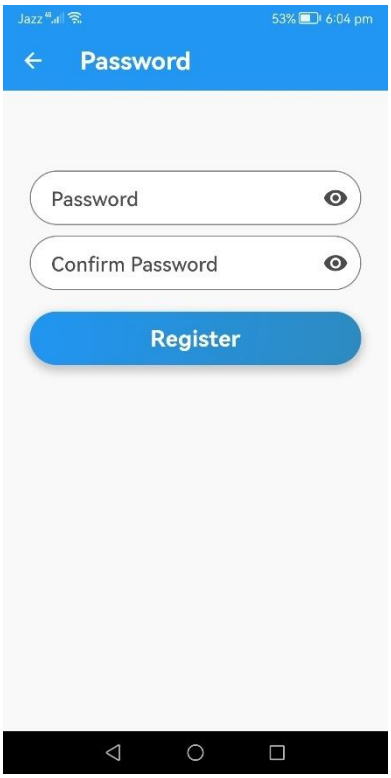

Figure 6.3: Registration Screen 3

6.4.2 Login

Enter your email and password, then tap **Login**.

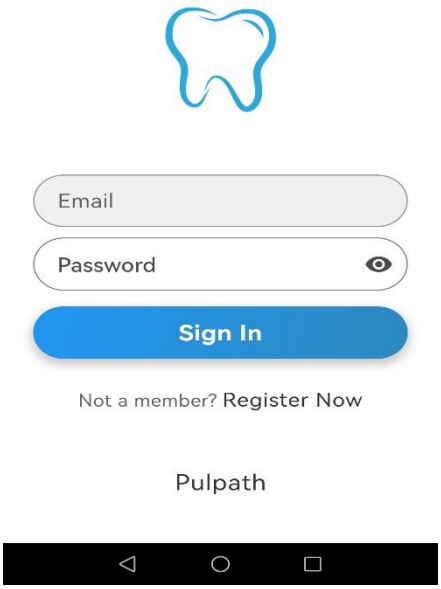

Figure 6.4: Login Screen

6.5 Navigation Guide

6.5.1 Main Features

6.5.1.1 Learning Modules Section

- View available learning modules.
- Navigate through the module to experience scenario-based learning
  - Interact with the learning content with the help of MCQs, EMQs, 3D models

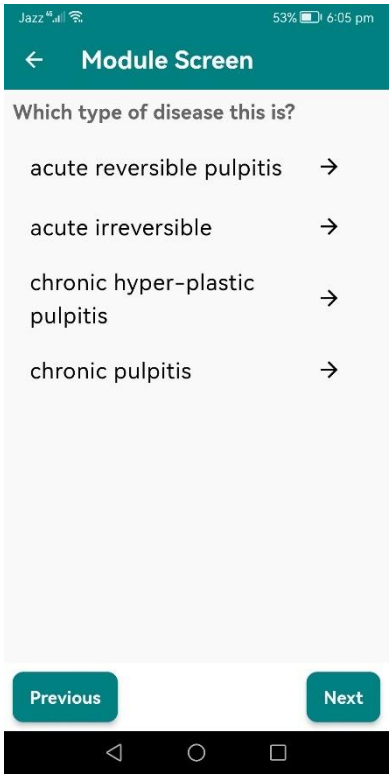

Figure 6.5: Learning Module Screen 1

Figure 6.6: Learning Module Screen 2

Figure 6.7: Learning Module Screen 3

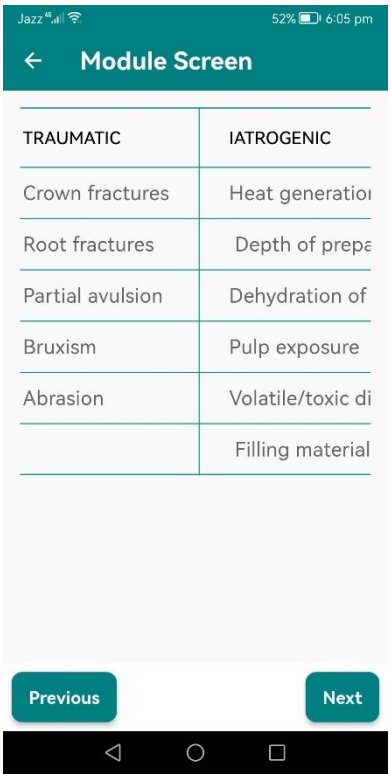

Figure 6.8: Learning Module Screen 4

Figure 6.9: Learning Module Screen 5

Figure 6.10: Learning Module Screen 6

6.5.1.2 Topics Section

- View available topics and chapters.
- Check progression with a progress bar.
- Access chapter details and mark them as completed.

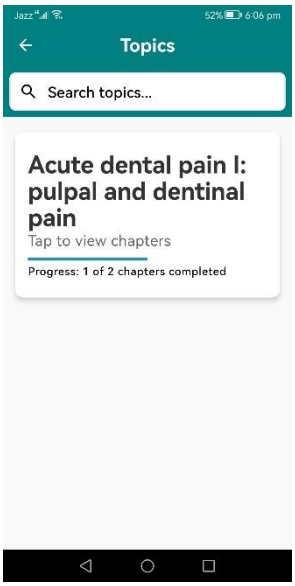

Figure 6.11: Learning Module Screen 7

6.5.1.3 Chapter Details

- View detailed content, including text, images, and 3D models.
- Scroll through descriptions and interact with models.

Figure 6.12: Learning Module Screen 8

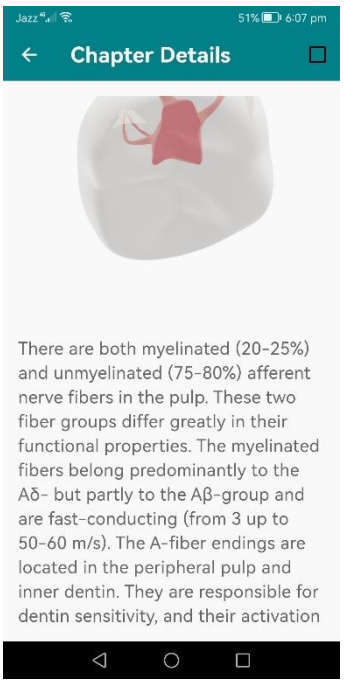

Figure 6.13: Learning Module Screen 9

6.5.1.4 Tests Section

- Take pre-tests and post-tests.
- View your scores after completion.

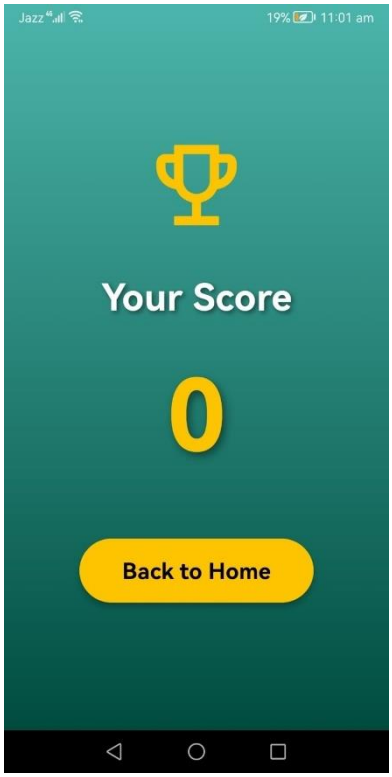

Figure 6.14: Test Result Screen

6.5.1.5 Profile Section

- Update personal details.
- View progression and scores.

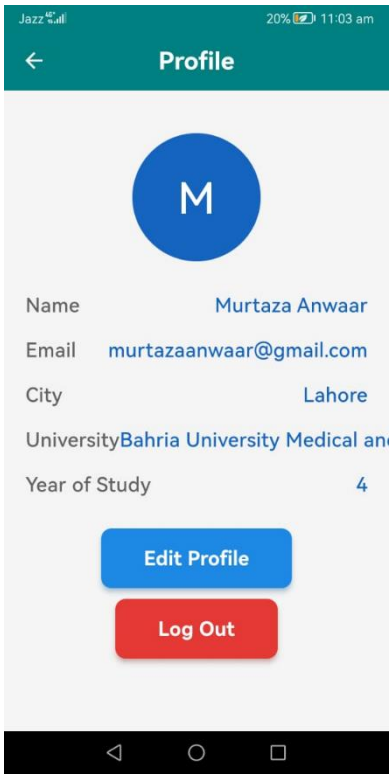

Figure 6.15: User Profile Screen

6.5.1.6 Navigation Options

- Use the side drawer for quick access to all sections.
- Use the back button to return to the previous screen.

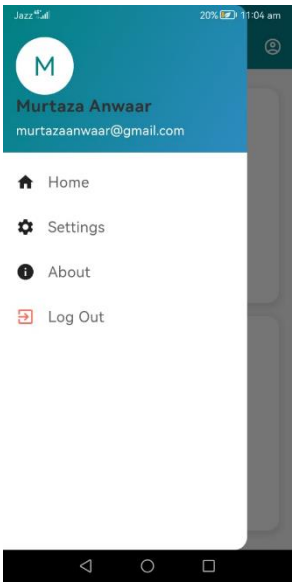

Figure 6.16: Navigation Drawer

6.5.2 Common Features

6.5.2.1 Dark Mode/Light Mode

Toggle Customize the app's appearance to your preference.

6.5.2.2 Progress Tracking

Automatically updates as you complete chapters and tests.

6.5.3 Advanced Features

6.5.3.1 Interactive 3D Models

Pinch, zoom, and rotate models for an immersive learning experience.

6.5.3.2 Dynamic Tests

Questions adapt to the topic being studied.

6.5.3.3 Faculty Features

Add, edit, and manage topics, chapters, and tests.

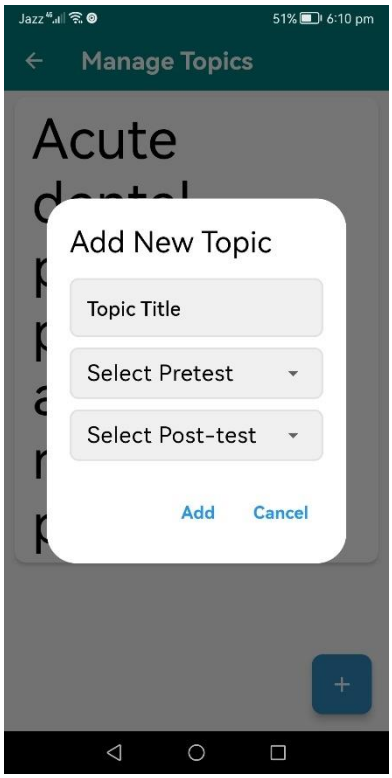

Figure 6.17: Add New Topic Screen 1

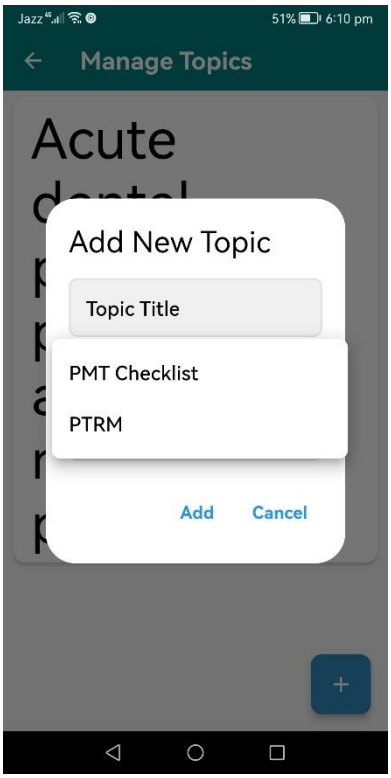

Figure 6.18: Add New Topic Screen 2

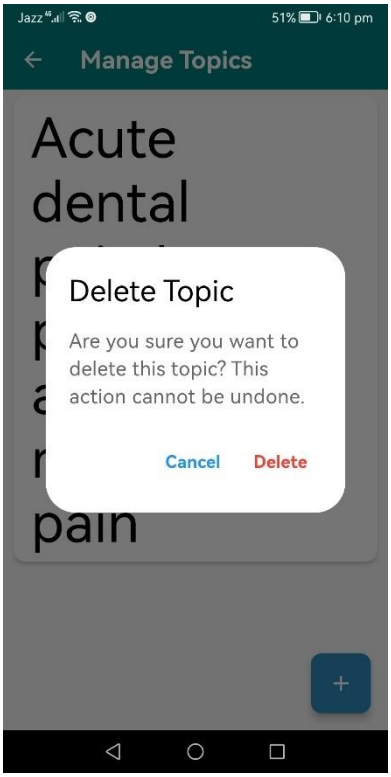

Figure 6.19: Delete Topic Screen

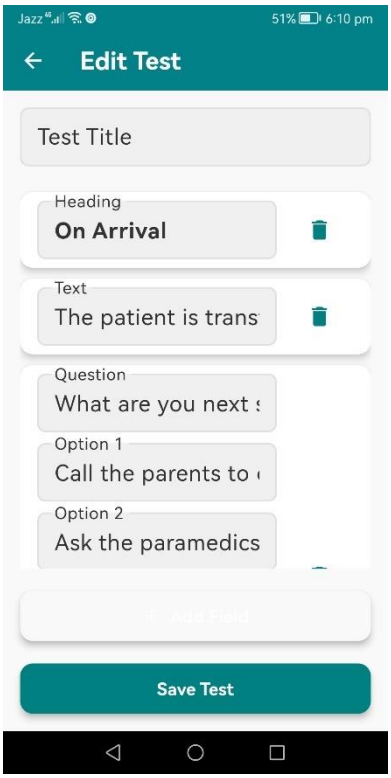

Figure 6.20: Edit Test Screen

6.5.4 Troubleshooting

6.5.4.1 App Not Loading

Ensure your internet connection is stable.

6.5.4.2 Errors in Test Submission

Retry or contact support.

6.5.4.3 Support & Feedback

- **Contact Us:** The methods for reaching out to the developers' team is mentioned in the app's "Developers" section.

6.5.5 Admin Panel

- A web based dedicated admin panel has been developed. The admin has the access to overview and modify content, user access, generate reports.

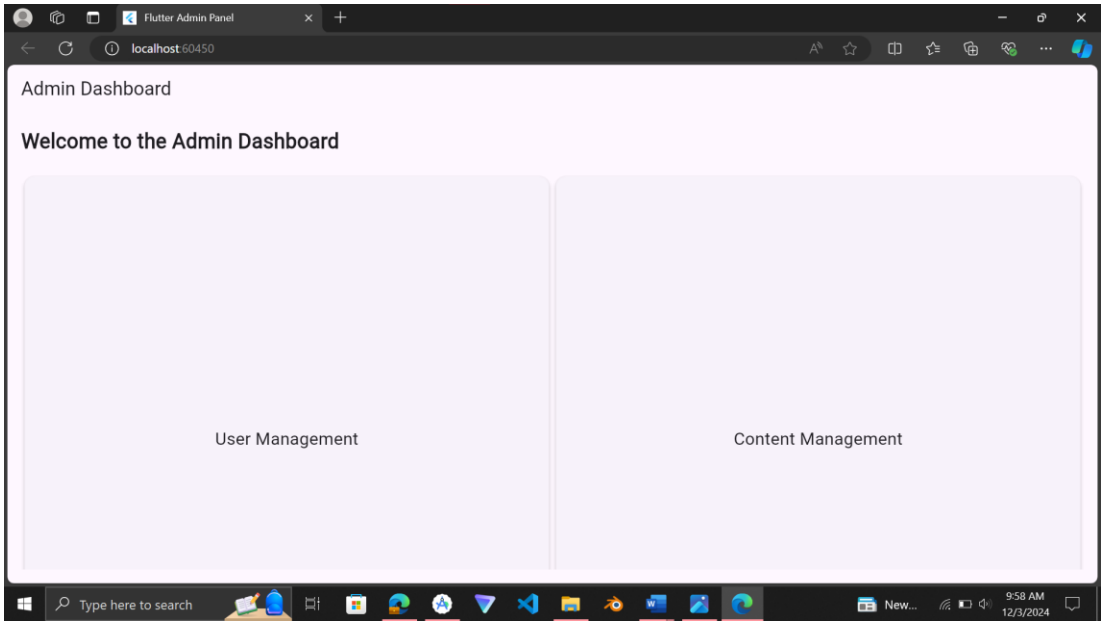

Figure 6.21: Admin Panel Screen 1

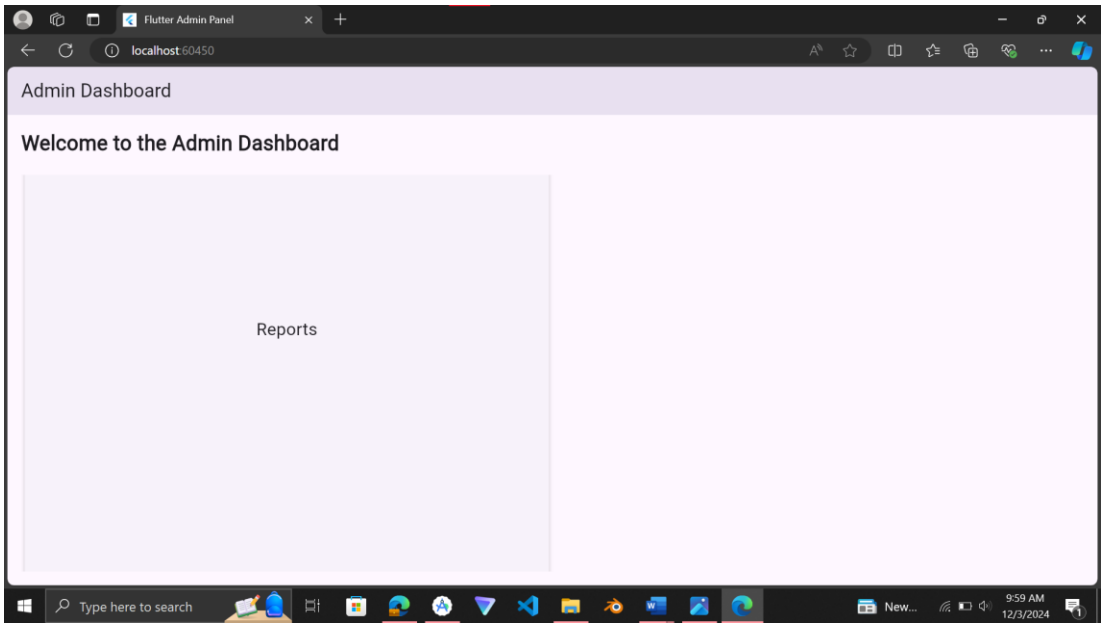

Figure 6.22: Admin Panel Screen 2

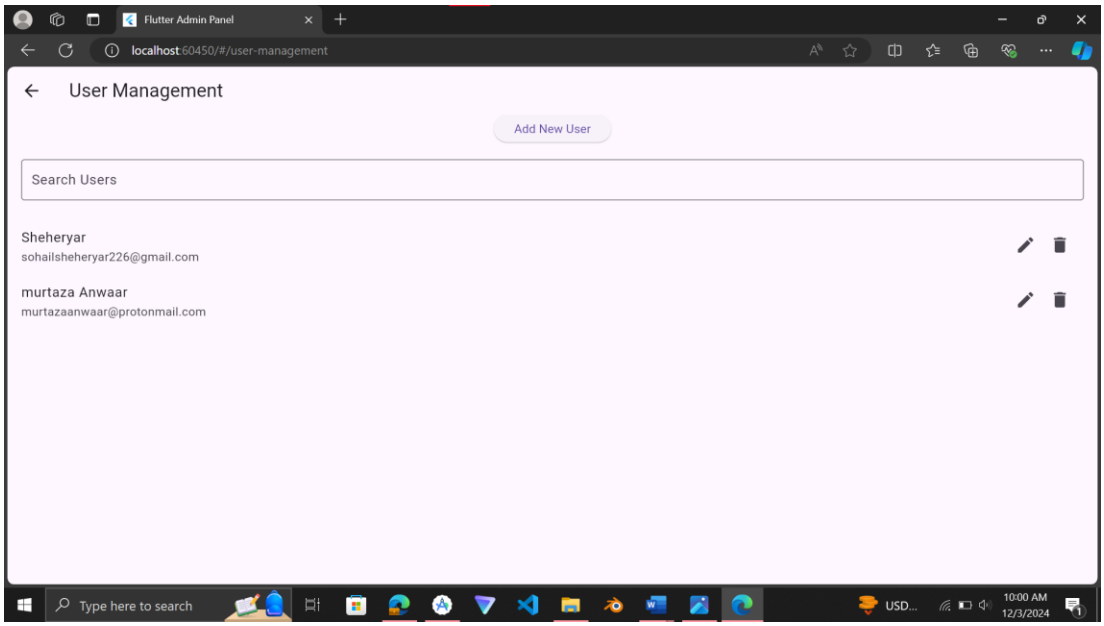

Figure 6.23: Admin Panel Screen 3

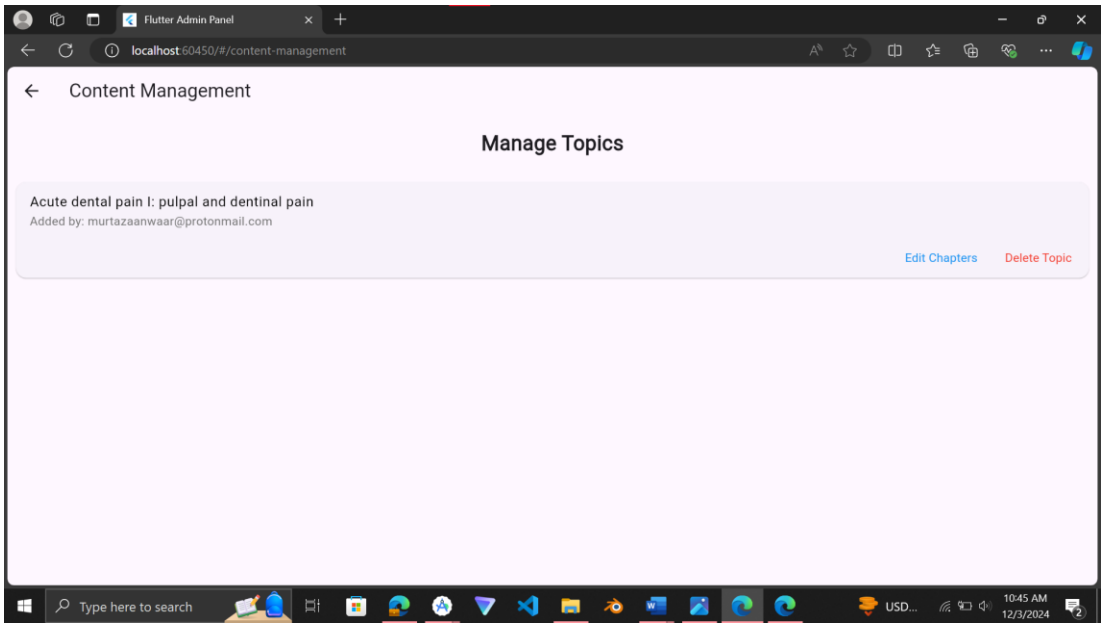

Figure 6.24: Admin Panel Screen 4

CHAPTER 7

Conclusion & Recommendations

7.1 Conclusion

The development of the e-learning application for dental students has successfully addressed the need for an interactive, accessible, and engaging platform to enhance dental education. By integrating innovative features such as scenario-based learning, 3D models, and assessments like MCQs and EMQs, the application provides a comprehensive learning experience. Additionally, the progress tracking system and test results enable students to monitor their growth, ensuring a structured approach to their studies.

The modular design of the application ensures flexibility, making it easy to expand and incorporate additional features in the future. The combination of modern technology and educational needs has resulted in an efficient tool that bridges the gap between theoretical knowledge and practical application in dental studies.

Overall, this project demonstrates the potential of technology to transform traditional educational methods, providing a scalable and user-friendly solution to improve learning outcomes.

7.2 Recommendations

7.2.1 Expand Content Variety

- Include more topics and chapters covering broader aspects of dental education.
- Collaborate with subject matter experts to ensure the accuracy and relevance of content.

7.2.2 Enhance 3D Model Features

- Enable more interactive functionalities, such as simulations or procedural animations, to deepen learning.

7.2.3 Incorporate Advanced Assessments

- Introduce subjective or open-ended questions for critical thinking evaluation.
- Provide personalized feedback and suggestions based on test performance.

7.2.4 Multi-Language Support

- Add language options to cater to a wider audience globally.

7.2.5 Gamification

- Integrate elements like badges, leaderboards, and rewards to motivate students and make learning more engaging.

7.2.6 Offline Access

- Allow content download for offline use, ensuring accessibility for students with limited internet connectivity.

7.2.7 Regular Updates

- Continuously update the application with new content and features based on user feedback and evolving educational needs.

7.2.8 Data Security

- Ensure the application complies with modern data privacy and security standards to protect user information.

By implementing these recommendations, the application can further solidify its role as a transformative tool in dental education and expand its reach and effectiveness.

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APPENDICES

Appendix A Collaborator's Biography

Dr. Asifa Iqbal
Dentist | Oral and Maxillofacial Surgeon

Dr. Asifa Iqbal is a practicing dentist and oral and maxillofacial surgeon with **over 15 years of experience**. She holds a **BDS** from **De'Montmorency College of Dentistry, Lahore**, and advanced qualifications from **King Edward Medical University, Lahore**.

The idea for the interactive e-learning application for dental students was conceived by Dr. Asifa to conduct a study on the efficacy of such platforms in enhancing dental education. Her expertise and collaboration were integral to the development of the application, ensuring it effectively addressed the learning needs of dental students.

Figure A1: The development team with Dr. Asifa Iqbal, our collaborator, and Dr. Iram Noreen, our supervisor, during the project discussion.

Appendix B Interview with Project Collaborator

Project: Interactive Educational Application in Odontogenic Oral Pathology

Supervisor: Dr. Iram Noreen

Agenda: Meeting with Collaborator

Members:

- Dr. Iram Noreen
- Dr. Asifa
- Murtaza Anwaar
- Sheheryar Sohail

Objective(s):

- **Review of Project Goals**
- **Discussion of Key Tasks and Responsibilities**
- **Clarification of Deliverables**

Collaborator's Questions:

Sr.no	Questions	Actions
1	What is your general understanding of Oral Pathology?	Oral Pathology involves studying diseases and abnormalities affecting the oral and maxillofacial regions. It focuses on diagnosing and understanding disease progression in tissues such as gums, teeth, tongue, and jaws. The e-learning app will include detailed educational materials

		covering various oral pathologies to aid students in understanding these conditions.
2	How will you integrate models with different phases of Disease progression?	• **3D Visualization:** Interactive 3D models will illustrate different stages of diseases, from healthy conditions to advanced stages. • **Phased Learning:** Content will be categorized by disease progression phases, providing students with structured, step-by-step learning. • **Interactive Features:** Sliders or clickable stages will allow users to explore models dynamically. • **Linked Resources:** Models will be integrated with chapter content for context.
3	Can an outsider be able to use the app?	Outsider access will be regulated: • **Guest Mode:** Provide limited access to sample chapters or preview materials. • **Authentication:** Full access will require user registration, ensuring only authorized individuals (students, teachers, or professionals) can access sensitive resources.

4	Based on these different logins, what can teacher login have access to?	Teachers will have access to: • Creating and managing topics and chapters. • Uploading educational materials, including 3D models and test content. • Monitoring student progress and performance. • Managing test scores and responses.
5	Can we add a time stamp to track student active hours?	A time stamp feature can be integrated to: • Track the duration students spend on specific topics, chapters, or tests. • Generate reports for active hours, helping teachers understand engagement levels.
6	I need a routing functionality when students like specific information can it be possible?	The app can incorporate a recommendation or routing system: • If a student marks specific information as useful, they can be routed to related topics or chapters. • Suggestions can be shown on their dashboard based on preferences or learning behavior.
7	A student wants to listen rather than read the content. How will it be done?	To support students who prefer listening over reading: • Include a **Text-to-Speech (TTS)** feature to convert text content into audio. • Upload pre-recorded audio lectures or explanations for chapters.

		• Allow students to toggle between reading and listening modes. •
8	How many accounts the app can handle?	The app will be designed to handle: • A large number of accounts by leveraging Firebase Authentication and Firestore for efficient user management. • Scalability measures will ensure smooth performance even with thousands of simultaneous users.

Appendix C Meeting Minutes with Collaborator

Bahria University,
Lahore Campus
Department of
Computer Sciences
(Spring 2024)

Project: Interactive Educational Application in Odontogenic Oral Pathology

Supervisor: Dr. Iram Noreen

Agenda: Meeting with Collaborator

Members:

- Dr. Iram Noreen
- Dr. Asifa
- Murtaza Anwaar
- Sheheryar Sohail

Objective(s):

- **Discussion related to first module**
- **Clarification of Deliverables**

Collaborator's Questions:

Sr.no	Questions	Actions
1	How does your application enhance the learning experience compared to traditional teaching methods?	Our application enhances learning by using 3D models and interactive features to visualize complex concepts, bridging the gap between theory and

		practice. It promotes active engagement, offers flexible access, and provides immediate feedback, surpassing the limitations of traditional methods.
2	I want to implement the Emq theme in the first module, Can it be possible?	Yes it can be possible by answering the multiple choice question in the app and the answer will be given as soon as the student select a choice eliminating the risk of further error.
3	What metrics or feedback mechanisms have you used to evaluate whether the quizzes and assessments are reinforcing the learning objectives effectively?	Score type evaluation is used in the app it will automatically add the assigned score to the student on answering correct.
4	How have you ensured the technical stability of the application, particularly across different platforms like desktop and mobile devices?	Yes, we developed the app in flutter which support both platforms.
5	Were there any significant technical challenges during development, such as performance issues or compatibility problems? How did you overcome them?	Yes integrating 3d models in the app, flutter_3d_obj library did not support these model. model_viewer_plus library supported these models.

Appendix D Project Progress Table

Month	Date	Agenda	Participants
March	1/03/24	Proposal Drafting	Murtaza, Sheheryar
April	5/04/24	Interview with Collaborator	Dr. Asifa Iqbal, Dr. Iram Noreen, Murtaza, Sheheryar
May	3/05/24	Domain Knowledge Meeting with collaborator	Dr. Asifa Iqbal, Murtaza, Sheheryar
June	7/06/24	Prototyping	Murtaza, Sheheryar
July	5/07/24	Development Initialization	Murtaza, Sheheryar
August	2/08/24	Module 1 – Discussion	Murtaza, Sheheryar
September	6/09/24	Module 1 – First Deliverable	Murtaza, Sheheryar
October	4/10/24	Module 2,3 - Deliverable	Murtaza, Sheheryar
November	1/11/24	Mock Demo	Dr. Iram Noreen, Murtaza, Sheheryar
December	1/12/24	Documentation	Murtaza, Sheheryar

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