



FPT UNIVERSITY

Capstone Project Document

Learner Management and 3D Simulation System for Crane Training Center

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Capstone Project code	FA25SE097

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Definition and Acronyms

Acronym	Definition
LSSCTC	Learner Management and 3D Simulation System for Crane Training Center
BA	Business Analysis
BR	Business Rule
ERD	Entity Relationship Diagram
GUI	Graphical User Interface
PM	Project Manager
SDD	Software Design Description
SPMP	Software Project Management Plan
SRS	Software Requirement Specification
UAT	User Acceptance Test
UC	Use Case

API	Application Program Interface
FE	Feature
SI	Simulation Feature
LI	Limitation
EX	Exclusion
SIM	Simulation
VR	Virtual Reality
HTTPS	Hypertext Transfer Protocol Secure
CORS	Cross-Origin Resource Sharing
NCCER	National Center for Construction Education and Research
ITI	Industrial Training International
REST	Transmission Control Protocol
DBMS	Database Management System
ORM	Object-Relational Mapping
PK	Primary Key
FK	Foreign Key
SMTP	Simple Mail Transfer Protocol
SQL	Structured Query Language
TE	Theory Exam (of Final Exam)
SE	Simulation Exam (of Final Exam)
PE	Practical Exam (of Final Exam)

I. Project Introduction

1. Overview

1.1 Project Information

- Project name: Learner Management and 3D Simulation System for Crane Training Center
- Project code: FA25SE097
- Group name: GFA25SE59
- Software type: Web App, Desktop App

1.2 Project Team

Full Name	Role	Email	Mobile
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2. Product Background

Crane operation training requires a combination of theoretical understanding and significant practical experience. Traditional training methods that rely exclusively on real cranes present several major challenges. These include high operational costs (fuel, maintenance, instructor time), limited availability of physical equipment for trainees, and most importantly, significant safety risks for beginners operating heavy machinery.

Training centers often struggle with the logistics of managing training schedules, effectively tracking the progress of numerous trainees, and ensuring a consistent quality of instruction. Furthermore, without modern simulation tools, trainees may lack sufficient and safe preparation before they are required to operate real, high-risk equipment. This situation leads to a demand for an integrated system that can streamline training center management while also providing a safe, realistic, and cost-effective 3D simulation environment to enhance learning efficiency and reduce operational risks.

3. Existing Systems

3.1 ITI (Industrial Training International)

Link 1: [ITI Simulator Capture](#)

Link 2: [ITI Courses](#)

ITI offers a complete ecosystem that combines its Learning Management System with a massive library of VR Crane Simulations. Performance metrics from the simulation (e.g., pass/fail, efficiency) are automatically fed back into the student's record in the LMS.

They offer a wide variety of scenarios and crane models. However, ITI Simulator relies on high-cost Virtual Reality (VR) hardware, which can be expensive to deploy to a large number of trainees simultaneously.

3.2 CM Labs Simulations (Vortex)

Link: [CM Labs Main Site](#)

CM Labs is a market leader in high-fidelity, physics-based simulation for heavy equipment. They are widely regarded for providing the most accurate simulation of crane physics and machine behaviour. CM Labs support both normal setup and high-cost alternative.

However, they are not a complete LMS and require training center to maintain a separate LMS integration. That leads to significant complexity and cost.

3.3 NCCER (National Center for Construction Education and Research)

Link: [NCCER Mobile Crane Course](#)

NCCER provides a standardized curriculum and a registry system (LMS) for managing craft training, assessments, and certifications, including for crane operators. This system is a leader in managing the theoretical and book-learning components of training.

However, NCCER is not integrated with any 3D Simulator, and highly relies on available devices. This creates a significant gap between theory and practice, introduces high safety risks for new trainees, and incurs high operational costs (fuel, machine wear, instructor time).

4. Business Opportunity

The heavy equipment training industry faces persistent operational and financial challenges. Training centers are constrained by the high operational costs of machine fuel and maintenance, significant safety risks for novice operators, and the low scalability of one-on-one physical instruction. Concurrently, the administrative burden of managing trainee schedules, tracking theoretical progress, and logging practical results is a major logistical inefficiency.

There is a strong demand for a single, cost-effective system that can streamline workflows through a central web-based Learning Management System, while cutting the gap between theory and high-risk practice by providing a safe, low-cost, and repeatable 3D simulation environment.

5. Software Product Vision

For crane training centers seeking to modernize their curriculum, enhance safety, and reduce operational costs, LSSCTC is an integrated software suite that provides a unified system for both theoretical and practical training.

The system combines a comprehensive web-based LMS for managing courses, users, and progress, with an accessible desktop 3D simulation application for hands-on practice. This approach empowers training centers to deliver a scalable and cost-effective program that improves trainee preparedness and safety, while simultaneously providing administrators and instructors with a centralized tool to manage the learning lifecycle.

6. Project Scope & Limitations

6.1 Major Features

6.1.1 Web Application for Admin

FE-01: Login/Logout.

FE-02: Manage personal profile: view profile, update profile, change password.

FE-03: Manage user account: view user account, add user account, deactivate user account.

FE-04: Manage program: view program, add new program, update program, assign course for program.

FE-05: Manage course: view course, add new course, update course.

FE-07: Manage class: view class, add new class for specific course, update class, assign instructor.

FE-08: Manage simulation timeslot: view slot, add new slot, update slot, assign practice to slot.

6.1.2 Web Application for Simulation Manager

FE-09: Manage personal profile: view profile, update profile, change password.

FE-10: Manage simulation component: view component, add new component, update component.

FE-11: Manage simulation task: view action, add new action, update action.

FE-12: Manage simulation practice: view practice, add new practice, update practice.

6.1.3 Web Application for Instructor

FE-13: Login/Logout.

FE-14: Manage personal profile: view profile, update profile, change password.

FE-15: Manage class member: view member, add new member.

FE-16: Manage class section: view section, add new section, update section.

FE-17: Manage learning material: view material, add new material, update material, assign material to section.

FE-18: Manage quiz: view quiz, add new quiz, update quiz, assign quiz to section.

FE-19: View list practices and can assign practices to class section.

FE-20: View trainee result on quizzes and practices and can provide direct feedback.

FE-21: View trainee overall performance in class and can confirm pass or fail result for each trainee in class.

FE-22: Manage final exam: setup Theory Exam, Simulation Exam, Practical Exam.

FE-23: Take attendance.

6.1.4 Web Application for Trainee

FE-24: Login/Logout.

FE-25: Manage personal profile: view profile, update profile, change password.

FE-26: View available programs, courses, classes, and can make enrolment.

FE-27: View class syllabus and sections.

FE-28: View learning material assigned to class section and can access or download material.

FE-29: View quizzes assigned to class section and can make attempt or view recorded results.

FE-30: View practices assigned to class section and can view recorded results.

FE-31: Take final exam

6.1.5 3D Simulation Application for Trainee (Desktop)

SI-01: Login/Logout.

SI-02: View list practices in which trainee is assigned to and can select a practice to make new attempt.

SI-03: View simulation guides and settings.

SI-04: View practice steps and step details (including target components, target actions, expected outcome).

SI-05: View simulation components, and can make action (inspect definition, lift, rotate).

SI-06: View step result and warning message when committing an error.

SI-07: View post-practice result (time, completion status).

6.2 Limitations & Exclusions

Limitations:

LI-01: Simulation Platform: The 3D Simulation Application (6.1.5) is a desktop-only application (Windows/Linux/macOS) and is not accessible via web browser or mobile device.

LI-02: Simulation Scope: The simulation practice does not perfectly represent real-world crane models and physics.

LI-03: Content Management: The system provides feature to manage program content and simulation settings, but it does not include creating core assets and scripts inside simulation environment.

Exclusions:

EX-01: Payment and Billing: The system does not support any payment processing or billing features.

EX-02: Communication: The system does not support comments, live chat or discussion forum. Feedback feature is private.

EX-03: Final Examination: The system is a training and preparedness tool, not a final certification authority. All official, final examinations (the hands-on, practical test with real crane vehicle, in-person written exams) are conducted offline and are outside the scope of this system.

EX-04: Course Certificate: The system issues Certificate of Training / Certificate of Completion to validate that a trainee has finished a course within the training centre. The issuance does not connect to, or submit result to, any government and regulatory body.

II. Project Management Plan

1. Overview

1.1 Scope & Estimation

#	WBS Item	Complexity	Est. Effort (man-days)
1	Web Application for Admin		22
1.1	FE-01: Login/Logout	Simple	2
1.2	FE-02: Manage personal profile	Simple	2
1.3	FE-03: Manage user account	Medium	4
1.4	FE-04: Manage program (assign courses)	Medium	5
1.5	FE-05: Manage course	Simple	3
1.6	FE-07: Manage class (assign instructor)	Medium	6
2	Web Application for Simulation Manager		32
2.1	FE-08 & FE-09: Auth & Profile	Simple	2
2.2	FE-10: Manage simulation component	Complex	6
2.3	FE-11: Manage simulation action	Medium	5
2.4	FE-12: Manage simulation practice	Complex	7
2.5	FE-13: Manage practice step	Complex	6
2.6	FE-14: Manage practice warning	Medium	3
2.7	FE-15: Manage simulation timeslot	Medium	3
3	Web Application for Instructor		28
3.1	FE-16 & FE-17: Auth & Profile	Simple	2
3.2	FE-18: Manage class member	Simple	2

3.3	FE-19 & FE-20: Manage sections & materials	Medium	6
3.4	FE-21: Manage quiz (assign to section)	Medium	6
3.5	FE-22: View & assign practices	Simple	3
3.6	FE-23: View results & provide feedback	Medium	5
3.7	FE-24: View overall performance & grading	Medium	4
4	Web Application for Trainee		24
4.1	FE-25 & FE-26: Auth & Profile	Simple	2
4.2	FE-27: View programs/enrollment	Medium	4
4.3	FE-28 & FE-29: View syllabus & materials	Simple	3
4.4	FE-30: Quiz attempt & history	Complex	8
4.5	FE-31: View practice results	Simple	3
4.6	System Integration (API & Database)	Complex	4
5	3D Simulation Application (Desktop)		45
5.1	SI-01: Login/Logout (API Integration)	Simple	3
5.2	SI-02: List practices & selection	Medium	4
5.3	SI-03 & SI-04: Guides, Settings & Steps UI	Medium	6
5.4	SI-05: Simulation Physics (Lift, Rotate, Inspect)	Complex	15
5.5	SI-06: Error detection & warning system	Complex	10
5.6	SI-07: Result calculation & submission	Medium	7
	Total Estimated Effort (man-days)		151

1.2 Project Objectives

#	Testing Stage	No. of Defects	% of Defect	Notes
1	Reviewing	40	35%	
2	System Test	45	40%	
3	Acceptance Test	20	25%	

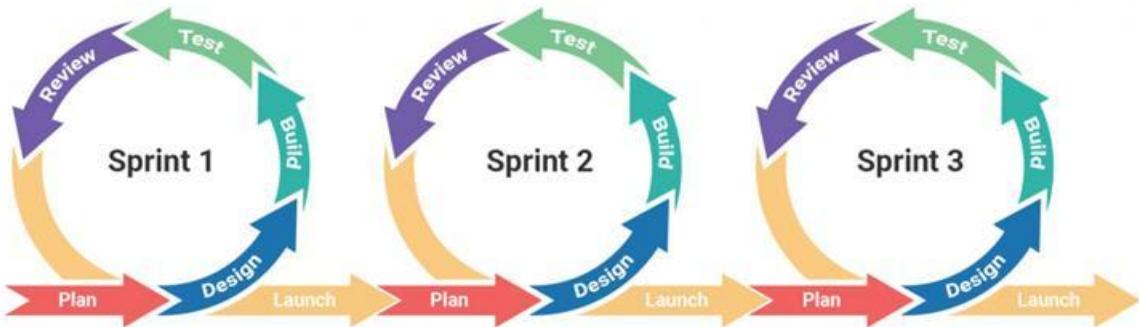
1.3 Project Risks

#	Risk Description	Impact	Possibility	Response Plans
1	Technology risk: to target available tools and framework for project overall requirements	High	Medium	Do research and testing of different technical solutions before developing main features.
2	Requirement misunderstanding risk: to correctly specify each requirement based on real-world scenarios and best-practice solution	High	High	Verify requirements with evaluation from realistic data or references, have reviews with stakeholders.

2. Management Approach

2.1 Project Process

The project will be executed using the Agile software development methodology, specifically the Scrum framework. This approach allows the team to adapt to changes quickly, deliver incremental value, and ensure continuous feedback throughout the development lifecycle.



Sprints: The development timeline is divided into 2-week Sprints. Each sprint focuses on delivering a specific set of features (from the Product Backlog) that results in a potentially shippable product increment.

Key Roles:

- **Product Owner (Leader):** Responsible for defining the product vision, managing the Product Backlog, and prioritizing features based on stakeholder value.

- Scrum Master (Rotational/Assigned): Ensures the team adheres to Scrum practices, removes obstacles (blockers), and facilitates meetings.
- Development Team (All Members): Cross-functional members responsible for designing, coding, testing, and integrating the software.

Scrum Ceremonies:

- Sprint Planning (Day 1 of Sprint): The team selects items from the Product Backlog to work on during the sprint and breaks them down into tasks.
- Daily Stand-up (15 mins): A brief daily meeting where members report what they did yesterday, what they will do today, and any blockers they are facing.
- Sprint Review (Last Day of Sprint): The team demonstrates the completed work to supervisors/stakeholders to gather feedback.
- Sprint Retrospective (After Review): The team discusses what went well, what didn't, and how to improve processes for the next sprint.

2.2 Quality Management:

To ensure the "Learner Management and 3D Simulation System" meets high-quality standards and functional requirements, the team will implement the following quality assurance measures:

Defect Prevention:

- Coding Standards: The team will adhere to standard C# (.NET) and JavaScript (React) coding conventions to ensure code readability and maintainability.
- Static Code Analysis: Tools will be used in the IDE (Visual Studio/VS Code) to catch syntax errors and potential bugs early during development.
- Clear Requirements: All User Stories must have defined "Acceptance Criteria" before development begins to prevent misunderstanding.

Reviewing:

- Peer Code Reviews: All code changes must be submitted via Pull Requests (PR) on GitHub. At least one other team member must review the code for logic errors, style violations, and potential performance issues before it is merged into the main or develop branch.
- Document Reviews: Project documents (SRS, SDD) are reviewed by the Supervisor and team members to ensure consistency and completeness.

Testing Strategy:

- Unit Testing: Developers are responsible for writing unit tests for critical business logic, particularly for the API (Backend) services and complex Simulation algorithms.
- Integration Testing: Verifying that different modules work together correctly.
 - Web App: Testing communication between the React Frontend and .NET Backend APIs.
 - Simulation: Testing the data exchange between the Unity Desktop App and the Backend Server (e.g., login, score submission).
- System Testing (Functional Testing): The team will execute manual test cases based on the SRS to verify that the system functions as a whole and meets all user requirements (e.g., An instructor assigning a quiz, a trainee completing a simulation).
- User Acceptance Testing (UAT): Conducted near the end of the project (or Sprint Reviews) where the Supervisors/Instructors test the system to confirm it meets their business needs.

Bug Tracking:

- Defects found during testing will be logged in GitHub Issues or the project management tool (Jira/Excel) with a priority level (Critical, High, Medium, Low) and assigned to a developer for fixing.

2.3 Training Plan:

Training Area	Participants	When, Duration	Waiver Criteria
Unity	All members	2 weeks	Mandatory
Blender	All members	2 weeks	Mandatory
ASP.NET	All members	2 weeks	Mandatory
React	All members	2 weeks	Mandatory
GitHub	All members	2 weeks	Mandatory

3. Project Deliverables:

#	Deliverable	Due Date	Notes
1	Project Introduction document	24/10/2025	Overall project description
2	Project Management document	26/10/2025	Project estimation and management approach
3	SRS document	05/11/2025	Software Requirement Specification
4	Software Design Document	15/11/2025	System Design, Detailed Design, Database
5	Software Testing Document	05/12/2025	Test Document, Test Report
6	Final Report Document	10/12/2025	Project Final Report
7	Web Application	10/12/2025	Project Web Application Product
8	3D Simulation Application	10/12/2025	Project Desktop Application Product
9	Source Code Repository	10/12/2025	Complete source code for all subsystems.
10	Project Package	10/12/2025	Final codes & documents

4. Responsibility Assignments

D-Do; R-Review; S-Support; I-Informed; <blank>- Omitted

Responsibility	NhatDNSE18223 6	DucDTSE18011 0	KhoiPDSE17046 2	QuangLNSE17041 5
Project Introduction document	D	R	R	R
Project Management document	D	R	R	R
SRS Document	S	R	D	D
Software Design Document	D	S	D	R
Software Testing Document	R	S	R	D
Final Report Document	D	R	S	S
Web Application	D	R	D	D
3D Simulation Application	R	D	R	S
Source Code Repository	D	R	R	R
Project Package	R	D	D	D

5. Project Communications

Communication Item	Who/ Target	Purpose	When, Frequency	Type, Tool, Method(s)
Working with supervisor	Supervisors (Mr. Ngo Dang Ha An and Mr. Pham Thanh Tri) and team members	<ul style="list-style-type: none"> Review Project requirement and documentation Demonstrate Major features Evaluate technologies, solutions and result 	1 time per week	Face to face, Google Meet
Working in team	Team members	<ul style="list-style-type: none"> Specify tasks, reviews and opinions Ask for member's help 	Always	Discord, Zalo, Face to face

		<ul style="list-style-type: none"> • Report working status to leader 		
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6. Configuration Management

6.1 Document Management

- Using Google Drive to save documentations: [Documentations](#)
- Using Google Sheet to take notes: [Sheet notes](#)
- Using Draw.io to save design and diagrams: [Diagrams](#)

6.2 Source Code Management

- Using GitHub to store source code:
 - Backend API Repository: github.com/hieuvau198/lssctc-api
 - Frontend Web App Repository: github.com/hieuvau198/lssctc-web
 - Simulation Desktop App Repository: github.com/hieuvau198/lssctc-simulator
- Follow these rules when using Git:
 - Commit convention:
 - Commit code with syntax: git commit -m "type: what-commit-does"
 - Types of commits include:
 - feat: new feature
 - fix: handle bug
 - config: change related to config file
 - docs: changes related to config file documentation
 - test: adding testing code
 - Pull request convention:
 - Attach a link to the task on Notion in the description of the pull request.
 - Do not push code directly to main/master branch. Let's create a new branch for every new task.
 - Tag the leader for code review.

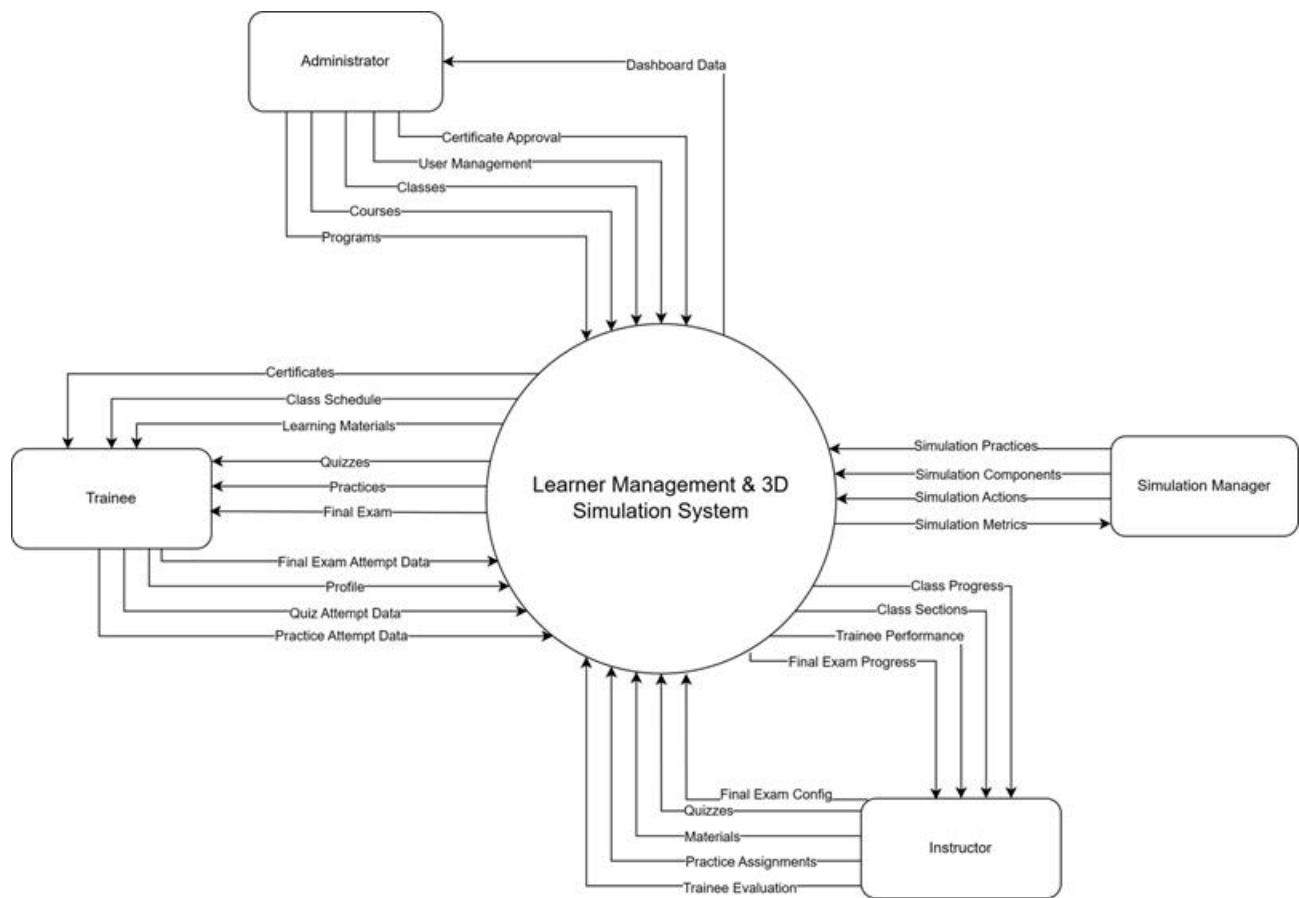
6.3 Tools & Infrastructures

Category	Tools / Infrastructure
Technology	Unity (Simulator), Blender (Modelling), .NET (Backend), React (frontend)
Database	Microsoft SQL Server
IDEs/Editors	Visual Studio, Visual Studio Code
Diagramming	Draw.io, Lucid chart
Documentation	Ms Office, Google Docs/Sheets
Version Control	GitHub (Source Codes), Google Drive (Documents)
Deployment server	Microsoft Azure
Project management	Jira, Google Sheets

III. Software Requirement Specification

1. Product Overview

The Learner Management and 3D Simulation System for Crane Training Center (LSSCTC) is an integrated software suite designed to address the high costs, significant safety risks, and logistical challenges of traditional crane operation training. The system provides a unified solution for both theoretical and simulated practical training.



2. User Requirements

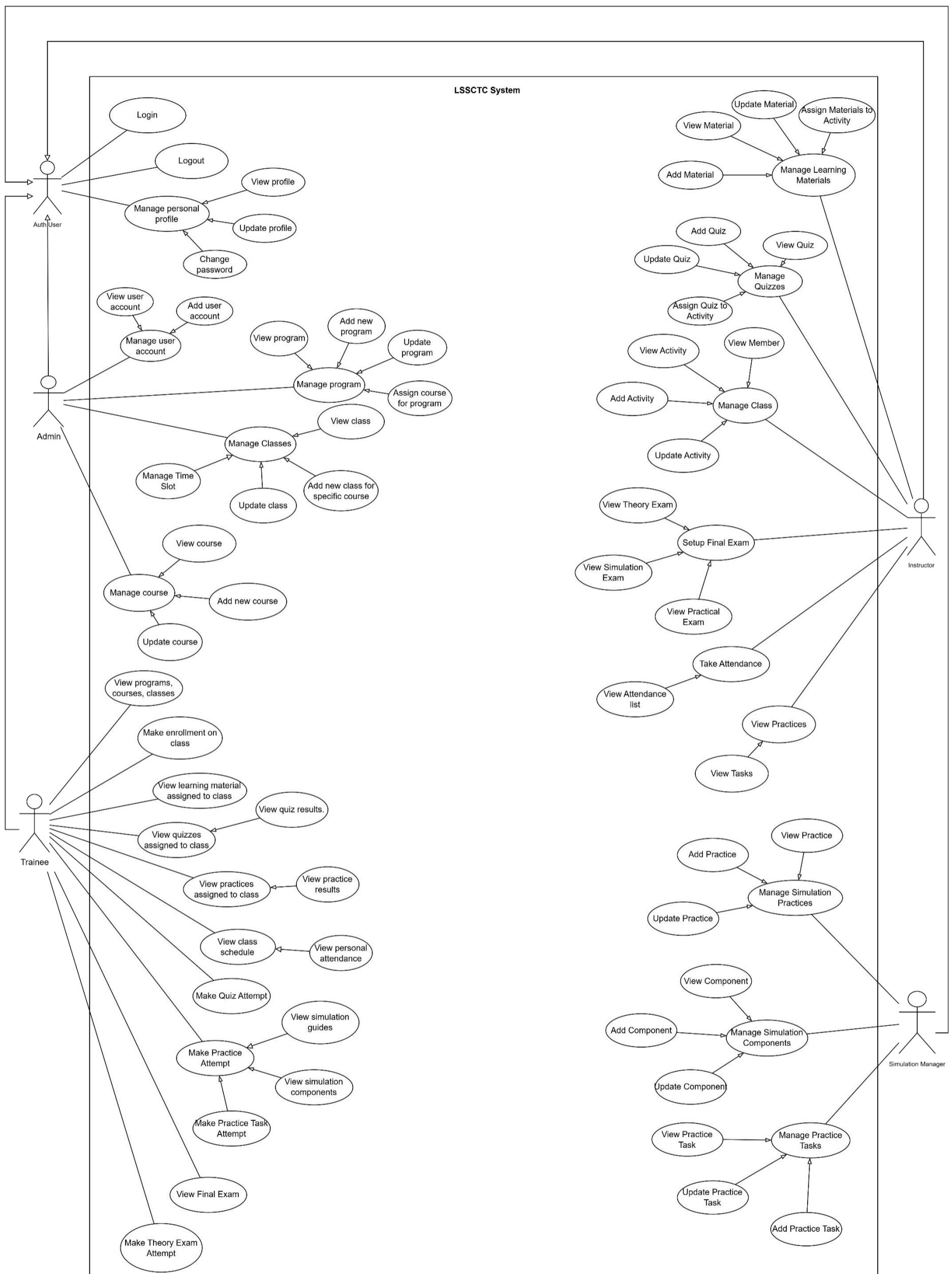
2.1 Actors

#	Actor	Description
1	Administrator	The Administrator is the top-level user responsible for the overall system setup and user management. Using the web application, they manage all user accounts, create and organize the academic structure by managing programs, courses, and classes.

2	Simulation Manager	The Simulation Manager is responsible for defining all aspects of the 3D simulation content. They manage the simulation practices, including simulation components, actions, and warnings.
3	Instructor	The instructor is responsible for managing the content and trainees within their assigned classes. Using the web application, they manage class members, organize class sections, and upload learning materials and quizzes. They also assign simulation practices to the class and are responsible for tracking trainee results, providing feedback, and confirming the final status for each trainee.
4	Trainee	The Trainee is the primary learner in the system. They use the web application to manage their profile, enroll in classes, access learning materials, and complete theoretical quizzes. They also use the separate 3D simulation desktop application to log in and perform practical crane simulation exercises.

2.2 Use Case

2.2.1 Use Case Diagram



2.2.2 Descriptions

ID	Use Case	Actors	Use Case Description
UC-01	Add Material	Instructor	This feature allows instructor add a new learning material (PDF, video, link) for teaching.
UC-02	Update Material	Instructor	This feature allows instructor update an existing learning material's info or file.
UC-03	View Material	Instructor	This feature allows instructor view the list and details of learning materials.
UC-04	Assign Materials to Section	Instructor	This feature allows instructor link selected materials to a section/partition for trainees to access.
UC-05	Add Quiz	Instructor	This feature allows instructor create a new quiz with basic information.
UC-06	Update Quiz	Instructor	This feature allows instructor edit a quiz's information.
UC-07	View Quiz	Instructor	This feature allows instructor view quizzes and their details.
UC-08	Assign Quiz to Section	Instructor	This feature allows instructor attach a quiz to a specific section/partition for delivery.
UC-09	Add Member	Instructor	This feature allows instructor add a trainee to the class roster.
UC-10	View Member	Instructor	This feature allows instructor view trainee profiles and class membership.
UC-11	Track Member Process	Instructor	This feature allows instructor track each trainee's study progress and results.
UC-12	View Section	Instructor	This feature allows instructor track each trainee's study progress and results.
UC-13	Add Section	Instructor	This feature allows instructor create a new section for the class.
UC-14	Update Section	Instructor	This feature allows instructor edit

			section information.
UC-15	Assign Practices to Section	Instructor	This feature allows instructor link practice activities to a section/partition.
UC-16	View Practices	Instructor	This feature allows instructor view practice list and details in the class/section.
UC-17	Confirm Pass/Fail Results	Instructor	This feature allows instructor view practice list and details in the class/section.
UC-18	Add Practice	Instructor	This feature allows instructor create a new practice activity.
UC-19	Update Practice	Instructor	This feature allows instructor edit an existing practice activity.
UC-20	View Practices	Instructor	This feature allows instructor view details of a specific practice activity.
UC-21	Add Component	Instructor	This feature allows instructor add a simulation component needed for practice.
UC-22	Update Component	Instructor	This feature allows instructor update a simulation component's information.
UC-23	View Component	Instructor	This feature allows instructor view the list and details of simulation components.
UC-24	Add Action	Instructor	This feature allows instructor add a simulation action/step used in practices.
UC-25	Update Action	Instructor	This feature allows instructor update a simulation action/step.
UC-26	View Action	Instructor	This feature allows instructor view the list and details of simulation actions.
UC-27	Add Component	Simulation Manager	This feature allows the simulation manager to add a new simulation component to the system.
UC-28	Update Component	Simulation Manager	This feature allows the simulation manager to edit or update existing simulation component information.
UC-29	View Component	Simulation Manager	This feature allows the simulation manager to view the list and details of simulation components.

UC-30	Add Action	Simulation Manager	This feature allows the simulation manager to add a new simulation action used in training practices.
UC-31	Update Action	Simulation Manager	This feature allows the simulation manager to edit or update existing simulation actions.
UC-32	View Action	Simulation Manager	This feature allows the simulation manager to view the list and details of simulation actions.
UC-33	Add Slot	Simulation Manager	This feature allows the simulation manager to create a new simulation timeslot for scheduling practices.
UC-34	Update Slot	Simulation Manager	This feature allows the simulation manager to update or reschedule an existing simulation timeslot.
UC-35	View Slot	Simulation Manager	This feature allows the simulation manager to view all simulation timeslots and their details.
UC-36	Assign Practice to Slot	Simulation Manager	This feature allows the simulation manager to assign a specific practice activity to a simulation timeslot.
UC-37	Add Practice Step	Simulation Manager	This feature allows the simulation manager to define and add new steps for a practice scenario.
UC-38	Update Practice Step	Simulation Manager	This feature allows the simulation manager to modify or reorder steps within a practice scenario.
UC-39	View Practice Step	Simulation Manager	This feature allows the simulation manager to view practice steps assigned to each practice activity.
UC-40	Add Warning	Simulation Manager	This feature allows the simulation manager to create new warning messages or alerts for simulation steps.
UC-41	Update Warning	Simulation Manager	This feature allows the simulation manager to modify or remove existing simulation warnings.
UC-42	View Warning	Simulation Manager	This feature allows the simulation manager to view all defined warnings and their details.
UC-43	Make enrollment programs/courses/classes	Trainee	This feature allows trainee submit an enrolment request to a program,

			course, or class.
UC-44	View programs, courses, classes	Trainee	This feature allows trainee view the catalog and details of available programs, courses, and classes.
UC-45	Access learning material	Trainee	This feature allows trainee access learning materials provided for their study.
UC-46	View learning material assigned to class section	Trainee	This feature allows trainee view materials specifically assigned to their class section.
UC-47	Download material	Trainee	This feature allows trainee download learning files for offline use.
UC-48	View quizzes assigned to class section	Trainee	This feature allows trainee see newly assigned quizzes for their section.
UC-49	Make attempt quizzes	Trainee	This feature allows trainee start and submit a quiz attempt.
UC-50	View recorded results	Trainee	This feature allows trainee view their quiz scores and attempt history.
UC-51	View practices assigned to class section	Trainee	This feature allows trainee view the list of practices assigned to their section.
UC-52	Select a practice to make a new attempt	Trainee	This feature allows trainee choose a practice and create a new attempt.
UC-53	View list practices	Trainee	This feature allows trainee browse the practice list available to them.
UC-54	Settings simulation guides	Trainee	This feature allows trainee configure guidance options and hints for simulation.
UC-55	View simulation guides	Trainee	This feature allows trainee read the simulation guidance before or during practice.
UC-56	View practice steps and step details	Trainee	This feature allows trainee review each step and its detailed instructions.
UC-57	View simulation components	Trainee	This feature allows trainee view components used in the simulation scenario.
UC-58	Perform simulation actions	Trainee	This feature allows trainee perform the required actions in the simulator.
UC-59	View post-practice result	Trainee	This feature allows trainee see overall results after completing a practice.

UC-60	View step result and warning message	Trainee	This feature allows trainee check each step's result and any warning messages.
UC-61	View user account	Admin	This feature allows admin view the list and details of user accounts in the system.
UC-62	Add user account	Admin	This feature allows admin create a new user account and assign a role.
UC-63	Deactivate user account	Admin	This feature allows admin deactivate or disable a user account.
UC-64	Manage user account	Admin	This feature allows admin manage all user accounts, including creating, viewing, and deactivating users.
UC-65	View program	Admin	This feature allows admin view the list and details of existing training programs.
UC-66	Add new program	Admin	This feature allows admin create a new training program in the system.
UC-67	Update program	Admin	This feature allows admin edit information of an existing training program.
UC-68	Assign course for program	Admin	This feature allows admin assign specific courses to a training program.
UC-69	Manage program	Admin	This feature allows admin manage all training programs, including viewing, updating, and course assignment.
UC-70	View class	Admin	This feature allows admin view the list and details of all classes in the system.
UC-71	Add new class for specific course	Admin	This feature allows admin create a new class linked to a selected course.
UC-72	Update class	Admin	This feature allows admin modify class information such as schedule or instructor.
UC-73	Manage classes	Admin	This feature allows admin manage all classes, including creating, updating, and viewing them.
UC-74	View course	Admin	This feature allows admin view the list and details of all courses in the system.

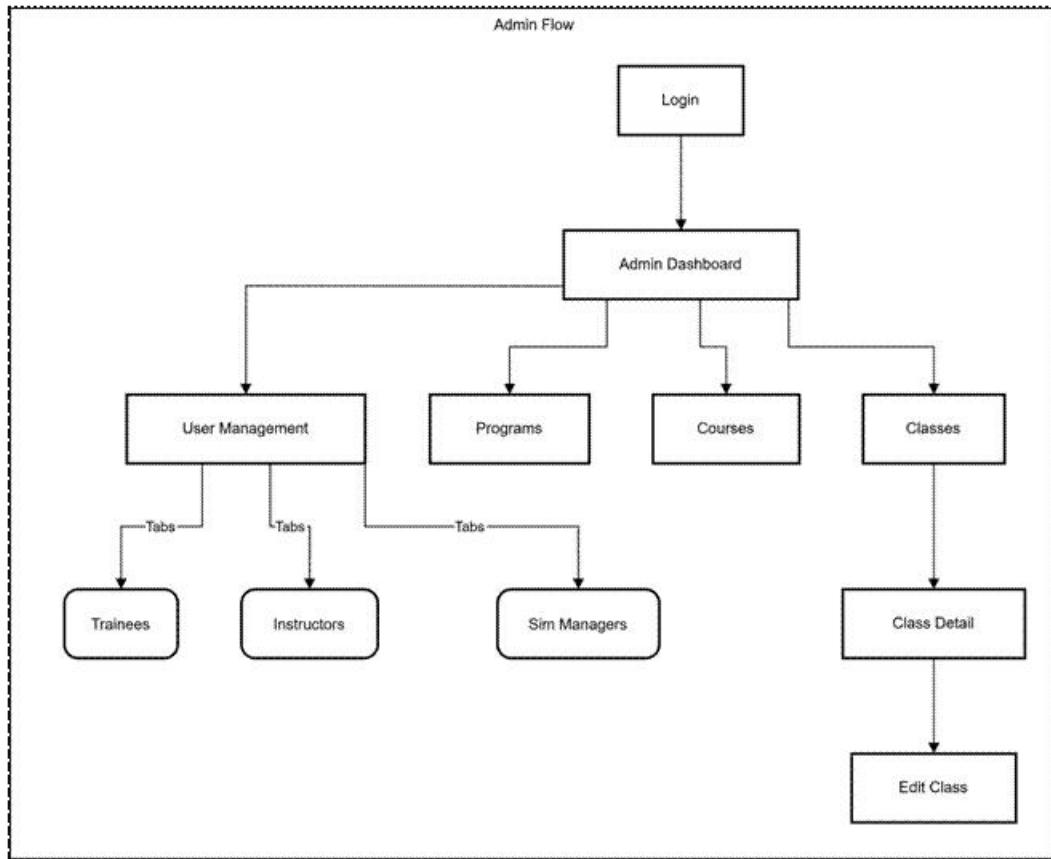
UC-75	Add new course	Admin	This feature allows admin create a new course record in the system.
UC-76	Update course	Admin	This feature allows admin edit the details of an existing course.
UC-77	Manage course	Admin	This feature allows admin manage all courses, including adding, updating, and viewing them.
UC-78	View programs, courses, classes	Admin	This feature allows admin view an overview list of all programs, courses, and classes in the system.
UC-79	Login	Auth User	This feature allows user login to the system by verifying their credentials and accessing authorized functions.
UC-80	Logout	Auth User	This feature allows user logout from the system securely and end their session.
UC-81	View profile	Auth User	This feature allows user view their personal profile information stored in the system.
UC-82	Update profile	Auth User	This feature allows user edit and update their personal profile details.
UC-83	Change password	Auth User	This feature allows user change their password for account security.
UC-84	Manage personal profile	Auth User	This feature allows user manage their personal profile, including viewing, editing, and changing password.

3. Functional Requirements

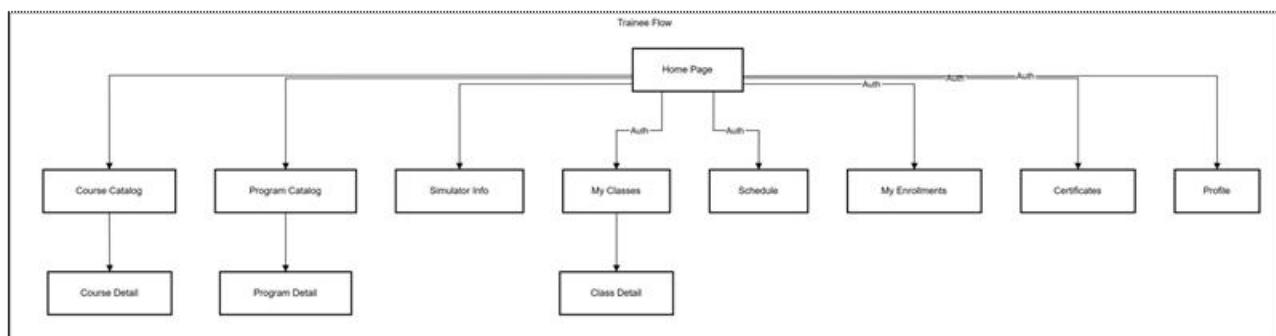
3.1 System Functional Overview

3.1.1 Screens Flow

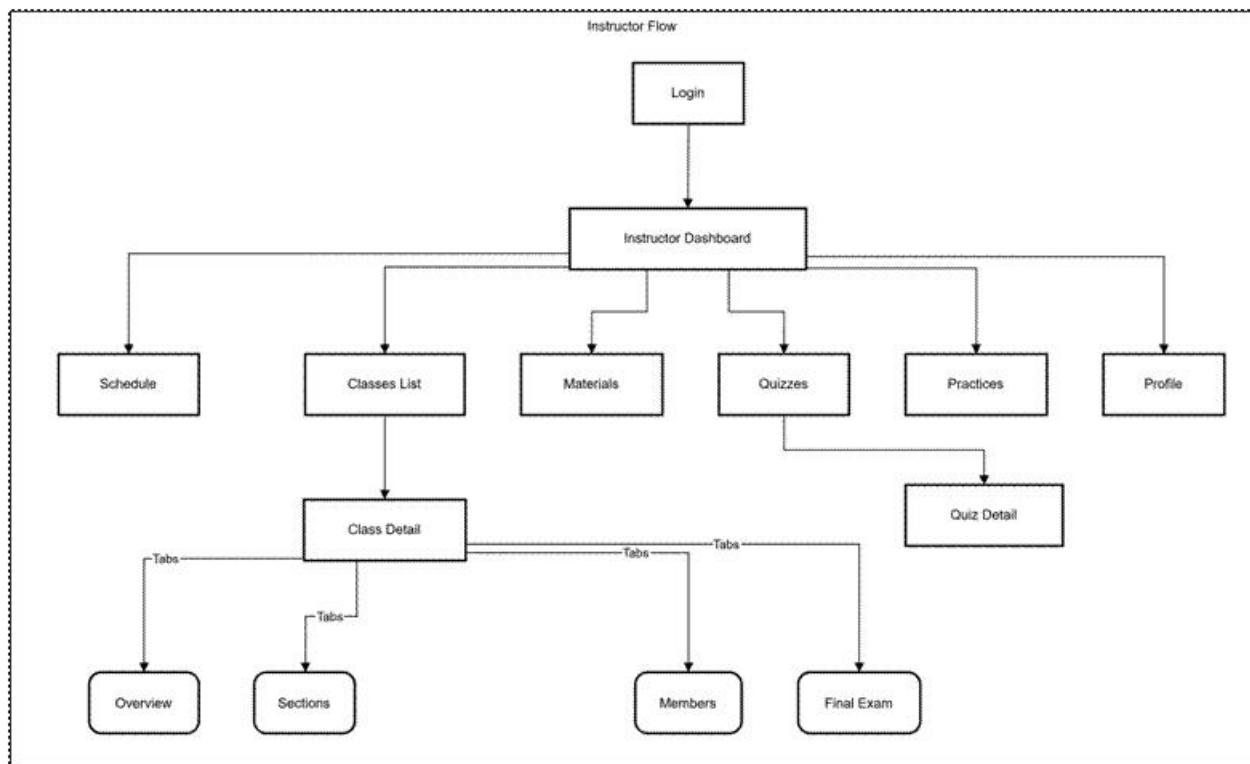
3.1.1.1 Admin Flow



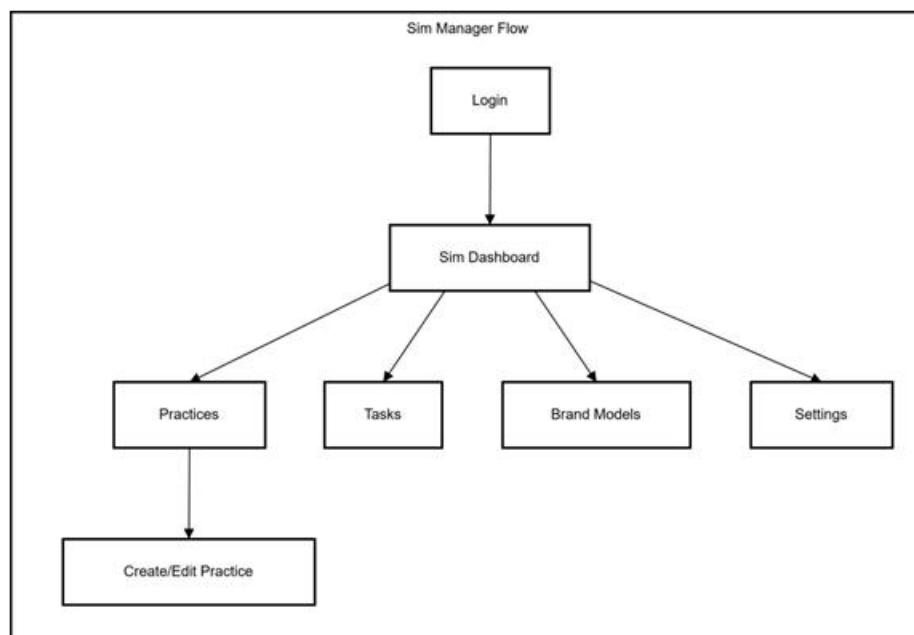
3.1.1.2 Trainee Flow



3.1.1.2 Instructor Flow



3.1.1.2 Simulation Manager Flow



3.1.2 Screen Descriptions

#	Feature	Screen	Description
1	Dashboard	Admin Dashboard	Overview of system statistics, user counts, and recent activities for Administrators.
2	Dashboard	Instructor Dashboard	Overview of assigned classes, upcoming schedules, and student performance metrics.
3	Dashboard	Sim Manager Dashboard	Status overview of active simulations, practice scenarios, and system health.
4	User Management	User Lists	Interfaces to view and manage Trainees, Instructors, and Simulation Managers (tabs/tables).
5	Program Management	Program List	Management of training programs, including creation and modification.
6	Program Management	Program Catalog	Public view for trainees to browse available training programs.
7	Course Management	Course List (Admin)	Administrative list of all courses to manage details and curriculum.
8	Course Management	Course Catalog	Public view for trainees to browse and view details of specific courses.
9	Class Management	Class Management (Admin)	List of classes for admins to create, edit, or view detailed class information.
10	Class Management	Instructor Classes	List of classes assigned to the instructor for teaching.
11	Class Management	My Classes (Trainee)	List of classes the trainee is currently enrolled in.
12	Class Management	Class Detail	Detailed view of a specific class (Overview, Sections, Members, Schedule, Exams).
13	Class Management	Schedule	Calendar view of teaching (Instructor) or learning (Trainee) sessions.
14	Class Management	Quizzes	Management of quizzes, including creation and editing questions (Instructor).
15	Class Management	Final Exam	Management and grading of final exams for a class.
16	Simulation	Practices Management	Creation and configuration of simulation practice scenarios and steps.
17	Simulation	Brand Models	Configuration of brand models used within simulations.
18	Class Management	Materials	Management of learning materials and resources for courses.
19	User	User Profile	View and edit personal account information.

	Management			
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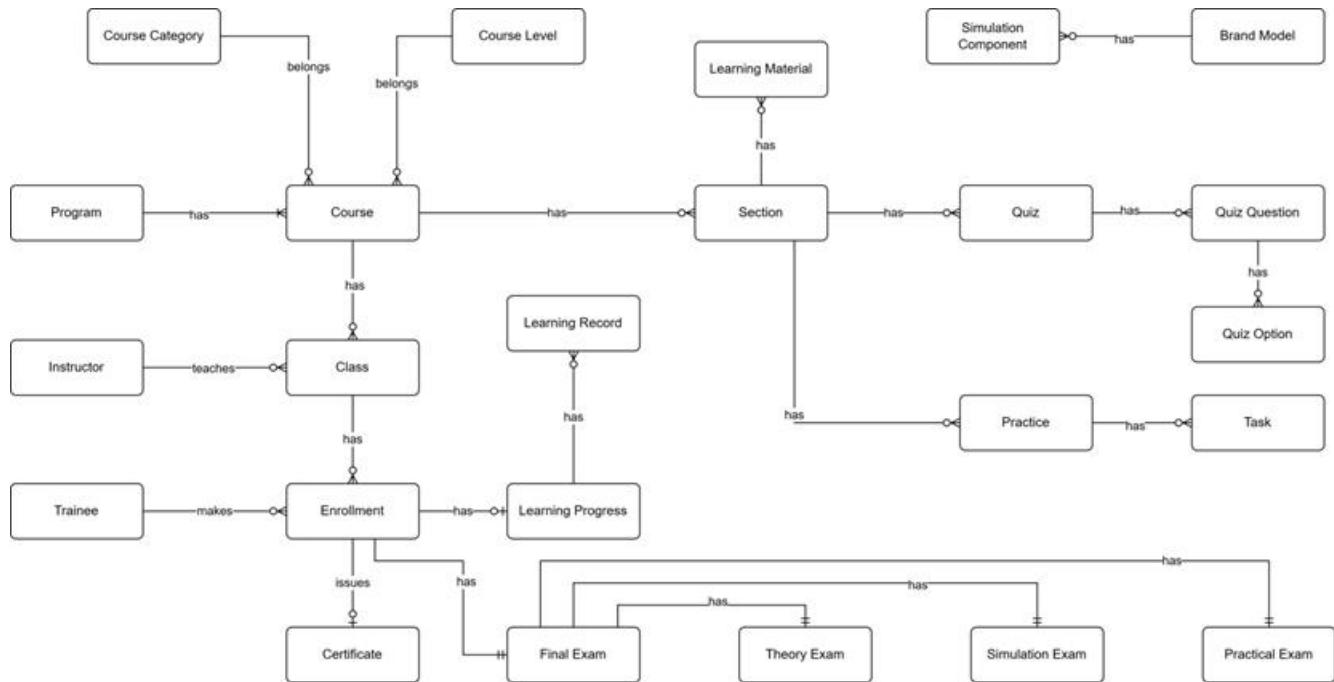
3.1.3 Screen Authorization

Screen	Admin	Instructor	Trainee	Sim Manager
Admin Dashboard	X			
Manage Users (Trainees, Instructors, etc.)	X			
Manage Programs & Courses (Admin)	X			
Manage Classes (Admin)	X			
Instructor Dashboard		X		
Instructor Schedule		X		
Teaching Classes (List & Detail)		X		
Class Attendance & Grading		X		
Content Management (Materials, Sections)		X		
Assessment Management (Quizzes, Practices)		X		
My Classes (Trainee)			X	
My Enrollments			X	
Trainee Schedule			X	
Certificates			X	
Sim Manager Dashboard				X
Manage Practices & Tasks				X
Manage Brand Models				X
Simulation Settings				X

3.1.4 Non-Screen Functions

#	Feature	System Function	Description
1	Authentication	Token Interception & Injection	Automatically intercepts outgoing API requests to inject the JWT authentication token into the headers, ensuring secure communication with the backend.
2	Security	Role-Based Access Control (RBAC)	Validates the current user's role against the allowed roles defined for each protected route. If the user lacks permission, it automatically redirects them to the login page or a forbidden page.
3	State Management	Global Session Store	Maintains the user's active session state (including profile data, role, and avatar URL) across different pages without requiring repeated API calls, using a client-side store (Zustand).
4	Localization	Dynamic Language Switching	Manages the application's locale settings, dynamically swapping text resources between English (en) and Vietnamese (vi) and persisting the preference without reloading the page.
5	Data Persistence	Cookie Management	Handles the secure storage and retrieval of authentication tokens and user preferences in browser cookies, allowing sessions to persist across browser restarts.
6	Utility	Time Slot Status Calculation	Automatically calculates the status of a schedule slot (e.g., "Present", "Past", "Future") based on the current system time compared to the slot's start and end times, used for rendering calendar interfaces.

3.1.5 Entity Relationship Diagram



3.1.6 Entity Relationship Description

#	Entity	Description
1	Course Category	Classification or categorization of courses by subject area or domain (e.g., Basic Crane Operations, Safety Procedures, Advanced Techniques). Provides organizational structure for grouping related courses. Each course belongs to one category.
2	Course Level	Defines the difficulty or skill level of a course (e.g., Entry Level, Intermediate, Advanced). Used to establish learning progression paths and prerequisite requirements. Each course is assigned one level to indicate target trainee proficiency.
3	Program	Comprehensive training program consisting of multiple courses designed to achieve specific certification or skill objectives. Programs define structured learning paths for trainees, combining courses in a logical sequence to build competencies for crane operator certification.
4	Course	Individual training course representing a specific subject or skill area within the crane training curriculum. Contains course content structured into sections, can be assigned to multiple programs, and serves as the foundation for class creation. Belongs to one category and one level.
5	Instructor	Teaching staff member responsible for delivering course instruction, managing class activities, creating learning materials and assessments, and evaluating trainee performance. Instructors are

		assigned to teach specific classes and provide guidance throughout the learning process.
6	Class	Scheduled instance of a course with defined start/end dates, assigned instructor, and enrolled trainees. Represents the actual delivery of course content to a specific group of trainees. Classes are where learning activities, assessments, and instruction occur.
7	Trainee	Student or learner enrolled in training programs to become certified crane operators. Trainees make enrollments in classes, access learning materials, complete quizzes and practices, take final exams, and track their learning progress toward certification.
8	Enrollment	Record of a trainee's registration in a specific class. Creates the relationship between trainee and class, enabling access to course materials, activities, and assessments. Enrollment triggers creation of learning progress tracking and final exam records.
9	Learning Material	Educational content resources such as videos, documents, presentations, or external links used to deliver course instruction. Materials are assigned to sections to provide trainees with reference and study resources. Can be reused across multiple sections.
10	Section	Logical unit or module within a course syllabus representing a specific topic or learning objective. Sections organize course content into manageable chunks and contain learning materials, quizzes, and practices. Defines the structure and sequence of course curriculum.
11	Quiz	Assessment tool containing multiple questions used to evaluate trainee understanding of theoretical concepts. Quizzes are assigned to sections, have defined pass criteria and time limits, and contribute to overall learning progress. Results are tracked through quiz attempts.
12	Quiz Question	Individual question within a quiz presenting a problem or prompt for trainees to answer. Questions are assigned point values (contributing to total quiz score of 10 points) and can support single or multiple correct answers through associated quiz options.
13	Quiz Option	Possible answer choice for a quiz question. Each option is marked as correct or incorrect and may have associated explanations. Multiple options per question enable various question types (multiple choice, select all that apply).
14	Practice	Simulation-based training scenario performed in the 3D crane simulator environment. Practices consist of ordered tasks that trainees must complete to demonstrate hands-on skills. Assigned to sections as practical learning activities with defined difficulty levels

		and attempt limits.
15	Task	Individual step or action within a simulation practice that trainees must perform correctly. Tasks define expected results for validation, and task completion is tracked during practice attempts. Tasks are reusable components across different practices.
16	Simulation Component	3D virtual representation of crane parts, controls, or environment objects used in simulation practices. Components are linked to brand models to represent real-world equipment and are referenced in tasks for interaction requirements.
17	Brand Model	Specification of real crane equipment brands and models being simulated in the training system. Defines manufacturer information, specifications, and links to simulation components that represent the physical equipment in virtual environment.
18	Learning Record	Historical record of trainee interactions with course sections, tracking what content has been accessed and when. Maintains audit trail of learning activities for compliance, reporting, and progress monitoring purposes.
19	Learning Progress	Comprehensive tracking of trainee advancement through enrolled courses. Records overall progress percentage, theory and practical scores, completion status, and timestamps. Central entity for monitoring trainee performance and determining certification readiness.
20	Certificate	Official document template awarded to trainees upon successful course or program completion. Defines certificate design, content structure, and requirements. Issued certificates are permanent records of trainee achievement for verification and credentialing purposes.
21	Final Exam	Comprehensive assessment conducted at course completion to evaluate trainee readiness for certification. Consists of three components (Theory, Practical, Simulation) that are weighted and combined for total score. Results determine pass/fail status and certificate eligibility.
22	Theory Exam	Written assessment component of final exam evaluating trainee understanding of theoretical concepts and safety knowledge. Implemented using the quiz system with defined pass criteria. One of three partial exams that compose the final exam.
23	Simulation Exam	Performance-based assessment component conducted in 3D simulator requiring trainees to demonstrate crane operation skills. Uses practice system with task-by-task evaluation. One of three

		partial exams contributing to final exam score and certification decision.
24	Practical Exam	Hands-on assessment component where trainees demonstrate physical crane operation skills evaluated by instructors using predefined checklists. Assesses real-world competencies beyond simulation environment. One of three partial exams required for certification.

4. Non-Functional Requirements

4.1 Security

- NFR-SEC-01 (Authentication): The system must use JWT (JSON Web Tokens) for stateless, secure API authentication.
- NFR-SEC-02 (Token Management): The system must support token revocation (blacklist) using Distributed Cache to prevent usage of compromised tokens before expiry.
- NFR-SEC-03 (Data Protection): Sensitive data (like passwords) must be hashed. The API must communicate over HTTPS (though RequireHttpsMetadata is currently false for dev, production requires true).
- NFR-SEC-04 (Access Control): API endpoints must be protected by Role-Based Authorization policies ensuring users can only access data pertinent to their role.

4.2 Performance & Scalability

- NFR-PERF-01: The system uses Distributed Memory Cache to handle high-frequency data access like token validation and OTP storage.
- NFR-PERF-02: Database interactions must use asynchronous operations (async/await) to prevent thread blocking under load.
- NFR-PERF-03: Large data sets (Users, Classes, Enrolments) must be returned via Pagination (Paged Result) to reduce network payload and database load.

4.3 Interoperability & Compatibility

- NFR-INT-01: The API must expose a Swagger/OpenAPI documentation interface for client integration.
- NFR-INT-02: The system must support CORS (Cross-Origin Resource Sharing) to allow requests from specific web clients (e.g., lssctc.site, localhost).
- NFR-INT-03: The system must support standard file formats for imports/exports, specifically Excel (.xlsx) and CSV.

4.4 Availability & Reliability

- NFR-REL-01: The system is built on .NET Core and Entity Framework Core, designed for cross-platform deployment.
- NFR-REL-02: External integrations (e.g., Email Service) must be implemented as Transient services to ensure fresh connections and reliability.

5. Business Rules

ID	Category	Rule Definition
BR-01	Authentication	Upon successful login to the web app , the system must redirect users to their role-based landing page: <ul style="list-style-type: none"> - Admin: Admin Dashboard - Simulation Manager: Simulation Manager Dashboard - Instructor: Instructor Dashboard - Trainee: Trainee Home Page
BR-02	Authentication	Upon successful login to the simulation app , users with the 'Trainee' role must be redirected to the home screen.
BR-03	Authentication	Deactivated accounts cannot log in or interact with the system.
BR-04	Authentication	The Username, Email, and Phone Number fields must be unique for each user account.
BR-05	Authentication	A user's Phone Number must be between 4 and 15 digits.
BR-06	Authentication	The Email field must adhere to a standard email format (e.g., user@domain.com).
BR-07	Authentication	A user's account profile can only be updated by the account owner.
BR-07	Authentication	A password reset request must require email verification.
BR-08	Permissions	The 'Admin' role has exclusive permissions to manage 'Simulation Manager', 'Instructor', and 'Trainee' accounts.
BR-09	Permissions	The 'Admin' role has exclusive permissions to: <ul style="list-style-type: none"> - Create and update programs. - Assign courses to a program. - Create and update courses. - Create and update course syllabi. - Manage classes.
BR-10	Permissions	Instructors can only manage content for classes to which they are assigned.
BR-11	Programs	A new program must be created with a Name and an Active Status.
BR-12	Programs	A program cannot contain duplicate course assignments.
BR-13	Programs	A program cannot be assigned more than 10 courses.
BR-14	Courses	Each course must have a unique Name and a unique Course Code.
BR-15	Courses	A new course must be created with a Name, Course Code.
BR-16	Courses	A course's learning section can only be updated if no classes are currently assigned to that course.
BR-17	Classes	Each class must have a unique Name and a unique Class Code.

BR-18	Classes	A class must be linked to a specific course upon creation.
BR-19	Classes	A class must have exactly one assigned 'Instructor'.
BR-20	Classes	Before a class starts, its learning content must mirror the learning sections of its parent course.
BR-21	Classes	Class content can only be updated when class status is 'Draft' or 'Open'.
BR-22	Classes	A class can only be started if all conditions are met: - At least one 'Trainee' is enrolled. - One 'Instructor' is assigned only. - Every class section contains at least one activity.
BR-23	Classes	Each class must have a unique Name and a unique Class Code.
BR-24	Trainee	A 'Trainee' must have a valid account before enrolling in any program.
BR-25	Trainee	A 'Trainee' cannot be enrolled in the same class more than once.
BR-26	Trainee	A 'Trainee' cannot be enrolled in two different classes that have conflicted schedules.
BR-27	Trainee	'Trainees' can only attempt quiz and practice when their session is valid.
BR-28	Class Activities	Each learning activity must be one of the following types: 'Material', 'Quiz', or 'Practice'.
BR-29	Class Activities	A new activity must be created with a Name, Type, and Order (sequence) number.
BR-30	Class Activities	A new learning material (e.g., 'Video', 'Document') must include a Name and either a Source File or Source URL.
BR-31	Class Activities	A Source File for learning material cannot exceed 50MB in size.
BR-32	Quizzes	A new quiz must be created with a Name and a Max Attempts value.
BR-33	Quizzes	A quiz must contain one or more questions.
BR-34	Quizzes	Each question must include answer options, and each option must be flagged as 'Correct' or 'Incorrect'.
BR-35	Quizzes	A quiz cannot contain more than 100 questions.
BR-36	Quizzes	A quiz question cannot have more than 20 answer options.
BR-37	Quizzes	The total score for every quiz must be exactly 10 points.
BR-38	Quizzes	The score of any single question must be greater than 0 and less than 10.
BR-39	Quizzes	The sum of all question scores within a quiz must equal 10.
BR-40	Quizzes	Only users with the 'Trainee' role can attempt a quiz.
BR-41	Quizzes	Every quiz attempt by a 'Trainee' must be recorded.

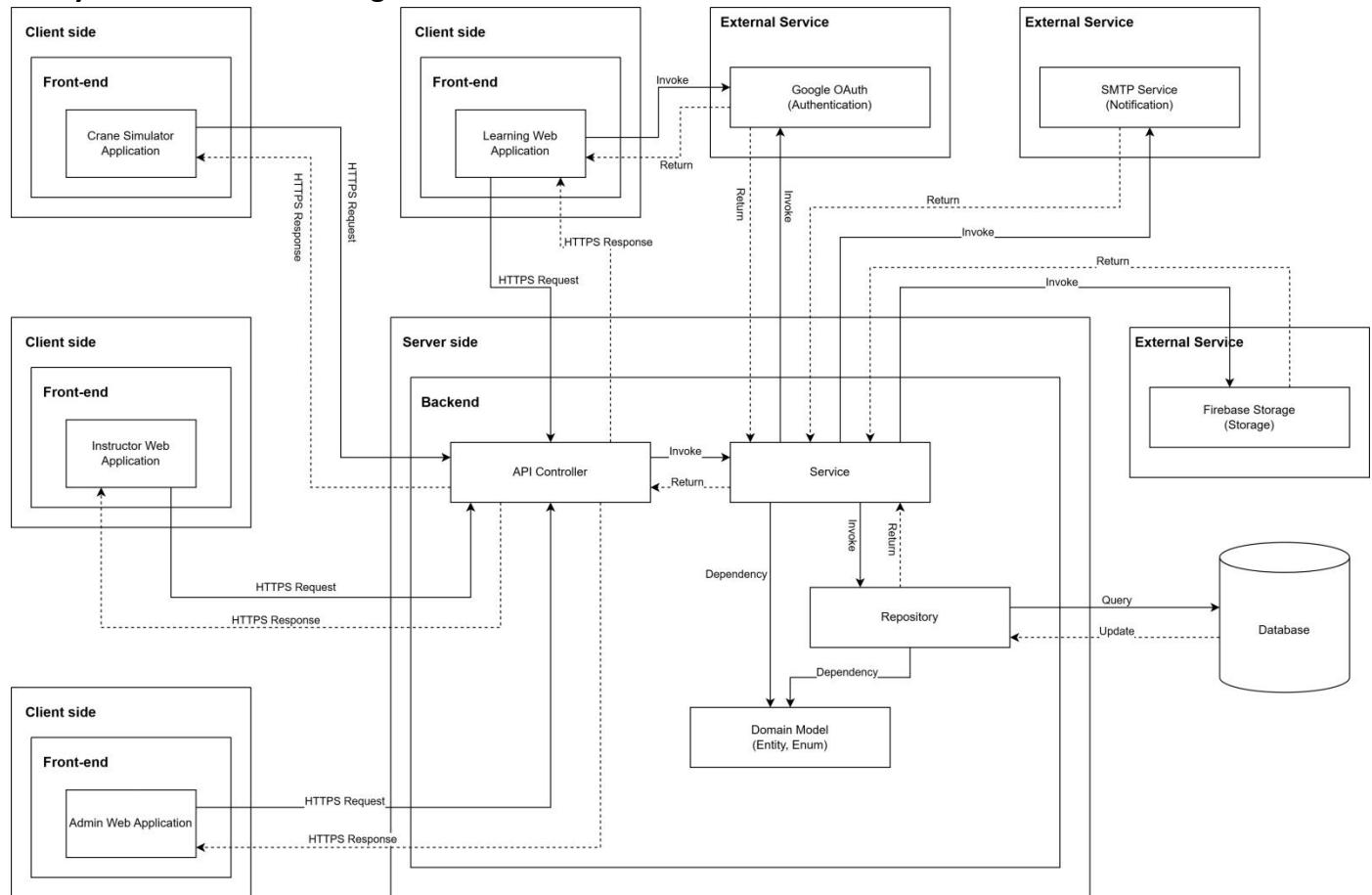
BR-42	Quizzes	A 'Trainee's' final quiz score must be determined by their latest attempt.
BR-43	Quizzes	'Trainees' cannot retake a quiz after reaching the Max Attempts limit.
BR-44	Simulation Practices	A simulation practice must contain between 1 and 20 tasks.
BR-45	Simulation Practices	Each practice task must have a unique 'task_code'.
BR-46	Simulation Practices	Each practice must have a unique 'practice_code'.
BR-47	Simulation Practices	A task cannot be assigned to a practice more than once.
BR-48	Simulation Practices	A new practice task must be created with a Name, Description, and Task Code.
BR-49	Simulation Practices	A new simulation practice must have a unique Name and a unique Practice Code.
BR-50	Simulation Practices	A new simulation Component must have a unique Name, and a unique Component Code.
BR-51	Simulation Practices	'Trainees' must be authenticated before accessing a simulation practice.
BR-52	Simulation Practices	'Trainees' can only start practices that are marked as 'Active' and are part of their assigned class.
BR-53	Simulation Practices	'Trainees' must complete all simulation tasks to finish a practice.
BR-54	Simulation Practices	While a 'Trainee' is taking a simulation practice: <ul style="list-style-type: none"> - The system must display guides and step descriptions. - The system must automatically advance to the next step upon successful completion of the current step. - The system must record the result of every step for evaluation.
BR-55	Simulation Practices	'Trainees' cannot retake a simulation practice after reaching the Max Attempts limit.
BR-56	Simulation Practices	'Trainees' must be authenticated before accessing a simulation practice.
BR-57	Simulation Practices	'Trainees' can only start a simulation final exam after input a correct Exam Code.
BR-58	Simulation Practices	'Trainees' can only access to the simulation final exam belongs to their enrolled classes.
BR-59	Simulation	While a 'Trainee' is taking a simulation final exam:

	Practices	<ul style="list-style-type: none"> - The system must display guides and step descriptions. - The system must automatically advance to the next task upon successful completion of the current step. - The system must record the result of every task for evaluation.
BR-60	Simulation Practices	'Trainees' cannot retake a simulation final exam after reaching the Max Attempts limit.

IV. Software Design Description

1. System Design

1.1 System Architecture Diagram

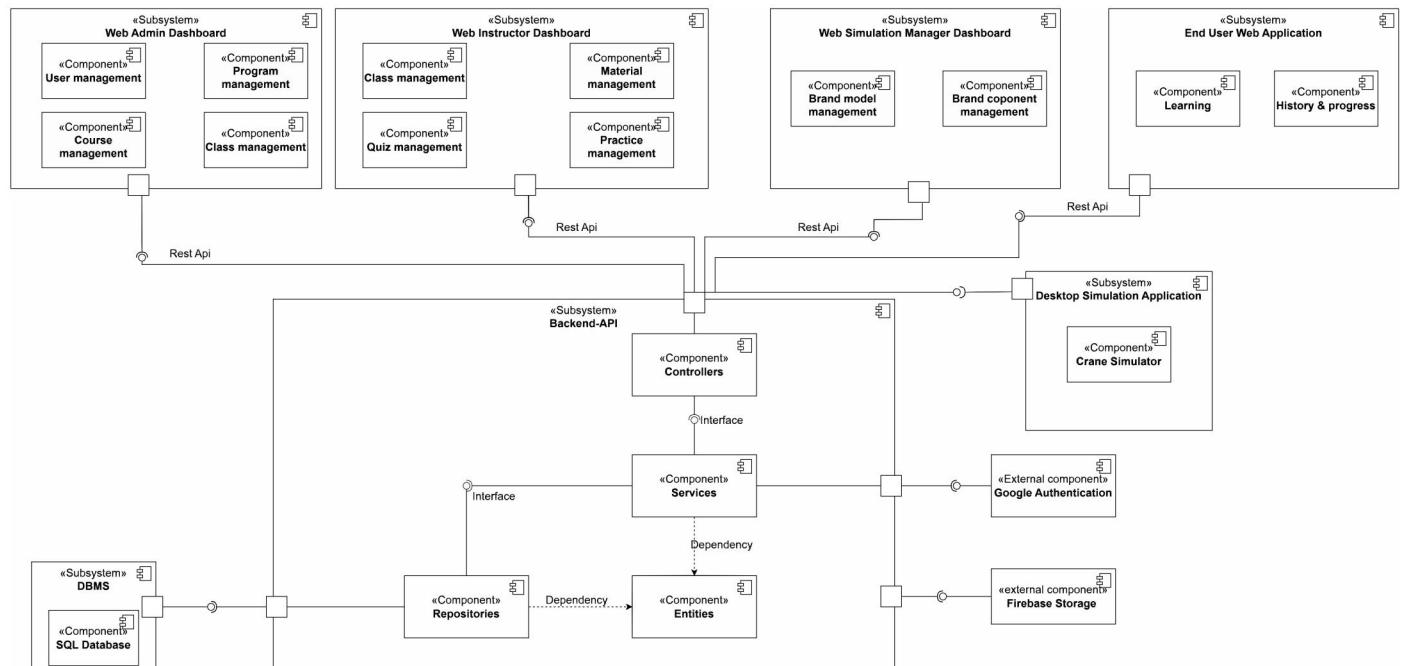


System Architecture Diagram Descriptions

No	Name	Description
1	Crane Simulator Application	Desktop application for practical crane operation training, communicates with backend via HTTPS to access training content and submit practice results
2	Learning Web	Web-based application for trainees to access learning materials, complete

	Application	courses, take quizzes, and track their learning progress
3	Instructor Web Application	Web application for instructors to manage classes, create and grade quizzes, provide feedback, and monitor student progress
4	Admin Web Application	Web application for administrators to manage users, programs, courses, system settings, and overall platform administration
5	API Controller	RESTful API layer that receives HTTPS requests from client applications, routes them to appropriate services, and returns responses
6	Service	Business logic layer containing core application logic, processing business rules, orchestrating workflows, and coordinating between controllers and repositories
7	Repository	Data access layer that abstracts database operations, handles CRUD operations, and manages data persistence using Entity Framework or similar ORM
8	Domain Model (Entity, Enum)	Domain entities and enumerations representing the core business objects and data structures (Users, Courses, Classes, Quizzes, etc.)
9	Database	SQL Server database storing all system data including users, courses, enrollments, quiz attempts, practice results, and certificates
10	Google OAuth (Authentication)	External authentication service for user login using Google accounts, providing secure OAuth 2.0 authentication flow
11	SMTP Service (Notification)	External email service for sending notifications, alerts, password resets, and course-related communications to users
12	Firebase Storage (Storage)	Cloud storage service for storing and serving media files including course materials, videos, images, documents, and user-uploaded content

1.2 Component Diagram



Component Diagram Descriptions

No	Name	Description
1	Web Admin Dashboard	Web administrative interface for Admin, including user management, program management, and course management features
2	User management	Component for managing users, handling account information, permissions, and user administration in the system
3	Program management	Component for managing training programs, organizing courses and curriculum
4	Course management	Component for managing courses, learning content, lectures, and materials
5	Web Instructor Dashboard	Web interface for instructors, including class management and quiz management
6	Class management	Component for managing classes, student lists, schedules, and attendance
7	Material management	Component for managing learning materials, lectures, videos, and attached files
8	Quiz management	Component for managing quizzes, questions, answers, and test results
9	Practice management	Component for managing practice exercises, assignments, and homework
10	Web Simulation Manager Dashboard	Simulation management interface, including brand model management and brand component management
11	Brand model management	Component for managing brand models in business simulation
12	Brand component management	Component for managing components and competitors in simulation
13	End User Web Application	Web application for end users (students), including learning features and history & progress tracking
14	Learning	Component handling the learning process, viewing lectures, and completing exercises for students
15	History &	Component tracking learning history and course completion progress for

	progress	students
16	End User Desktop Application	Desktop application for end users, including practical training features
17	Practical Training	Component handling practical exercises on desktop application
18	Firebase Storage	Firebase file storage service for storing images, videos, documents, and attached files
19	Backend API	Backend API system handling business logic, including Controllers, Services, Repositories, and Entities
20	Controllers	Controller layer handling HTTP requests from clients, routing to corresponding services
21	Services	Business logic layer containing business rules and system processing logic
22	Repositories	Data access layer handling CRUD operations with the database
23	Entities	Layer defining data objects (data models) mapped to the database
24	Google Authentication	Component authenticating users through Google OAuth, supporting Google account login
25	DBMS	Database management system containing SQL Database storing all system data
26	SQL Database	SQL database (PostgreSQL/MySQL) storing user data, courses, exercises, and learning results

2. Database Design

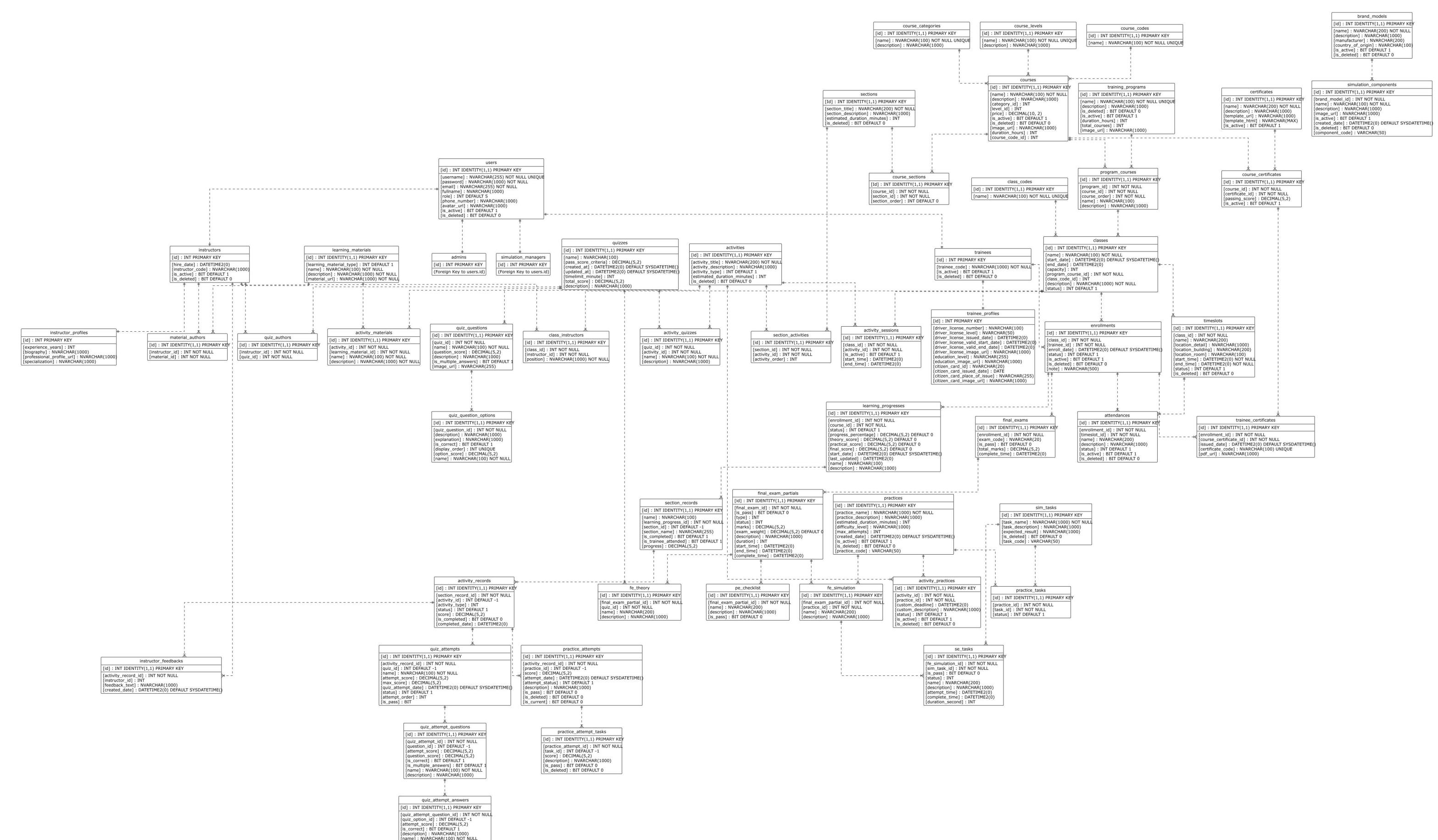


Table Descriptions

No	Table	Description
1	users	Stores the core account information for all system users including login credentials and contact info. - Primary keys: id - Foreign keys: None
2	admins	Stores specific information for users with the Admin role, linked to the main user record. - Primary keys: id - Foreign keys: id
3	simulation_managers	Stores specific information for Simulation Managers, linked to the main user record. - Primary keys: id - Foreign keys: id
4	instructors	Stores specific information for Instructors, including employment details. - Primary keys: id - Foreign keys: id
5	trainees	Stores specific information for Trainees/Learners. - Primary keys: id - Foreign keys: id
6	instructor_profiles	Contains detailed profile information for instructors such as experience and biography. - Primary keys: id - Foreign keys: id
7	trainee_profiles	Contains detailed profile information for trainees, including driver license and citizen card details. - Primary keys: id - Foreign keys: id
8	course_categories	Lookup table for defining different categories of courses. - Primary keys: id - Foreign keys: None
9	course_levels	Lookup table for defining the difficulty or progression levels of courses. - Primary keys: id - Foreign keys: None
10	course_codes	Lookup table for standardized course codes. - Primary keys: id - Foreign keys: None
11	courses	Stores the main course definitions including metadata like price and duration. - Primary keys: id - Foreign keys: category_id, level_id, course_code_id
12	training_programs	Defines high-level training programs that aggregate multiple courses. - Primary keys: id - Foreign keys: None
13	program_courses	Junction table linking Courses to Training Programs, defining the order of courses within a program. - Primary keys: id

		- Foreign keys: program_id, course_id
14	sections	Defines content sections that organize activities within a course. - Primary keys: Id - Foreign keys: None
15	course_sections	Junction table mapping sections to courses and defining their sequence. - Primary keys: Id - Foreign keys: course_id, section_id
16	activities	Stores individual learning activities (e.g., lessons, quizzes) that belong to sections. - Primary keys: id - Foreign keys: None
17	learning_materials	Stores information about study materials like documents or videos. - Primary keys: id - Foreign keys: None
18	material_authors	Links learning materials to the instructors who authored them. - Primary keys: id - Foreign keys: instructor_id, material_id
19	section_activities	Junction table mapping activities to specific sections and defining their order. - Primary keys: id - Foreign keys: section_id, activity_id
20	activity_materials	Links learning materials to specific activities. - Primary keys: id - Foreign keys: activity_id, learning_material_id
21	quizzes	Defines quiz assessments including time limits and passing criteria. - Primary keys: id - Foreign keys: None
22	quiz_authors	Links quizzes to the instructors who created them. - Primary keys: id - Foreign keys: instructor_id, quiz_id
23	quiz_questions	Stores questions belonging to a specific quiz. - Primary keys: id - Foreign keys: quiz_id
24	quiz_question_options	Stores the possible answer options for a quiz question. - Primary keys: id - Foreign keys: quiz_question_id
25	activity_quizzes	Junction table linking a Quiz to an Activity entity. - Primary keys: id - Foreign keys: quiz_id, activity_id
26	practices	Defines practical training exercises or simulation scenarios. - Primary keys: id - Foreign keys: None
27	sim_tasks	Defines specific tasks or steps required within a simulation. - Primary keys: id - Foreign keys: None
28	practice_tasks	Junction table linking simulation tasks to a practice scenario. - Primary keys: id - Foreign keys: practice_id, task_id
29	activity_practices	Junction table linking a Practice to an Activity entity. - Primary keys: id - Foreign keys: activity_id, practice_id

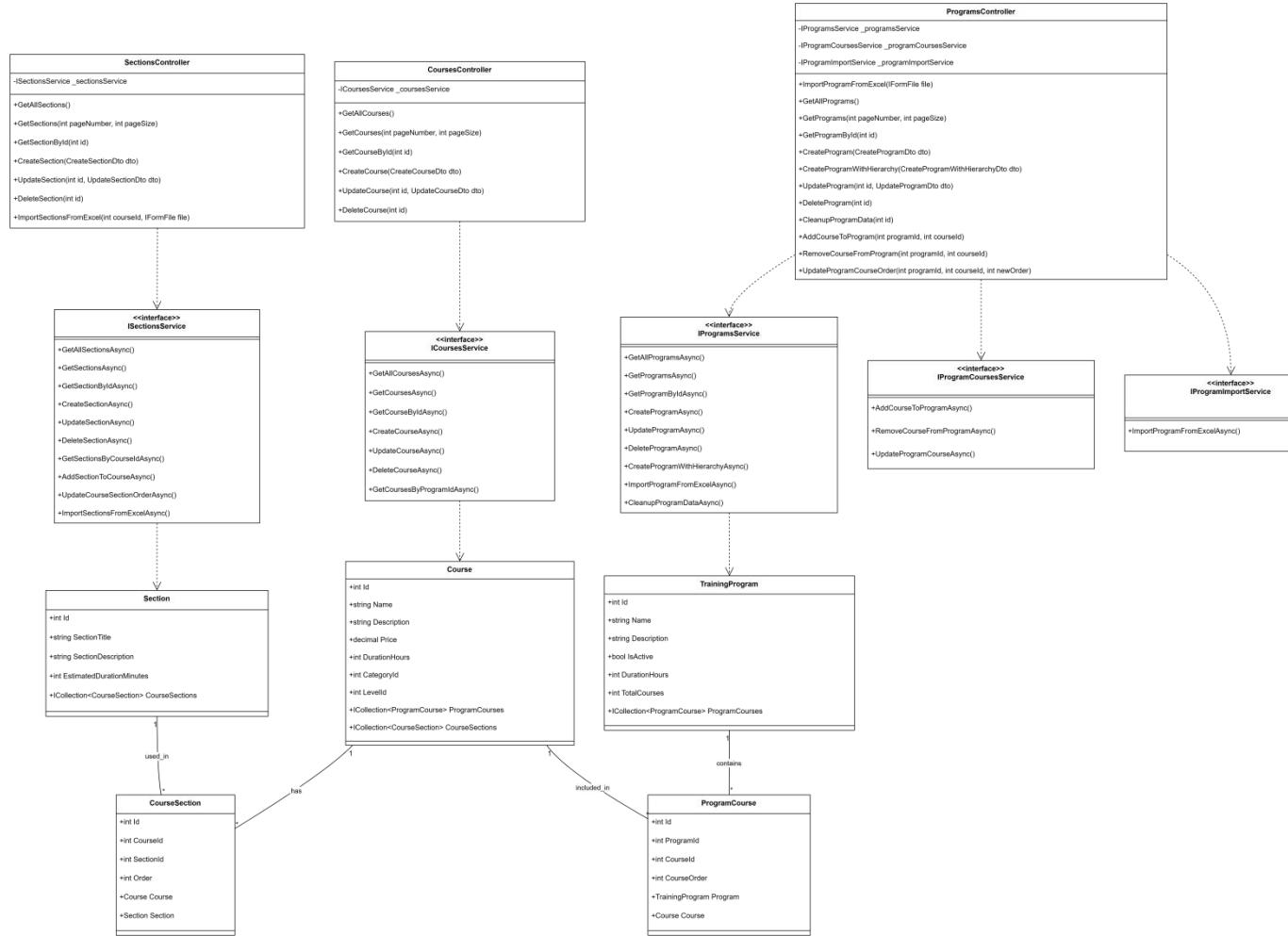
30	brand_models	Specific brand models of equipment (cranes) used in simulations. - Primary keys: id - Foreign keys: None
31	simulation_components	Stores detailed components associated with specific brand models. - Primary keys: id - Foreign keys: brand_model_id
32	class_codes	Lookup table for standardized class codes. - Primary keys: id - Foreign keys: None
33	classes	Represents a scheduled instance of a course (program course) with start/end dates. - Primary keys: id - Foreign keys: program_course_id, class_code_id
34	class_instructors	Assigns instructors to specific classes with a designated position. - Primary keys: id - Foreign keys: class_id, instructor_id
35	enrollments	Records the registration of a trainee in a specific class. - Primary keys: id - Foreign keys: class_id, trainee_id
36	timeslots	Defines specific scheduling slots (date/time/location) for a class. - Primary keys: id - Foreign keys: class_id
37	attendances	Tracks trainee attendance for specific timeslots. - Primary keys: id - Foreign keys: enrollment_id, timeslot_id
38	activity_sessions	Schedules specific activities within a class timeframe. - Primary keys: id - Foreign keys: class_id, activity_id
39	final_exams	Stores the overall record of a final exam for an enrollment. - Primary keys: id - Foreign keys: enrollment_id
40	final_exam_partials	Stores specific parts (theory/practical) of a final exam. - Primary keys: id - Foreign keys: final_exam_id
41	pe_checklist	Stores checklist items for grading practical final exams. - Primary keys: id - Foreign keys: final_exam_partial_id
42	fe_theory	Links a final exam partial to a specific theory quiz. - Primary keys: id - Foreign keys: final_exam_partial_id, quiz_id
43	fe_simulation	Links a final exam partial to a specific simulation practice. - Primary keys: id - Foreign keys: final_exam_partial_id, practice_id
44	se_tasks	Tracks the result of specific tasks within a simulation final exam. - Primary keys: id - Foreign keys: fe_simulation_id, sim_task_id
45	certificates	Defines certificate templates available in the system. - Primary keys: id - Foreign keys: None

46	course_certificates	Links certificates to courses, defining passing requirements. - Primary keys: id - Foreign keys: course_id, certificate_id
47	trainee_certificates	Records certificates issued to trainees upon course completion. - Primary keys: id - Foreign keys: enrollment_id, course_certificate_id
48	learning_progresses	Tracks the overall progress of a trainee within an enrollment. - Primary keys: id - Foreign keys: enrollment_id
49	section_records	Tracks a trainee's completion status for specific course sections. - Primary keys: id - Foreign keys: learning_progress_id
50	activity_records	Tracks the detailed status and score of a trainee for specific activities. - Primary keys: id - Foreign keys: section_record_id
51	instructor_feedbacks	Stores feedback provided by instructors on specific activity records. - Primary keys: id - Foreign keys: activity_record_id, instructor_id
52	practice_attempts	Records a specific attempt by a trainee to complete a practice activity. - Primary keys: id - Foreign keys: activity_record_id
53	practice_attempt_tasks	Records the result of individual tasks within a practice attempt. - Primary keys: id - Foreign keys: practice_attempt_id
54	quiz_attempts	Records a specific attempt by a trainee to complete a quiz. - Primary keys: id - Foreign keys: activity_record_id
55	quiz_attempt_questions	Records the trainee's answer/score for a specific question in a quiz attempt. - Primary keys: id - Foreign keys: quiz_attempt_id
56	quiz_attempt_answers	Records the specific option selected by a trainee for a question. - Primary keys: id - Foreign keys: quiz_attempt_question_id

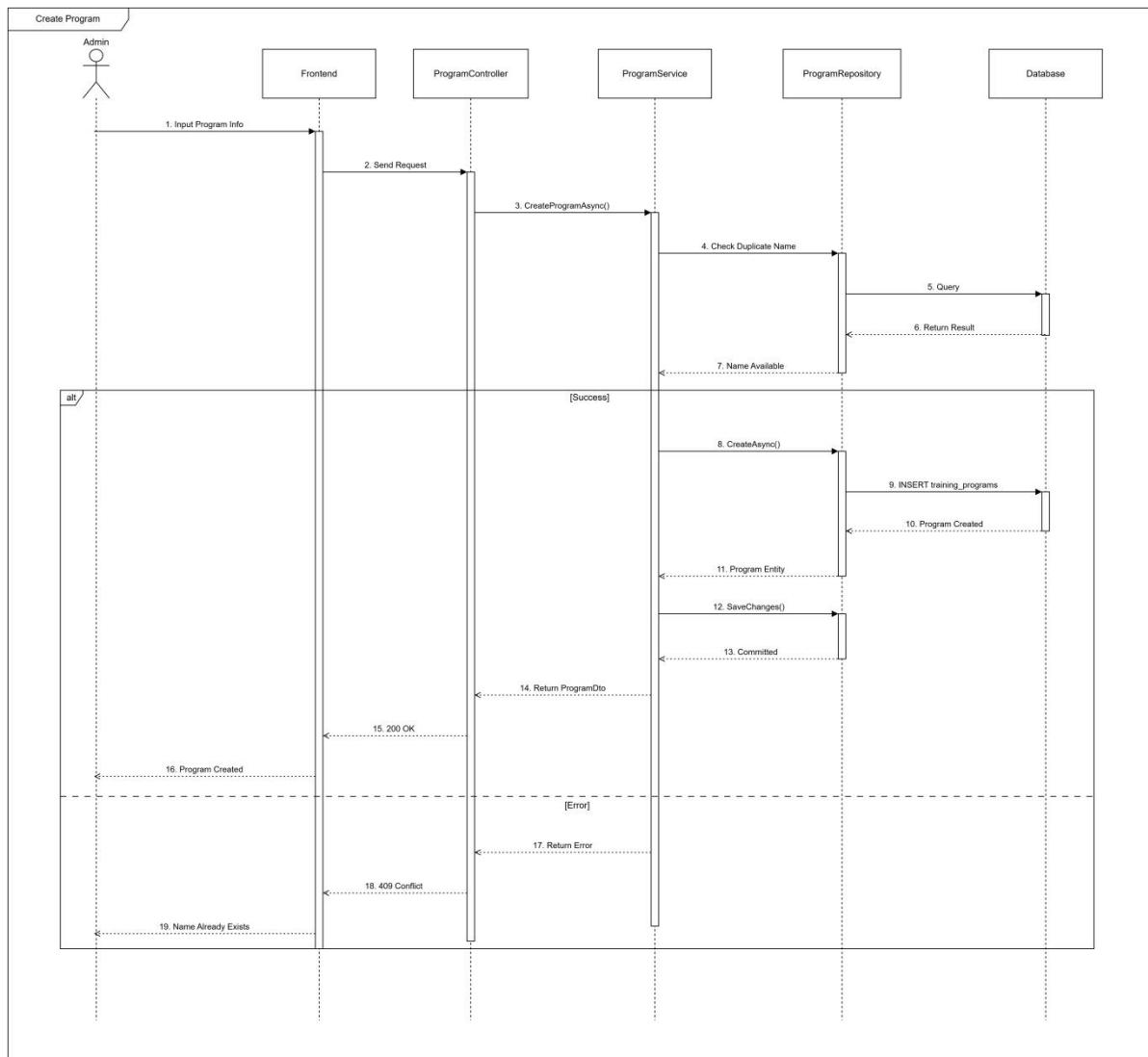
3. Detailed Design

3.1 Program & Course Management

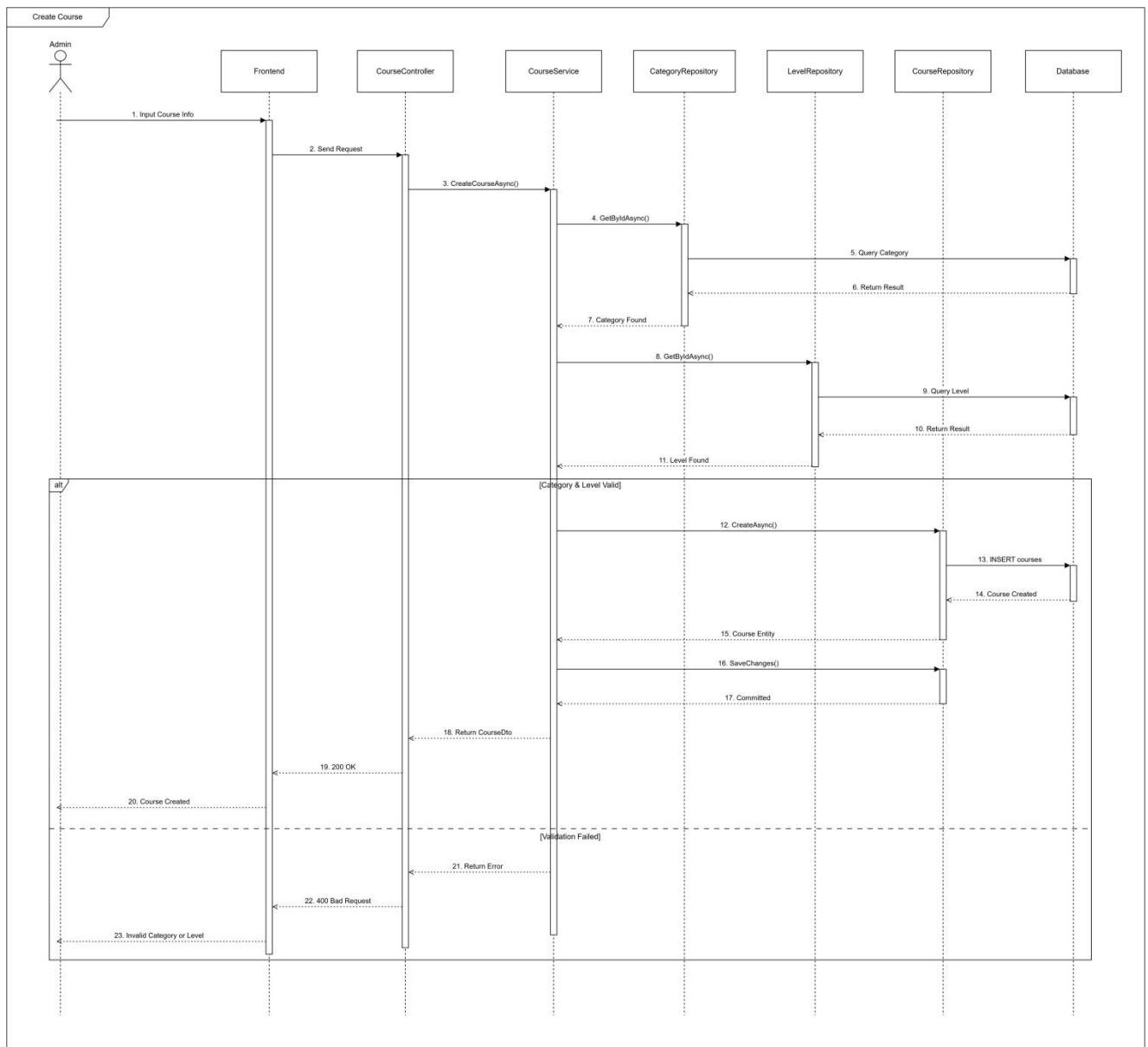
3.1.1 Class Diagram



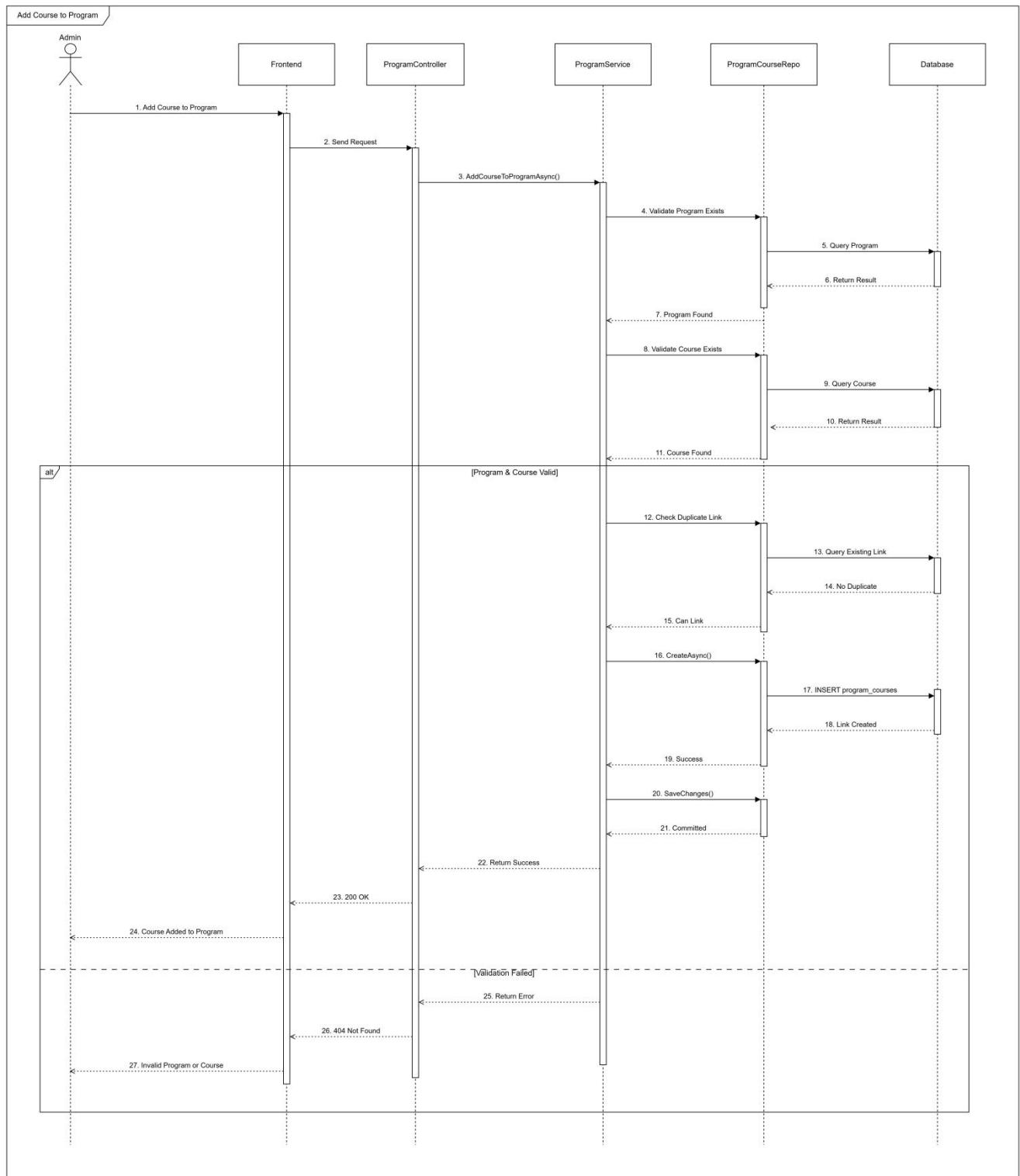
3.1.2 Sequence Diagram - Admin Creates Program



3.1.3 Sequence Diagram - Admin Creates Course



3.1.4 Sequence Diagram - Admin Adds Course To Program

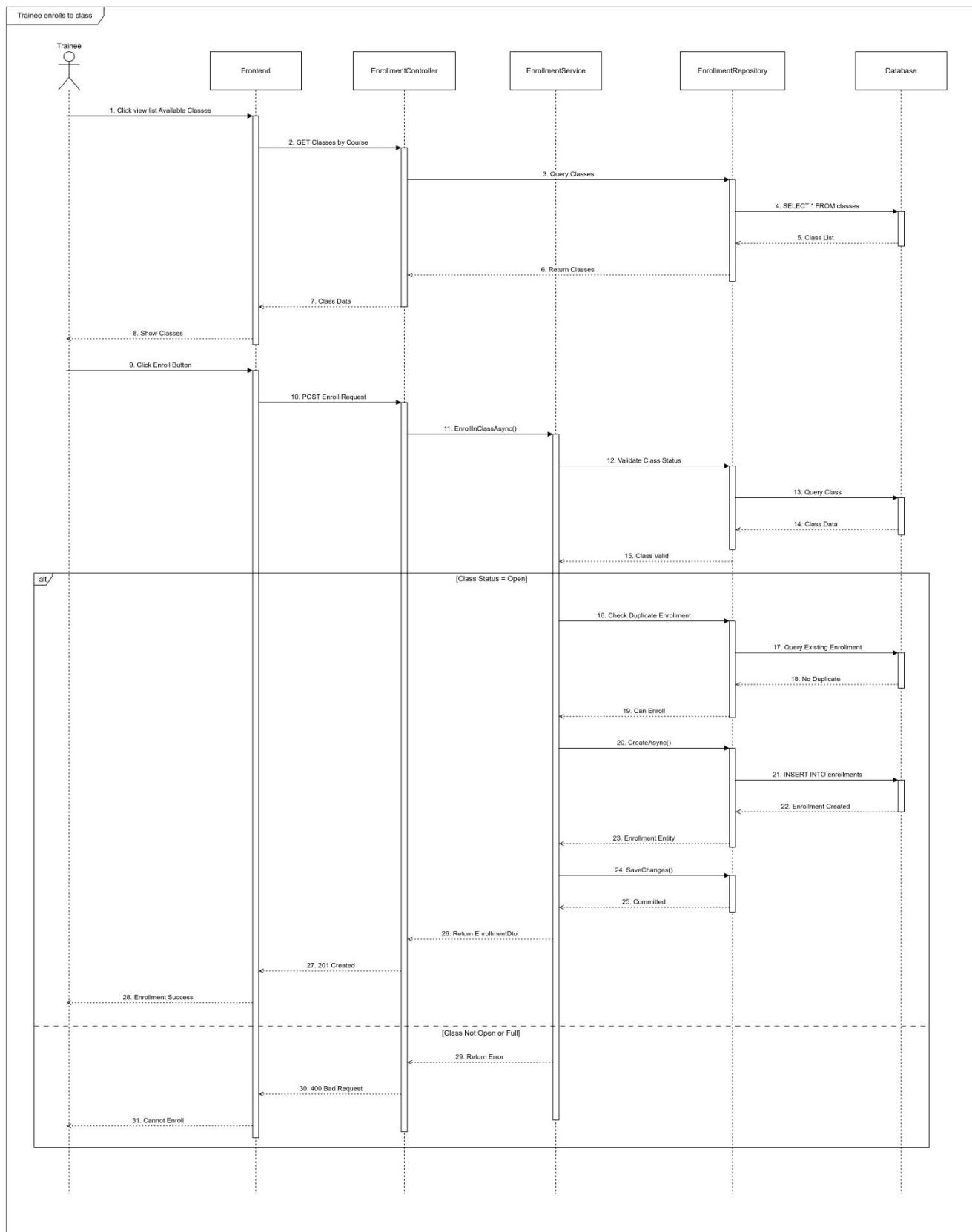


3.2 Class Management & Enrollment

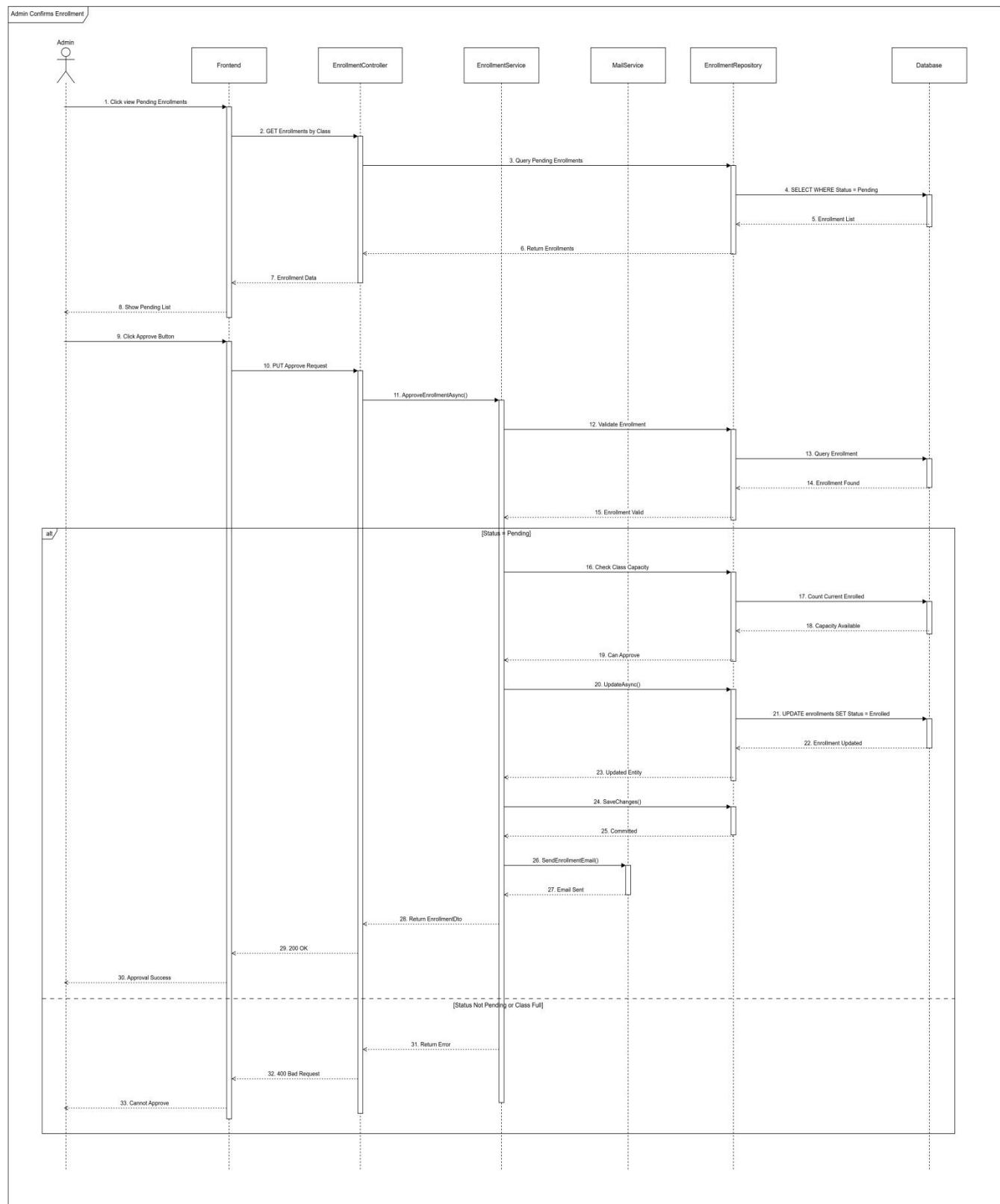
3.2.1 Class Diagram



3.2.2 Sequence Diagram - Trainee Enrolls to Class

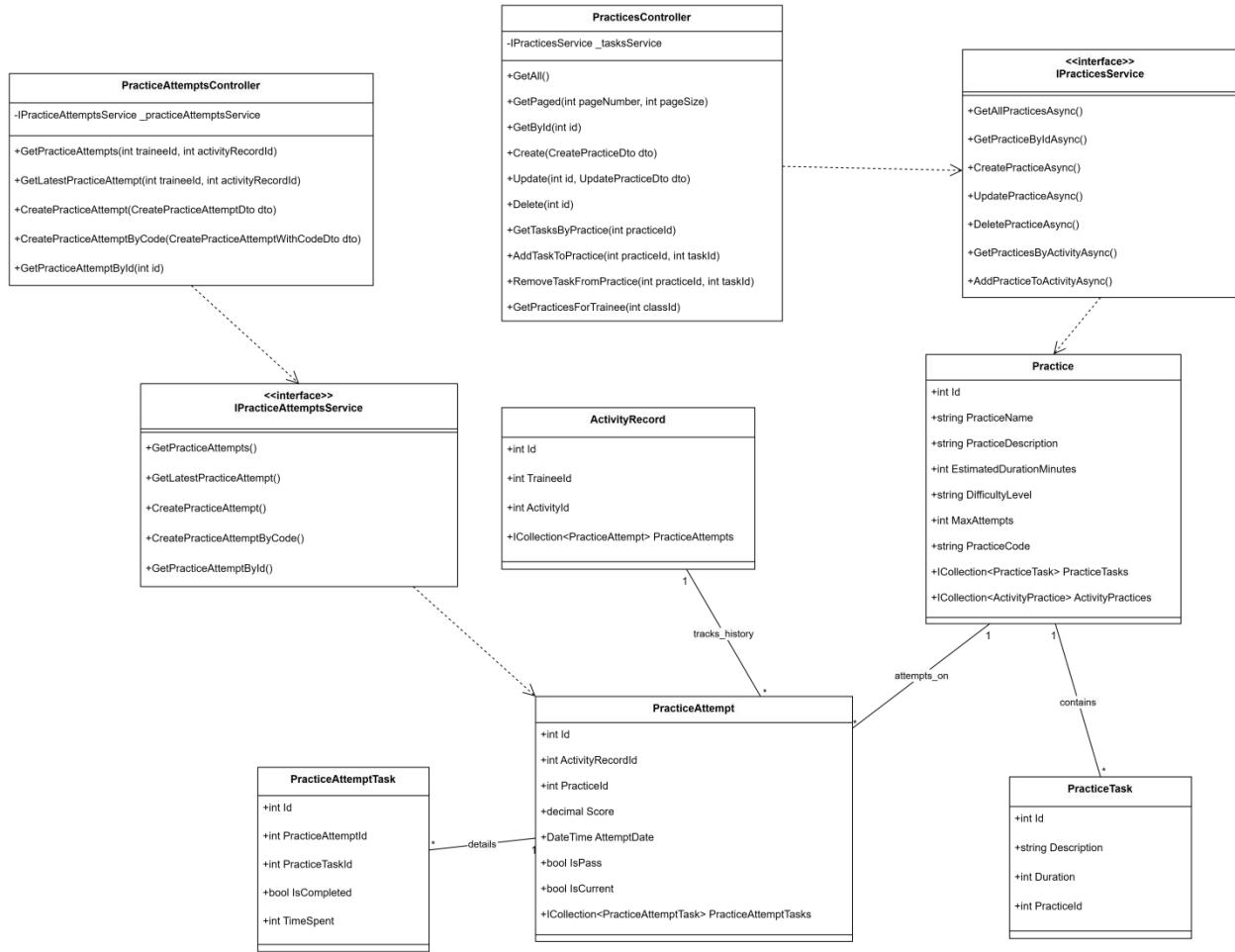


3.2.3 Sequence Diagram - Admin Confirms Enrollment

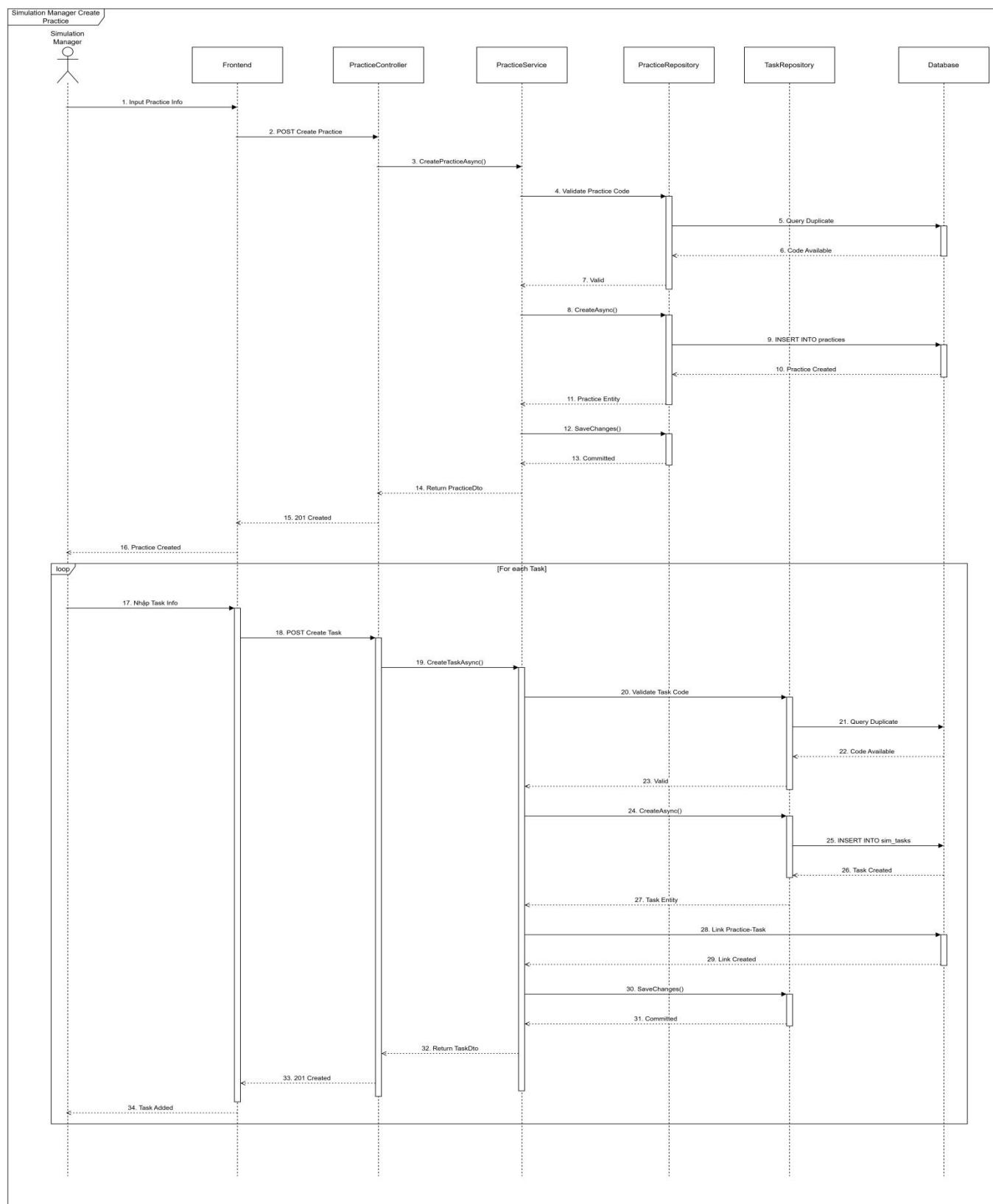


3.3 Simulation Practice Management

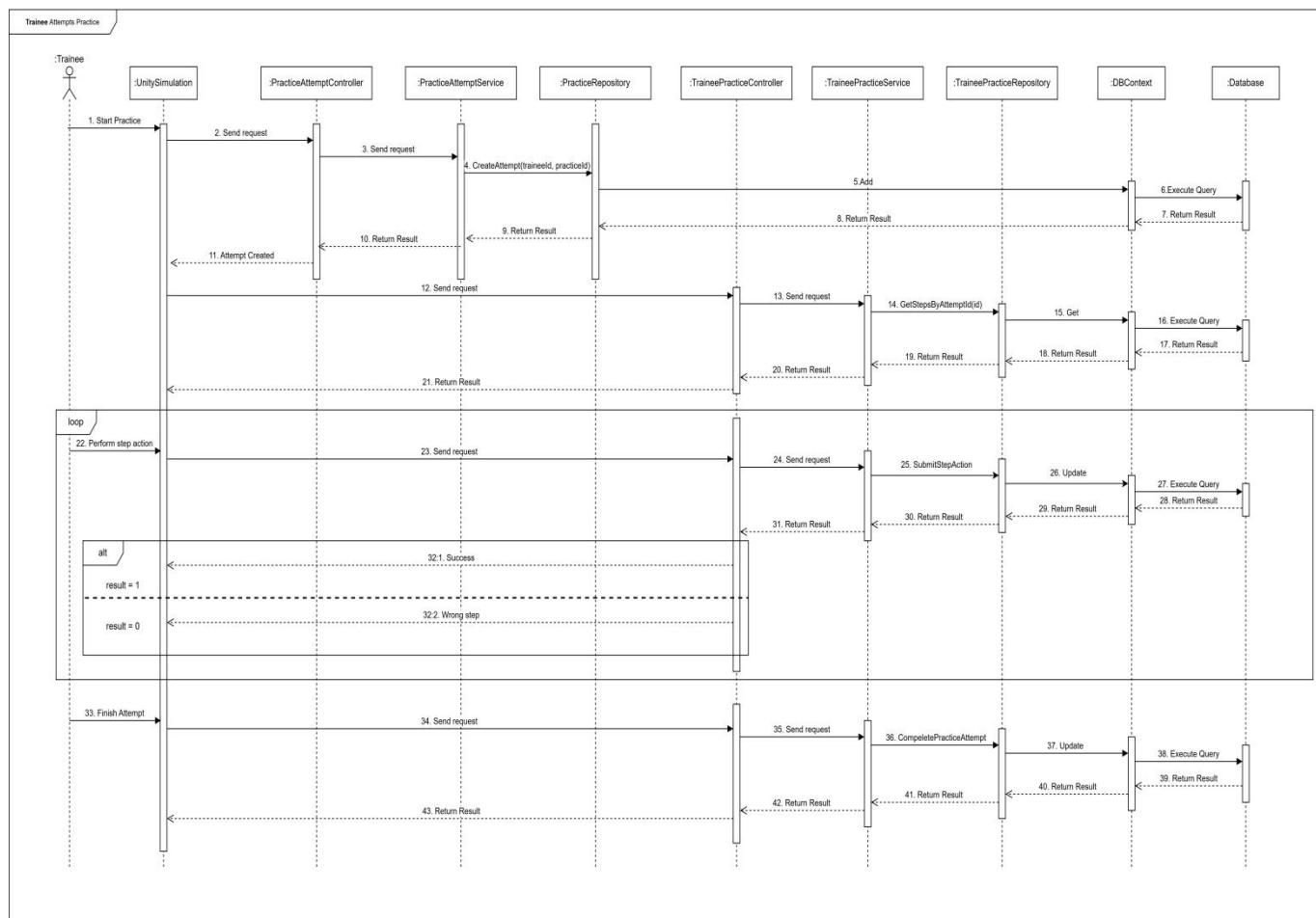
3.3.1 Class Diagram



3.3.2 Sequence Diagram - Simulation Manager Creates Practice

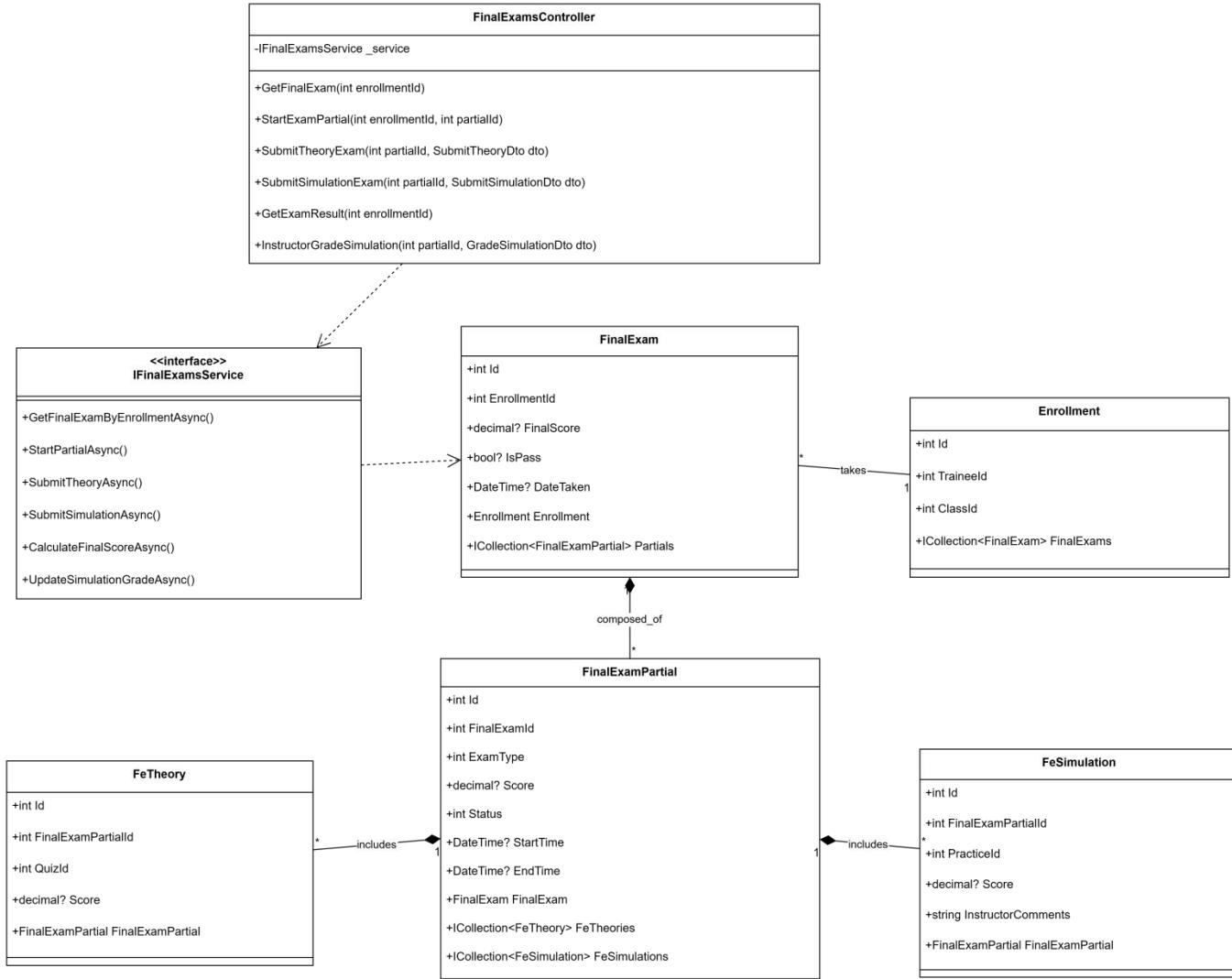


3.3.3 Sequence Diagram - Trainees Attempt Practice

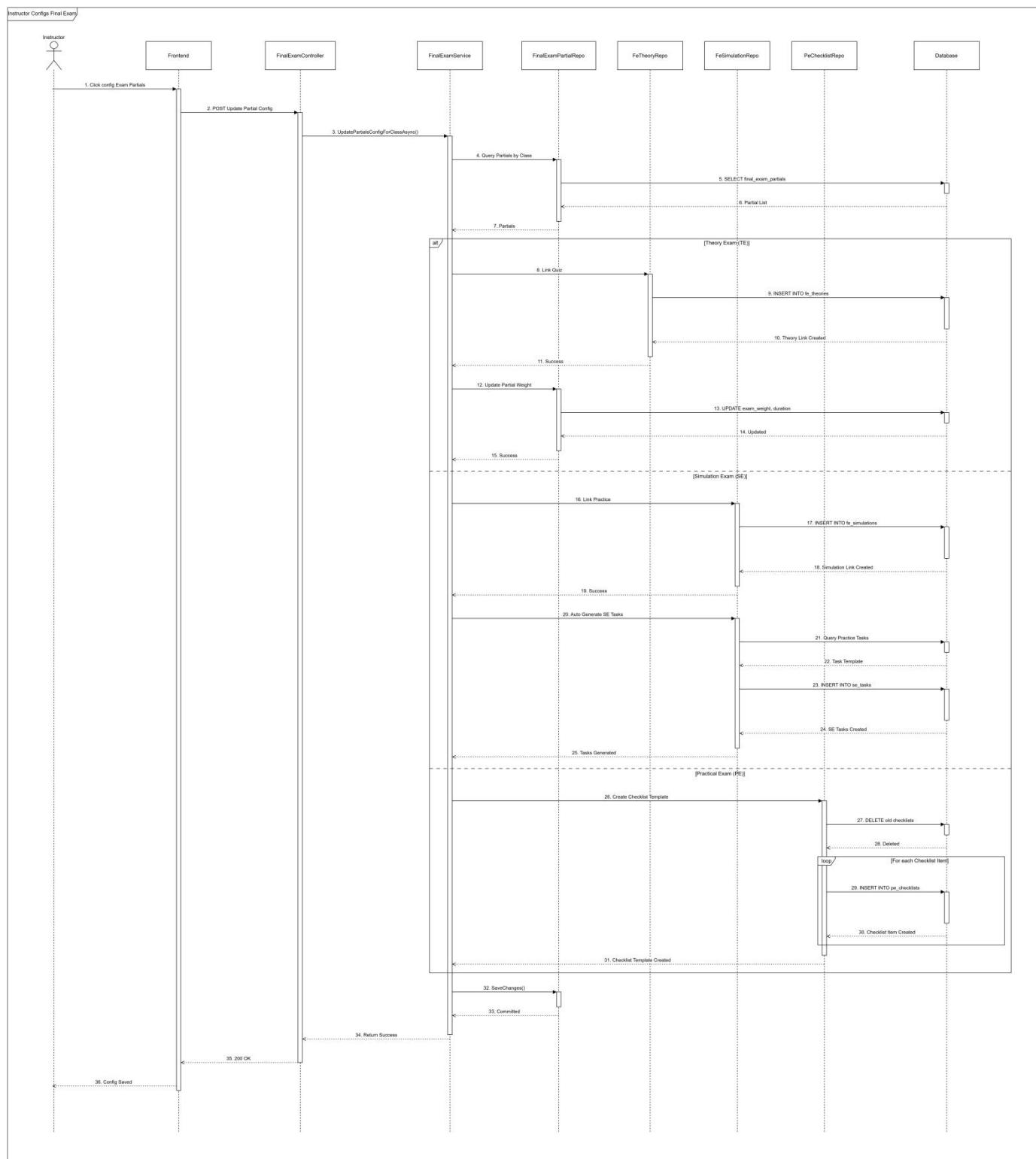


3.4 Final Exam Management

3.4.1 Class Diagram

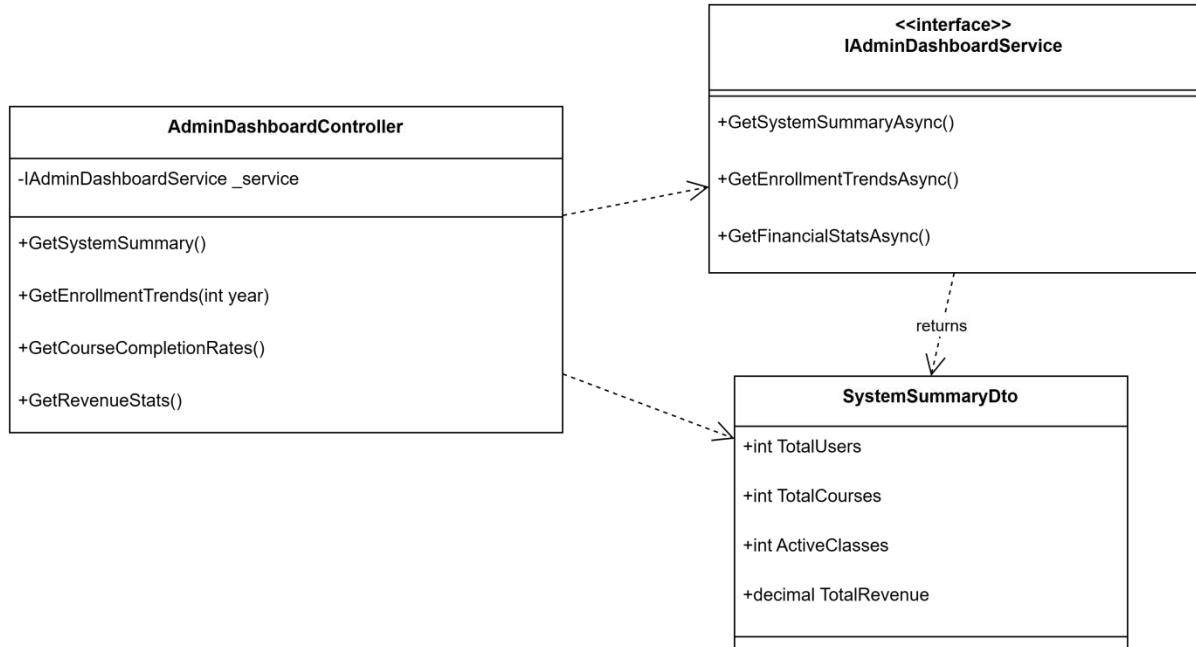


3.4.2 Sequence Diagram - Instructor Configs Final Exam

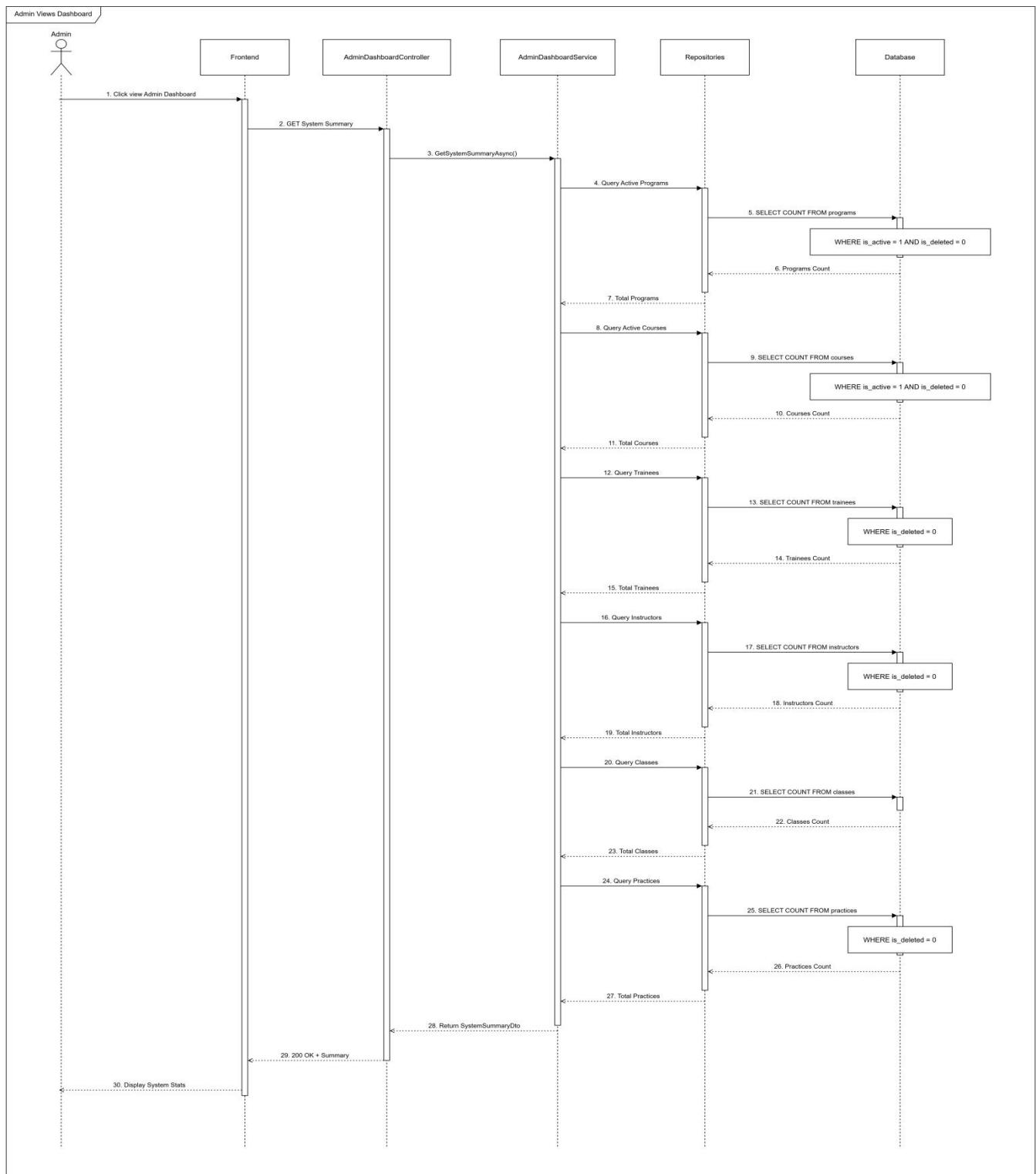


3.5 Dashboard & Reports

3.5.1 Class Diagram



3.5.2 Sequence Diagram - Admin Views Dashboard



V. Software Testing Documentation

1. Overall Description

1.1 Test Model

The project follows the Agile Testing Model. Testing is performed continuously alongside development sprints (Sprint 1 to Sprint 4).

- Requirement Analysis: Analyze SRS to identify test scenarios.
- Test Design: Create Test Cases (Excel).
- Test Execution: Execute Functional and Integration tests.
- Defect Tracking: Log issues on GitHub and re-test after fixing.

1.2 Testing Levels

- **Unit Testing:** Performed by Developers using xUnit (BE) and localized component testing (FE).
- **Integration Testing:** Verifying communication between React FE, .NET API, and the Simulation Client.
- **System Testing:** End-to-end testing of full workflows (e.g., Enrollment -> Learning -> Exam -> Certificate).
- **Acceptance Testing (UAT):** Validating the system against user requirements (Admin, Instructor, Trainee flows).

1.3 Testing Types

- **Functional Testing:** Verifying all features against SRS (CRUD, Workflows).
- **UI/UX Testing:** Ensuring responsiveness and usability (React components).
- **API Testing:** Validating data integrity using Postman.
- **Security Testing:** Verifying Role-based Access Control (RBAC) and JWT Authentication.

2. Test Plan

2.1 Test Stages

Type of Test	Stage of Test			
	Unit	Integration	System	Acceptance
Function Test	X	X	X	X
User Interface Test			X	X
Performance Tests		X	X	
Security Test		X	X	
Data Integrity Test	X	X	X	

2.2 Resources

- a. Human Resources (Refer to Team Involvements table in Section I.2)
- b. Environment

Purpose	Tool	Provider	Version
Backend Server	.NET 8 Web API	Microsoft	Hosted on Azure/Localhost
Frontend Client	ReactJS (Vite)	Open Source	Node.js v18+
Database	SQL Server	Microsoft	Azure SQL / SQL Server 2019
Simulation Client	Unity Build	Unity Tech	Windows Executable (.exe)
Browser	Google Chrome	Google	Latest Version
API Testing	Swagger / Swagger UI / Swagger Editor	OpenAPI Initiative	Latest Version
IDE	VS Code / Visual Studio	Microsoft	Code Editing

2.3 Test Milestones

Milestone Task	Effort (md)	Start Date	End Date
Test Planning	2	10/11/2025	11/11/2025
Test Case Design	5	12/11/2025	18/11/2025
Environment Setup	1	19/11/2025	19/11/2025
Test Execution (Round 1)	5	20/11/2025	26/11/2025
Bug Fixing & Retest	3	27/11/2025	05/12/2025
Final Report Generation	1	06/12/2025	12/12/2025

2.4 Deliverables

No	Deliverables	Due Date
1	Report 5 - Test Documentation (This document)	14/12/2025
2	Report 5 - Test Cases (Excel File)	14/12/2025
3	Test Execution Reports (CSV/Excel)	14/12/2025
4	Bug Log / Defect List	14/12/2025

3. Test Cases

Detailed test cases are provided in the attached file: [Report5_Test Report.xlsx](#). The test suite covers the following modules:

- Training Content & Curriculum Management:** Program, Course, Class, Section management.
- Trainee Enrollment & Learning Process:** Enrollment flow, "My Classes", learning materials.
- Simulation Integration:** Launching Sim client, syncing scores and results.
- Trainee Final Exam Module:** Theory and Simulation exams, grading logic.
- Dashboard Management:** Admin, Instructor, and Sim Manager analytics.

4. Test Reports

Summary of Test Execution (Source: Test Statistics.csv):

- **Total Test Cases:** 197
- **Passed:** 191
- **Failed:** 0
- **Pending/NA:** 6 (Skipped scenarios or future features)
- **Pass Rate:** ~96.95%

No	Module Name	Passed	Failed	Pending	N/A	Total TCs
1	<i>Training Content & Curriculum Management</i>	50	0	0	0	56
2	<i>Trainee Enrollment & Learning Process</i>	73	0	0	0	73
3	<i>Simulation Integration & Practice Session</i>	9	0	0	0	9
4	<i>Trainee Final Exam Module</i>	36	0	0	0	36
5	<i>Dashboard Management</i>	23	0	0	0	23
Total		191	0	0	0	197

VI. Release Package & User Guides

1. Deliverable Package

1.1 Source codes & documents

No.	Items	Sub-Items	Type	Version
	Code Package			

No.	Items	Sub-Items	Type	Version
1	LSSCTC Backend API	Web Service	Modify	10.5
2	LSSCTC Frontend Web App	User Web Application	Modify	9.3
3	LSSCTC Simulator Desktop App	User Desktop Application	Modify	3.0
Database				
1	Tables	lssctc_db_script.sql	Modify	N/A
Documents				
1	Project Introduction	Report1_Project Introduction.docx	Modify	1.0
2	Project Management Plan	Report2_Project Management Plan.docx	Modify	1.0
3	Software Requirement Specification	Report3_Software Requirement Specification.docx	Modify	1.0
4	Software Design Document	Report4_Software Design Document.docx	Modify	1.0
5	Test Documentation	Report5_Test Documentation.docx	Modify	1.0
6	Software User Guides	Report6_Software User Guides.docx	Modify	1.0
7	Final Project Report	Report7_FinalProjectReport.docx	Modify	1.0

1.2 Known Issues, Limitations & Restrictions

- npm install fails: Delete the node_modules folder and package-lock.json file, then run npm install again.
- Port 5173 already in use: Stop the process currently using the port or change the port number in the vite.config.js file.
- API calls fail with CORS error: Verify that the backend server is running and configured to accept requests from http://localhost:5173.
- Google OAuth not working: Ensure the Client ID in the .env file is correct and the Redirect URIs in the Google Cloud Console match your local URL.
- Blank page appears after loading: Open the browser developer tools console to check for JavaScript errors or missing environment variables.
- Module not found errors: Run npm install again to ensure all required dependencies are downloaded.

2. Installation Guides

2.1 System Requirements

2.1.1 Hardware Requirements

Component	Minimum	Recommended
CPU	At least 2 GHz x64-bit CPU	Intel Core I5, 4GHz
Memory	At least 8GB RAM	16GB RAM
Storage	10GB SSD	15GB SSD

Network	Internet Connection	500 Mbps
---------	---------------------	----------

Table 1: Hardware Requirements

2.1.2 Software Requirements

Component	Software & Version	Description
Operating System	Windows 10/11, macOS 10.15+, or Linux (Ubuntu 20.04+)	Operating system for running project
DBMS	SQL Server 2019 or Azure SQL Database	Database management system
Server Environment	.NET 8.0 SDK	Environment for running backend API
Frontend Environment	Node.js 18.17.0 or higher	Environment for running frontend application
Package Manager	NPM 9.x or higher	Package manager for frontend dependencies
IDE	Visual Studio Code 1.80+ or Visual Studio 2022	Tool for viewing and editing code
VCS	Git 2.30+	Tool for managing code version
Web Browser	Chrome 90+, Firefox 88+, Edge 90+, or Safari 14+	Browser for accessing web application
Database Tool	SQL Server Management Studio (SSMS) 19+ or Azure Data Studio	Tool for database management

Table 2: Software Requirements

2.2 Setup Files

2.2.1 Database Files

- **lssctc_db-script-v5.sql:** Complete database schema script for SQL Server
- **seed-data.sql:** Initial seed data for system (users, roles, course categories, etc.)

2.2.2 Backend Files

- **lssctc-api.zip:** Complete backend API solution
 - Contains: Controllers, Services, Models, Repositories, and Configuration files
 - Main project: Lssctc.ProgramManagement
 - Shared library: Lssctc.Share

2.2.3 Frontend Files

- **lssctc-web.zip:** Complete frontend web application
 - Contains: React components, Pages, Routes, Layouts, and Assets
 - Main entry: src/main.jsx

- Configuration: vite.config.js, package.json

2.2.4 Configuration Files

- **appsettings.json**: Backend API configuration (connection strings, JWT settings)
- **appsettings.Development.json**: Development-specific settings
- **.env. example**: Frontend environment variables template

2.3 Installation Instruction

2.3.1 Setup Environment

Step 1: Install Required Software

● Download and Install .NET 8.0 SDK

- Visit: <https://dotnet.microsoft.com/download/dotnet/8.0>
- Download .NET 8.0 SDK for your operating system
- Run installer and follow installation wizard

● Download and Install Node.js 18.17.0 or higher

- Visit: <https://nodejs.org/>
- Download LTS version (18.17.0 or newer)
- Run installer and follow installation wizard

● Download and Install SQL Server 2019

- Visit: <https://www.microsoft.com/en-us/sql-server/sql-server-downloads>
- Download SQL Server 2019 Developer Edition (free)
- Run installer and select:
 - Database Engine Services
 - SQL Server Replication
 - Client Tools Connectivity
- Configure authentication mode: **Mixed Mode** (SQL Server and Windows Authentication)
- Set SA password (remember this for connection string)
- Verify installation using SQL Server Configuration Manager

● Download and Install SQL Server Management Studio (SSMS)

- Visit: <https://docs.microsoft.com/en-us/sql/ssms/download-sql-server-management-studio-ssms>
- Download latest version (19.x)
- Run installer
- Launch SSMS and connect to local SQL Server instance

- **Download and Install Visual Studio Code**

- Visit: <https://code.visualstudio.com/>
- Download for your operating system
- Install recommended extensions:
 - C# Dev Kit
 - C# Extensions
 - JavaScript (ES6) code snippets
 - ESLint
 - Prettier - Code formatter
 - Thunder Client (for API testing)

- **Download and Install Git**

- Visit: <https://git-scm.com/downloads>
- Download for your operating system
- Run installer with default options

Step 2: Configure Git

- Set your name and email
 - git config --global user.name "Your Name"
 - git config --global user.email "your. email@example.com"
- Verify configuration
 - git config --list

Step 3: Connect Git with GitHub Account

- Generate SSH key (if not already exists)
 - ssh-keygen -t ed25519 -C "your.email@example.com"
- Start SSH agent
 - eval "\$(ssh-agent -s)"
- Add SSH key to agent
 - ssh-add ~/.ssh/id_ed25519
- Copy public key to clipboard (Windows)
 - clip < ~/.ssh/id_ed25519.pub
- Copy public key to clipboard (macOS)

- pbcopy < ~/.ssh/id_ed25519.pub
- Copy public key to clipboard (Linux)
 - cat ~/ssh/id_ed25519.pub | xclip -selection clipboard
- Go to GitHub → Settings → SSH and GPG keys → New SSH key
- Paste your public key and save

Step 4: Clone Repositories

- Create project directory
 - mkdir lssctc-project
 - cd lssctc-project
- Clone backend repository
 - git clone https://github.com/hieuvau198/lssctc-api.git
- Clone frontend repository
 - git clone https://github.com/hieuvau198/lssctc-web.git

2.3.2 Setup Database

Step 1: Create Database

- Open **SQL Server Management Studio (SSMS)**
- Connect to your local SQL Server instance
- Right-click on **Databases** → Select **New Database**
- Database name: LSSCTC_DB
- Click **OK**

Step 2: Execute Database Script

- Open **lssctc_db-script-v5.sql** in SSMS
 - File → Open → File → Select lssctc_db-script.sql
- Ensure **LSSCTC_DB** is selected in database dropdown
- Click **Execute** button or press F5
- Wait for script execution to complete
- Verify tables are created:
 - USE LSSCTC_DB;
 - GO
- SELECT TABLE_SCHEMA, TABLE_NAME

- FROM INFORMATION_SCHEMA.TABLES
- WHERE TABLE_TYPE = 'BASE TABLE'
- ORDER BY TABLE_NAME;
- Expected output: 40+ tables including users, roles, courses, classes, quizzes, etc.

Step 3: Execute Seed Data (Optional)

- Open **seed-data.sql** in SSMS
- Execute script to populate initial data:
 - Default admin account
 - Course categories and levels
 - Course and class codes
 - Material types
- Verify seed data:
- SELECT * FROM users;
- SELECT * FROM course_categories;
- SELECT * FROM course_levels;

Step 4: Verify Database Connection String

- Server name: localhost or (local) or .
 - Database name: LSSCTC_DB
 - Authentication: SQL Server Authentication or Windows Authentication
 - Example connection string:
 - Server=localhost;Database=LSSCTC_DB;User Id=sa;Password=YourPassword;TrustServerCertificate=True
-

2.3.3 Setup and Run Backend API

Step 1: Navigate to Backend Project

- cd lssctc-project/lssctc-api/Lssctc/Lssctc.ProgramManagement

Step 2: Configure Application Settings

- Open **appsettings.json** in text editor or VS Code
- Update your custom value for: "ConnectionStrings", "JwtConfig", "EmailSettings"
- **Generate JWT Secret Key** (recommended):
 - Generate random 32-character key using PowerShell (Windows)
 - Generate random 32-character key using openssl (macOS/Linux)

- **Configure Email Settings** (for OTP functionality):
 - Use Gmail account
 - Enable 2-Factor Authentication
 - Generate App Password: <https://myaccount.google.com/apppasswords>
 - Use App Password in configuration (not your Gmail password)

Step 3: Restore NuGet Packages

- Restore all dependencies
 - dotnet restore

Step 4: Build Project

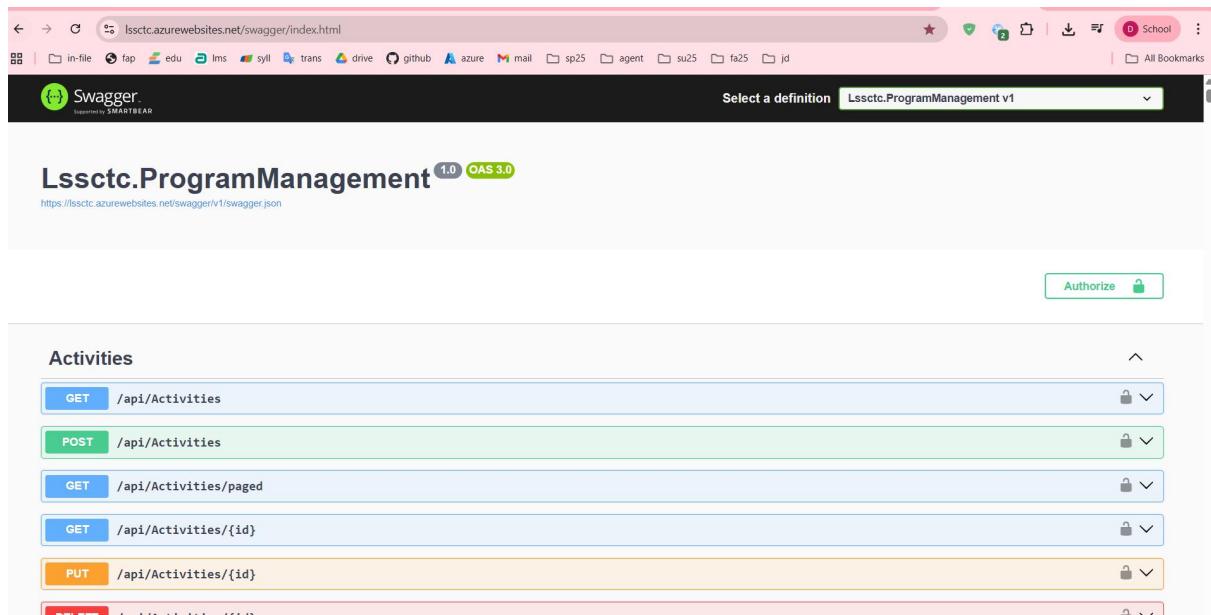
- Build project
 - dotnet build
 - Expected output: Build succeeded.

Step 5: Run Backend API

- Run in development mode
 - dotnet run

Step 6: Verify API is Running

- Open web browser
- Navigate to: <http://localhost:5000/swagger>
- You should see Swagger UI with all API endpoints



File: screenshot_swagger_ui_homepage.png

```

"openapi": "3.0.1",
"info": {
  "title": "lsctc.ProgramManagement",
  "version": "1.0"
},
"paths": {
  "/api/Activities": {
    "get": {
      "tags": [
        "Activities"
      ],
      "responses": {
        "200": {
          "description": "OK"
        }
      }
    },
    "post": {
      "tags": [
        "Activities"
      ],
      "requestBody": {
        "content": {
          "application/json": {
            "schema": {
              "$ref": "#/components/schemas/CreateActivityDto"
            }
          },
          "text/json": {
            "schema": {
              "$ref": "#/components/schemas/CreateActivityDto"
            }
          },
          "application/*+json": {
            "schema": {
              "$ref": "#/components/schemas/CreateActivityDto"
            }
          }
        },
        "responses": {
          "200": {
            "description": "OK"
          }
        }
      }
    }
  }
}

```

4. Test authentication endpoint:

- Expand **POST /api/Authens/login-username**
- Click **Try it out**
- Enter test credentials (if seeded)
- Click **Execute**
- Verify 200 OK response with JWT token

The screenshot shows the Swagger UI interface for the **Authens** endpoint. The URL is `/api/Authens/login-username`. The method is **POST**. The parameters section shows "No parameters". The request body section has a dropdown set to `application/json`, and the JSON content is:

```
{
  "username": "admin1",
  "password": "admin1"
}
```

At the bottom, there is a blue **Execute** button.

2.3.4 Setup and Run Frontend Web Application

This section outlines how to configure, run, and verify the frontend client interface.

Step 1: Installation

- Navigate to the project directory and install the required dependencies.

Step 2: Environment Configuration

- Set up the connection to the backend and external services.
- Create the configuration file:
- Windows: copy .env.example .env
- macOS/Linux: cp .env.example .env
- Edit the .env file
- Optional: Google OAuth Setup To enable "Sign in with Google," create a project in the Google Cloud Console:
 - Type: OAuth 2.0 Web Application
 - Origin: http://localhost:5173
 - RedirectURI: http://localhost:5173/auth/callback
 - Action: Paste the generated Client ID into your .env file.

Step 5: Production Build (Optional)

- To prepare the application for final deployment:
- Build: Run npm run build to generate the dist/ folder.
- Preview: Run npm run preview to test the build at http://localhost:5173.

2.3.5 Deployment to Production

Backend Deployment Options:

Option 1: Deploy to Azure App Service

1. Install Azure CLI
2. Login to Azure:
3. az login
4. Create App Service:
5. az webapp create --resource-group myResourceGroup --plan myAppServicePlan --name lssctc-api --runtime "DOTNET:8.0"
6. Deploy:
7. dotnet publish -c Release
8. az webapp deploy --resource-group myResourceGroup --name lssctc-api --src-path ./bin/Release/net8.0/publish.zip
9. Configure connection string in Azure Portal
10. Update JWT and Email settings

Option 2: Deploy to Docker Container

1. Create Dockerfile in backend project root:

2. FROM mcr.microsoft.com/dotnet/aspnet:8.0
3. WORKDIR /app
4. COPY ./publish .
5. ENTRYPOINT ["dotnet", "Lssctc.ProgramManagement.dll"]
6. Build and run:
7. dotnet publish -c Release -o ./publish
8. docker build -t lssctc-api .
9. docker run -p 5000:80 lssctc-api

Frontend Deployment Options:

Option 1: Deploy to Vercel

1. Install Vercel CLI:
2. npm install -g vercel
3. Login:
4. vercel login
5. Deploy:
6. vercel --prod
7. Configure environment variables in Vercel dashboard

Option 2: Deploy to Azure Static Web Apps

1. Build production bundle:
2. npm run build
3. Create Static Web App in Azure Portal
4. Connect to GitHub repository
5. Configure build settings:
 - App location: /
 - API location: (empty)
 - Output location: dist
6. Azure will automatically build and deploy on push

Option 3: Deploy to Netlify

1. Install Netlify CLI:
2. npm install -g netlify-cli
3. Build:

4. npm run build
5. Deploy:
6. netlify deploy --prod --dir=dist

Database Deployment:

Deploy to Azure SQL Database

1. Create Azure SQL Database in Azure Portal
2. Export local database using SSMS:
 - o Right-click database → Tasks → Generate Scripts
 - o Select all objects
 - o Save script
3. Connect to Azure SQL Database
4. Execute script to create schema

Update connection string in backend configuration

3. User Manual

3.1 Terms and definitions

Term	Definition
LSSCTC	Learner Management and 3D Simulation System for Crane Training Center
Admin	System administrator with full access to all features and user management
Instructor	Teacher/trainer who creates course content, quizzes, and evaluates trainees
Trainee	Student enrolled in crane operation training courses
Program Manager	Role responsible for curriculum design and course orchestration
Simulation Manager	Role responsible for managing 3D simulation components and scenarios
Training Program	Complete curriculum consisting of multiple courses leading to certification
Course	Individual training module covering specific crane operation topics
Section	Subdivision within a course containing organized activities
Activity	Learning task within a section (material, quiz, or practice)

Learning Material	Educational content (PDF, video, image, URL) provided to trainees
Quiz	Assessment containing multiple-choice or single-choice questions
Practice	Hands-on simulation task for skill development and evaluation
Class	Group of trainees enrolled in a program with scheduled sessions
Timeslot	Scheduled session for class instruction with date, time, and instructor
Enrollment	Trainee's registration and participation in a specific class
Activity Record	Trainee's progress and completion status for an activity
Quiz Attempt	Trainee's submission of a quiz with scored results
Practice Attempt	Trainee's completion of a practice session with performance metrics
Simulation Component	3D model or asset used in crane operation simulation environment
Brand Model	Specific crane manufacturer and model configuration
JWT	JSON Web Token - authentication token for API access
OTP	One-Time Password - 6-digit code for password reset verification
WebGL	Web Graphics Library - browser technology for 3D rendering

3.2 System requirements

For End Users (Trainees, Instructors):

- Operating System:
 - Windows 10/11 (64-bit)
 - macOS 10.15 (Catalina) or later
 - Linux (Ubuntu 20.04+ or equivalent)
- Web Browser:
 - Google Chrome 90+ (Recommended)
 - Mozilla Firefox 88+
 - Safari 14+ (macOS only)
 - Microsoft Edge 90+
- Internet Connection:
 - Minimum: 5 Mbps (for video streaming and general use)
 - Recommended: 10 Mbps (for 3D simulation)
- Display Resolution:

- Minimum: 1366x768
 - Recommended: 1920x1080 or higher
- Input Devices:
 - Mouse and keyboard (required)
 - Trackpad supported but not recommended for simulation

For Simulation Features:

- RAM:
 - Minimum: 8GB
 - Recommended: 16GB
- Graphics Card:
 - Dedicated GPU with WebGL 2.0 support
 - NVIDIA GTX 1050 or equivalent
 - AMD Radeon RX 560 or equivalent
- Storage:
 - 2GB free space for cached 3D models and textures
- CPU:
 - Minimum: Intel Core i5 or AMD Ryzen 5
 - Recommended: Intel Core i7 or AMD Ryzen 7

For System Administrators:

- All of the above, plus:
- Access to SQL Server Management Studio or Azure Data Studio
- Network access to application server and database server

Remote desktop or SSH access to servers (for on-premise deployment)

3.3 Application Usage

a. Overview

The LSSCTC system is a web-based Learning Management System integrated with 3D crane operation simulation capabilities. It consists of:

1. Frontend (Web Application): React-based single-page application
2. Backend (API): .NET 8 RESTful API with JWT authentication
3. Database: SQL Server relational database
4. 3D Engine: WebGL-based simulation environment (planned)

b. Feature 1: Authentication & User Management

Purpose: Secure user authentication with multiple login methods and role-based access control

Available Functions:

1. Login with Username/Password
2. Login with Email/Password
3. Login with Google OAuth

4. Password Reset (OTP-based)

5. Logout

Profile View and Update

c. Feature 2: Admin - Course Management

Purpose: Create, organize, and manage training courses

Available Functions:

1. View All Courses (with pagination, search, sort)

2. Create New Course

3. Edit Course Details

4. Delete Course (soft delete)

5. Assign Course to Programs

View Course Enrollments

d. Feature 3: Admin - Class Management

Purpose: Organize trainees into classes, assign instructors, and manage schedules

Available Functions:

1. View All Classes

2. Create New Class

3. Edit Class Details

4. View Class Enrollments

5. Approve/Reject Enrollments

6. Manage Class Timeslots (Schedule)

Assign Instructors

e. Feature 4: Instructor - Quiz Management

Purpose: Create assessments to evaluate trainee knowledge and understanding

Available Functions:

1. Create Quiz with Questions

2. Import Quiz from Excel Template

3. Edit Quiz and Questions

4. Delete Quiz

5. Assign Quiz to Activity

View Quiz Attempts and Results

Create Quiz:

Step-by-Step Instructions:

1. Login as Instructor

2. Navigate to Instructor Dashboard

3. Click "Quizzes" in sidebar

Bài kiểm tra

1-1 trong tổng số 1 bài kiểm tra

Nhập từ Excel + Tạo Bài kiểm tra

#	Tên	Thời gian (phút)	Điểm đậu	Tổng điểm	Thao tác
1	Quiz test	25	6 điểm	10 điểm	

1-1 trong tổng số 1 bài kiểm tra < 1 > 10 / page

instructor

4. Quizzes list page displays showing your created quizzes

Bài kiểm tra

1-1 trong tổng số 1 bài kiểm tra

Nhập từ Excel + Tạo Bài kiểm tra

#	Tên	Thời gian (phút)	Điểm đậu	Tổng điểm	Thao tác
1	Quiz test	25	6 điểm	10 điểm	

1-1 trong tổng số 1 bài kiểm tra < 1 > 10 / page

instructor

5. Click "Create New Quiz" button

The screenshot shows a user interface for creating quizzes. On the left, there's a sidebar with navigation items like 'Giảng viên' (Instructor), 'Bảng điều khiển' (Control Panel), 'Lịch dạy' (Teaching Schedule), 'Lớp học' (Class), 'Tài liệu' (Materials), 'Bài kiểm tra' (Quiz test), and 'Thực hành' (Practical). Below this is a user profile icon labeled 'instructor'. The main area has a title 'Bài kiểm tra' (Quiz) and a sub-section '1-1 trong tổng số 1 bài kiểm tra' (1-1 out of 1 quiz). It includes a search bar, a table with one row ('Quiz test'), and a progress bar at the bottom. To the right, a modal window titled 'Tạo Bài kiểm tra' (Create Quiz) is open. It contains fields for 'Tên' (Name) with placeholder 'VD: Kiến thức An toàn Cơ bản', 'Điểm đầu (diểm)' (Starting point points) set to 5, 'Thời gian (phút)' (Time minutes) set to 20, and a 'Mô tả' (Description) text area. At the bottom of the modal, there's a summary section with a green bar indicating 'Tổng điểm Bài kiểm tra' (Total score Quiz) is 10.00 / 10, followed by four boxes: 'Câu hỏi' (Question) with value 1, 'Tổng điểm' (Total score) with value 10.00, 'TB / Câu' (Average per question) with value 10.00, and 'Điểm chấm lại' (Regrade points) with value 0.00. A note says 'Tổng điểm phải bằng 10' (Total score must be 10). Below this is a detailed view of 'Câu hỏi 1' (Question 1) with fields for 'Nội dung Câu hỏi' (Question content) with placeholder 'Vui lòng nhập nội dung câu hỏi', 'Điểm' (Score) set to 10.0, and a 'Mô tả' (Description) text area.

6. Quiz creation form opens (may be multi-step)

Step 1: Quiz Basic Information

X Tạo Bài kiểm tra

X Hủy

Tạo Bài kiểm tra

* Tên Bài kiểm tra

VD: Kiến thức An toàn Cơ bản

* Điểm đậu (diểm)

5

* Thời gian (phút)

20

Mô tả

Mô tả tùy chọn

Câu hỏi

Tổng điểm Bài kiểm tra

10.00 / 10

Câu hỏi

1

Tổng điểm

10.00

TB / Câu

10.00

Điểm còn lại

0.00

Tổng điểm phải bằng 10

1 Câu hỏi 1

10 điểm



Nội dung Câu hỏi *

Vui lòng nhập nội dung câu hỏi

Điểm *

10.0

Mô tả

Mô tả (tùy chọn)

7. Fill in quiz information:

- Quiz Name: "Mobile Crane Safety Assessment"
- Description: "Test your knowledge of crane safety procedures"
- Duration: 30 minutes

- Passing Score: 7

8. Click "Next"

Step 2: Add Questions

INSERT SCREENSHOT HERE: Add Questions Section

1 Câu hỏi 1 10 điểm

Nội dung Câu hỏi * Điểm *

Vui lòng nhập nội dung câu hỏi 10.0

Mô tả

Mô tả (tùy chọn)

Tùy chọn + Thêm

A Tùy chọn 1

✓ Đáp án đúng 10.0 điểm

Giải thích cho đáp án này (tùy chọn)

+ Thêm câu hỏi

9. Click "Add Question" button

10. Question form appears

1 Câu hỏi 1

Nội dung Câu hỏi * **Điểm ***

Vui lòng nhập nội dung câu hỏi **10.0**

Mô tả

Mô tả (tùy chọn)

Tùy chọn **+ Thêm**

A Tùy chọn 1 **Đáp án đúng** **10.0 điểm**

Giải thích cho đáp án này (tùy chọn)

+ Thêm câu hỏi

11. Fill in question details:

- Question Text: "What is the safe minimum distance from a power line for crane operations?"
- Score Points: 10
- Explanation: "Regulations often require at least 10 meters depending on voltage."

12. Add Options:

- Click "Add Option" button for each option

INSERT SCREENSHOT HERE: Add Option Interface

Tùy chọn **+ Thêm**

A Tùy chọn 1 **Đáp án đúng** **2.5 điểm**

Giải thích cho đáp án này (tùy chọn)

B Tùy chọn 2 **Đáp án đúng** **0.0 điểm**

Giải thích cho đáp án này (tùy chọn)

13. Enter options:

- Option 1: "1 meter" (not correct)
- Option 2: "3 meters" (not correct)
- Option 3: "10 meters" (check "Is Correct")
- Option 4: "50 meters" (not correct)

1 Câu hỏi 1 2.5 điểm trash

Nội dung Câu hỏi * Điểm *
What is the safe minimum distance from a power line for crane operation? 2.5

Mô tả
Regulations often require at least 10 meters depending on voltage.

Tùy chọn + Thêm

A 1 meter trash 0.0 điểm
 Đáp án đúng
Giải thích cho đáp án này (tùy chọn)

B 3 meter trash 0.0 điểm
 Đáp án đúng
Giải thích cho đáp án này (tùy chọn)

C 10 meter trash 2.5 điểm
 ✓ Đáp án đúng
Giải thích cho đáp án này (tùy chọn)

D 50 meter trash 0.0 điểm
 Đáp án đúng
Giải thích cho đáp án này (tùy chọn)

14. Click "Save Question"

15. Question is added to quiz questions list

Bài kiểm tra

1-2 trong tổng số 2 bài kiểm tra

Create quiz successfully

Nhập từ Excel

+ Tạo Bài kiểm tra

#	Tên	Thời gian (phút)	Điểm đậu	Tổng điểm	Thao tác
1	Mobile Crane Safety Assessment	30	7 điểm	10 điểm	
2	Quiz test	25	6 điểm	10 điểm	

1-2 trong tổng số 2 bài kiểm tra < 1 > 10 / page

16. Repeat steps 9-15 to add more questions

- Add at least 2-10 questions per quiz

Bài kiểm tra

1-2 trong tổng số 2 bài kiểm tra

Create quiz successfully

Nhập từ Excel

+ Tạo Bài kiểm tra

#	Tên	Thời gian (phút)	Điểm đậu	Tổng điểm	Thao tác
1	Mobile Crane Safety Assessment	30	7 điểm	10 điểm	
2	Quiz test	25	6 điểm	10 điểm	

1-2 trong tổng số 2 bài kiểm tra < 1 > 10 / page

17. Review Quiz:

- Check all questions are added
- Verify total points
- Ensure at least one correct option per question

18. Click "Save Quiz" button

19. Success message: "Quiz created successfully"

The screenshot shows a web-based quiz management system. At the top, there's a blue header bar with the title "Bài kiểm tra" and a message "Create quiz successfully". Below the header is a search bar with placeholder text "Tim kiem bài kiểm tra..." and a magnifying glass icon. To the right of the search bar are two buttons: "Nhập từ Excel" and "+ Tạo Bài kiểm tra". The main content area displays a table of quizzes:

#	Tên	Thời gian (phút)	Điểm đậu	Tổng điểm	Thao tác
1	Mobile Crane Safety Assessment	30	7 điểm	10 điểm	
2	Quiz test	25	6 điểm	10 điểm	

At the bottom of the page, there's a footer navigation bar with the text "1-2 trong tổng số 2 bài kiểm tra" and a page number "1" in the center. To the right of the page number is a dropdown menu "10 / page".

API Endpoint Used:

POST /api/Quizzes/with-questions

Request Body:

```
{  
  "name": "Mobile Crane Safety Assessment",  
  "description": "Test your knowledge.. .",  
  "durationMinutes": 30,  
  "passingScore": 70,  
  "isRandomizeQuestions": true,  
  "isRandomizeOptions": true,  
  "showCorrectAnswers": true,  
  "isActive": true,  
  "questions": [  
    {  
      "questionText": "What is the safe minimum distance.. .",  
      "score": 2.5,  
      "isMultiple": false,  
      "options": [  
        {"text": "A", "isCorrect": false},  
        {"text": "B", "isCorrect": true},  
        {"text": "C", "isCorrect": false},  
        {"text": "D", "isCorrect": false}  
      ]  
    }  
  ]  
}
```

```
"explanation": "Regulations often require.. .",
  "options": [
    { "optionText": "1 meter", "isCorrect": false },
    { "optionText": "3 meters", "isCorrect": false },
    { "optionText": "10 meters", "isCorrect": true },
    { "optionText": "50 meters", "isCorrect": false }
  ],
},
{ ... more questions... }
]
}
```

Response (200 OK):

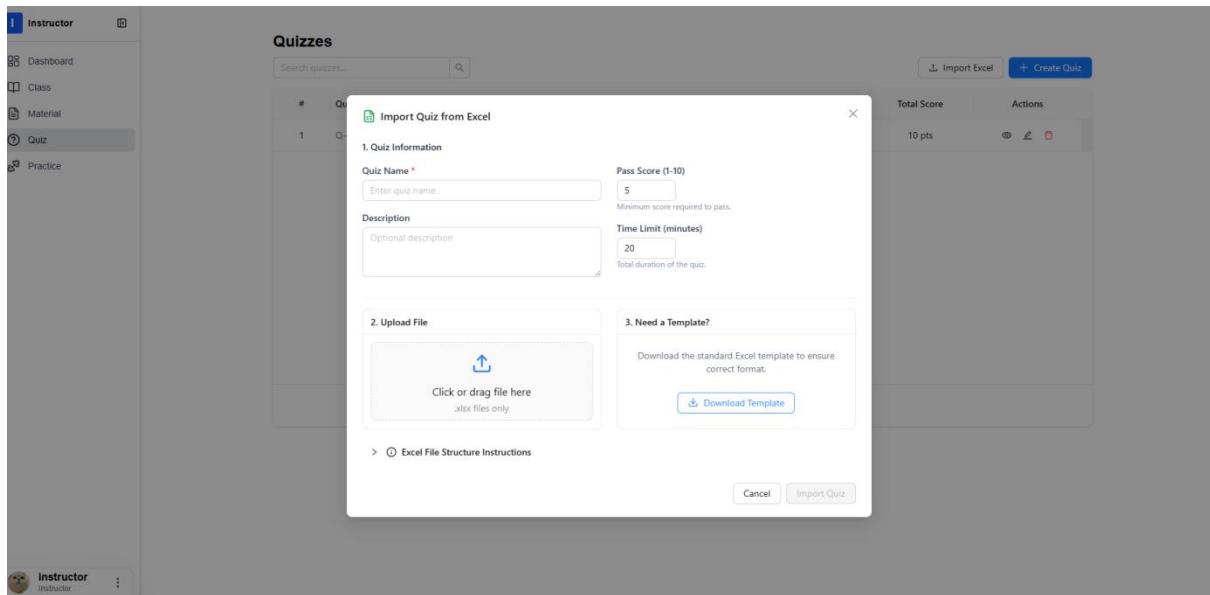
```
{
  "status": 200,
  "message": "Create quiz successfully",
  "data": { "quizId": 45 }
}
```

Import Quiz:

Import Quiz from Excel

Step-by-Step Instructions:

1. Download Excel template first:
 - Navigate to Quizzes page
 - Click "Import Quiz" dropdown
 - Select "Download Template"



2. Template Excel file downloads

A	B	C	D	E	F	G
Question Name	Score	Is Multiple	Description	Option Name	Is Correct	Explanation
1. What must the operator check before operating the crane?	2.5	FALSE	Safety Check	Check engine oil, coolant, tires, and brake system.	TRUE	Mandatory safety procedure.
2. What must the operator check before operating the crane?	2.5	FALSE	Safety Check	Just check if the key is present.	FALSE	Incorrect and dangerous.
3. When deploying outriggers, which requirement is correct?	2.5	FALSE	Crane Technique	Fully extend outriggers and use pads on soft ground.	TRUE	Ensures maximum stability.
4. When deploying outriggers, which requirement is correct?	2.5	FALSE	Crane Technique	Extend outriggers halfway to save space.	FALSE	Risk of tipping over.
5. Hand signal: Arm extended, palm down, moving hand horizontally means?	2.5	FALSE	Hand Signals	Emergency Stop.	TRUE	Standard ISO signal.
6. Hand signal: Arm extended, palm down, moving hand horizontally means?	2.5	FALSE	Hand Signals	Raise the boom.	FALSE	Incorrect signal.
7. Which action is STRICTLY PROHIBITED when operating a crane?	2.5	FALSE	Safety Rules	Using the crane hook/bucket to lift people.	TRUE	Strictly forbidden by safety regulations.
8. Which action is STRICTLY PROHIBITED when operating a crane?	2.5	FALSE	Safety Rules	Operating at night with proper lighting.	FALSE	Allowed if visibility is good.
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						
25.						
26.						
27.						
28.						
29.						
30.						
31.						

3. Fill in template:

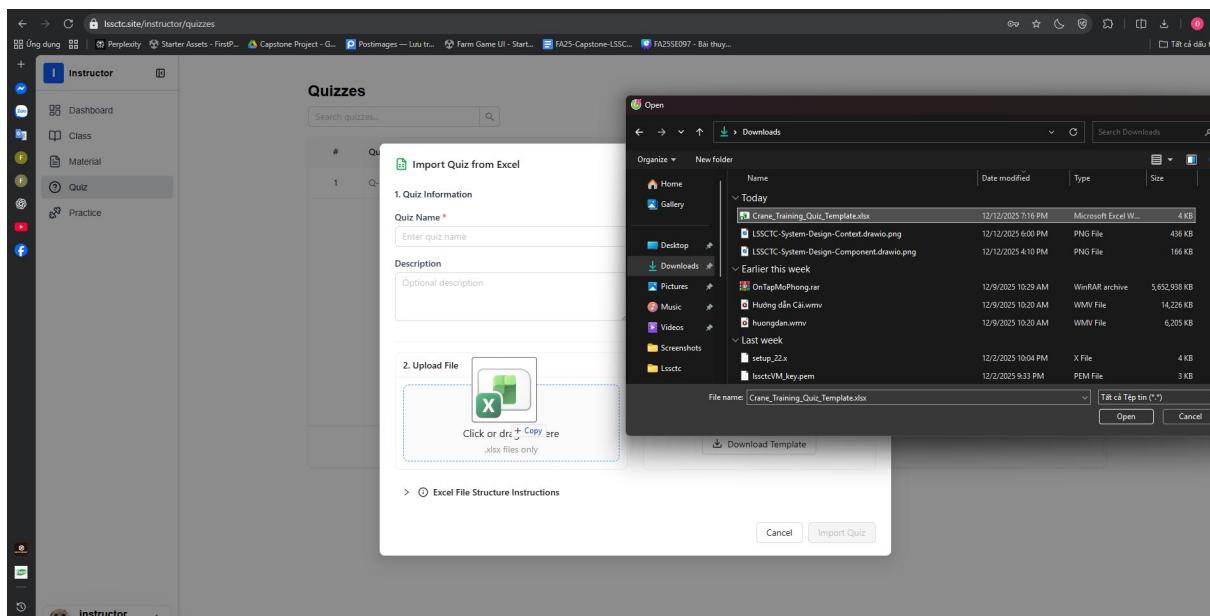
- Each question can have multiple rows (one per option)
- Question Name must be same for all options of same question
- Is Multiple: true/false
- Is Correct: true/false (only ONE true for single choice)

Crane_Training_Quiz_Template.xlsx - Protected View • Saved to this PC

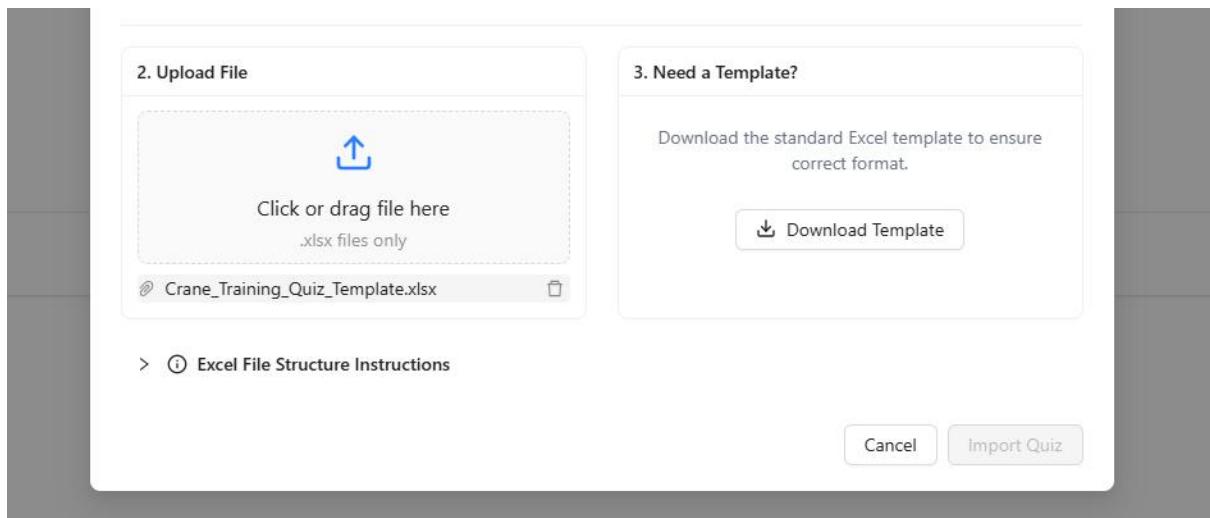
PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to edit, it's safer to stay in Protected View. [Enable Editing](#)

A	B	C	D	E	F	G	H	I
Question Name	Score	Is Multiple	Description	Option Name	Is Correct	Explanation		
What must the operator check before operating the crane?	2,5	FALSE	Safety Check	Check engine oil, coolant, tires, and brake system.	TRUE	Mandatory safety procedure.		
What must the operator check before operating the crane?	2,5	FALSE	Safety Check	Just check if the key is present.	FALSE	Incorrect and dangerous.		
When deploying outriggers, which requirement is correct?	2,5	FALSE	Crane Technique	Fully extend outriggers and use pads on soft ground.	TRUE	Ensures maximum stability.		
When deploying outriggers, which requirement is correct?	2,5	FALSE	Crane Technique	Extend outriggers halfway to save space.	FALSE	Risk of tipping over.		
Hand signal: Arm extended, palm down, moving hand horizontally means?	2,5	FALSE	Hand Signals	Emergency Stop.	TRUE	Standard ISO signal.		
Hand signal: Arm extended, palm down, moving hand horizontally means?	2,5	FALSE	Hand Signals	Raise the boom.	FALSE	Incorrect signal.		
Which action is STRICTLY PROHIBITED when operating a crane?	2,5	FALSE	Safety Rules	Using the crane hook/bucket to lift people.	TRUE	Strictly forbidden by safety regulations.		
Which action is STRICTLY PROHIBITED when operating a crane?	2,5	FALSE	Safety Rules	Operating at night with proper lighting.	FALSE	Allowed if visibility is good.		

4. Save Excel file as .xlsx format
5. Return to Quizzes page
6. Click "Import Quiz" → "Import from Excel"



7. Drag file into drop zone or click "Browse Files"
8. Select your filled Excel file
9. File name appears in dialog



f. Feature 5: Simulation Practice

1. Download file exe

LSSCTC Trang chủ Chương trình Mô phỏng Giới thiệu Đăng nhập Vie

Trang chủ > Simulator

Nền tảng Mô phỏng 3D

Tải xuống và cài đặt ứng dụng mô phỏng cần cầu 3D để thực hành các tình huống vận hành với vật lý thực tế và theo dõi đánh giá.

[Tải File](#) [Link Dự phòng](#)

[Phiên bản Mô phỏng Mới nhất](#) Phiên bản: v1.0.0 • Kích thước ước tính: 450MB • Nền tảng: Windows 10/11 (64-bit) [Tải Mô phỏng](#)

[Hướng dẫn Cài đặt](#)

- Nhập vào [Tải Mô phỏng](#) để tải trình cài đặt (.exe).
- Xác minh chữ ký file nếu chính sách của bạn yêu cầu (nhấp chuột phải → Properties → Digital Signatures).
- Chạy trình cài đặt và làm theo các bước trên màn hình. Chấp nhận các phần phụ thuộc cần thiết (Visual C++ runtime, DirectX) nếu được nhắc.
- Khởi chạy ứng dụng. Lần đầu tiên khởi động, bạn sẽ được yêu cầu nhập thông tin đăng nhập (giống như đăng nhập web).
- Cho phép truy cập mạng ra ngoài để theo dõi dữ liệu thời gian thực (công 443).

[Tổng quan Sử dụng](#)

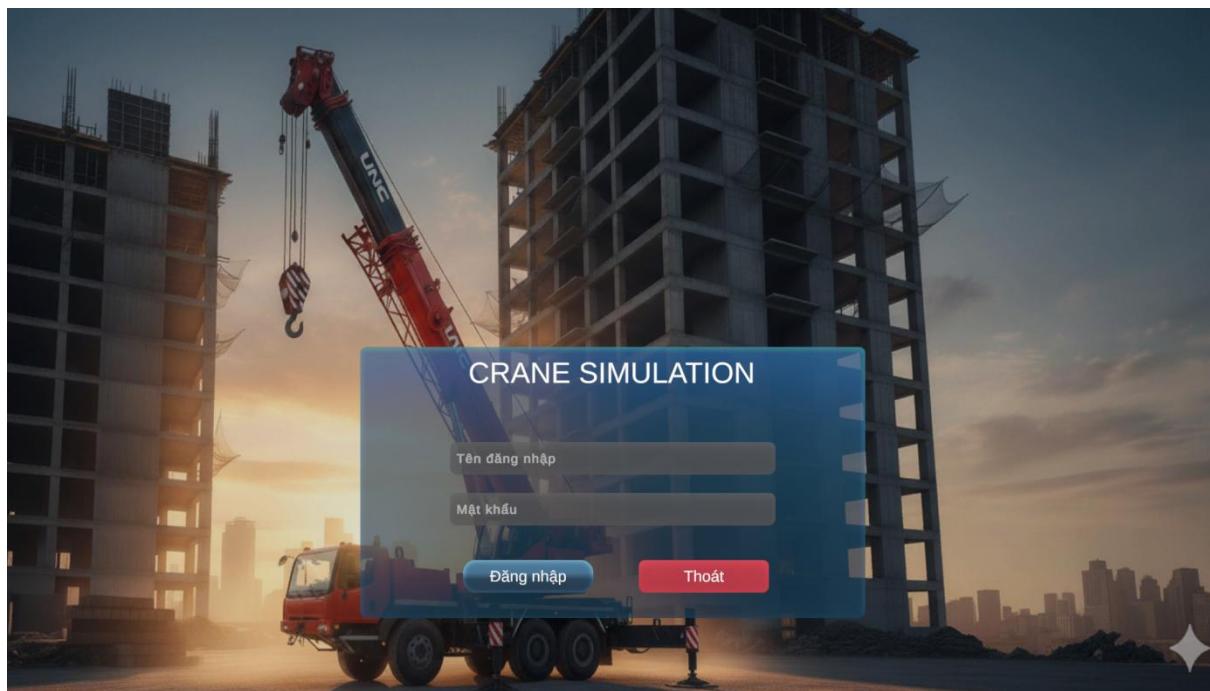
Sau khi đăng nhập, chọn một **Tình huống** từ bảng bên trái. Mỗi tình huống mô tả các mục tiêu cần thiết và ngưỡng an toàn.

- Ánh xạ Điều khiển:** Mở Settings → Controls để xem cách bố trí joystick / bàn phím.
- Bảng Telemetry:** Các chỉ số tải, góc cần cầu, tốc độ gió và lề an toàn theo thời gian thực.
- Chế độ Đánh giá:** Khi được bật, các hành động của bạn sẽ được ghi lại để giảng viên xem xét.

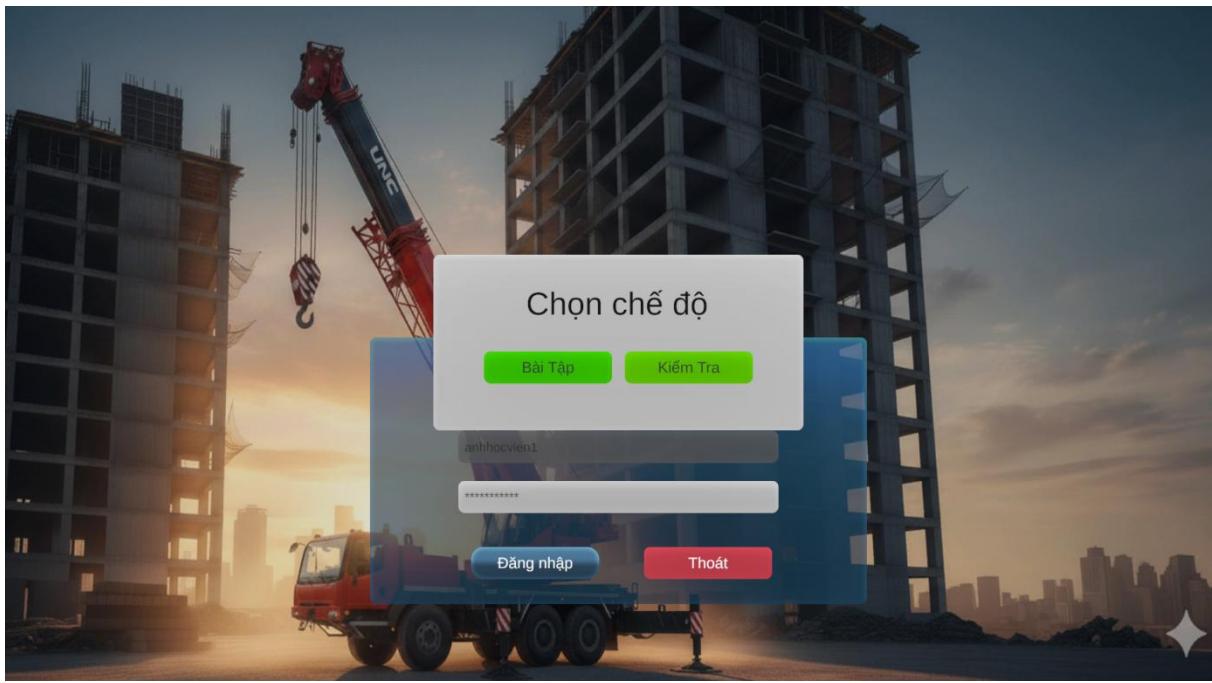
2. Open CraneSimulator.exe file

Name	Date modified	Type	Size
CraneSimulator_BurstDebugInformation....	12/12/2025 8:08 PM	File folder	
CraneSimulator_Data	12/12/2025 8:09 PM	File folder	
D3D12	12/12/2025 8:08 PM	File folder	
MonoBleedingEdge	12/12/2025 8:08 PM	File folder	
CraneSimulator.exe	12/12/2025 8:08 PM	Application	657 KB
UnityCrashHandler64.exe	12/12/2025 8:08 PM	Application	1,496 KB
UnityPlayer.dll	12/12/2025 8:08 PM	Application extens...	32,888 KB

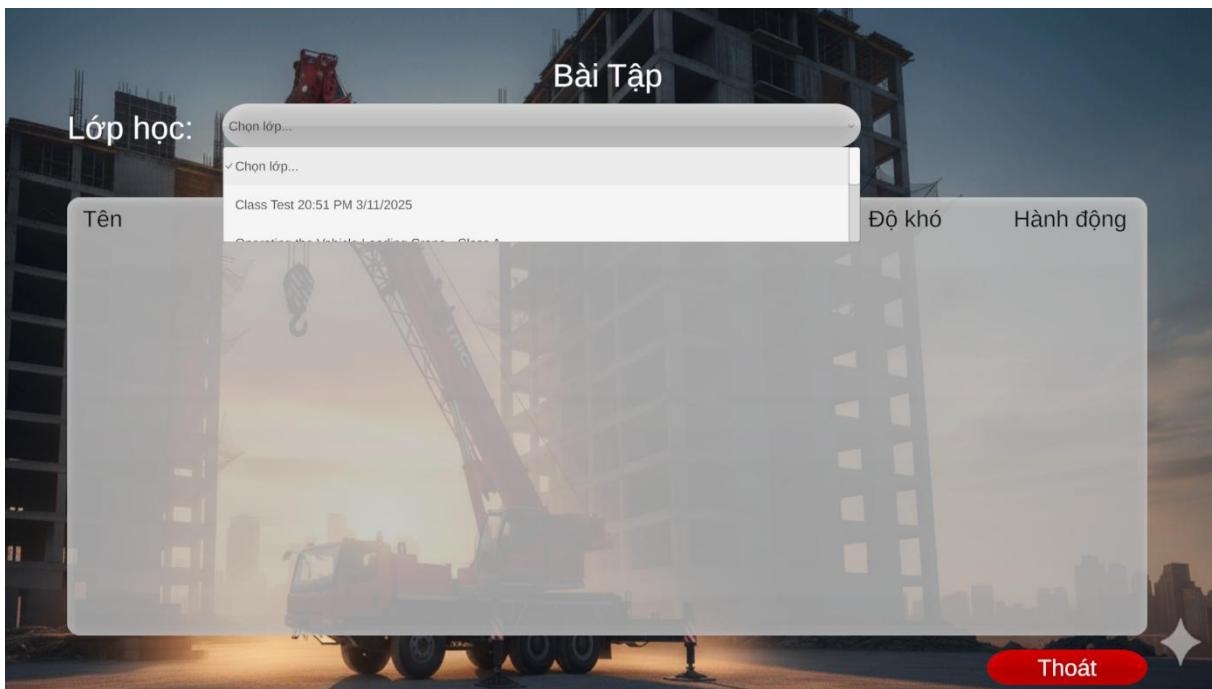
3. Login with username, password



4. Select practice mode



5. Select Class



6. Select practice to start

Bài Tập

Lớp học:

Ôn tập an toàn & vận hành xe cẩu tự hành (Crane)

Tên	Mô tả	Thời gian	Độ khó	Hành động
Kiểm tra thiết bị	Học viên phải di quanh cần cẩu và kiểm tra tất cả các bộ phận như móc cẩu, cần chính, chân chống, trụ xoay và bảng điều khiển.	10 min	Cơ bản	Bắt đầu

Thoát

7. Finish practice