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23EE505 – MERN STACK

(Or your relevant course code)

A MINI PROJECT REPORT

Submitted by

YOURNAMEHERE

(

YOURREGISTERIDHERE

)

in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

in

YOURDEPARTMENTNAMEHERE

SRI KRISHNA COLLEGE OF TECHNOLOGY KOVAIPUDUR, COIMBATORE-641042.

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Certified that this Mini Project report titled **"KNOWLEDGE DELIVERY PLATFORM"** is the Bonafide work of

YOURNAMEHERE

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) who carried out the project work under my supervision.

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This project has been submitted for the end semester Mini project viva voce Examination held on

$$DATEHERE$$

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INTERNAL EXAMINER

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

(This is a sample. Please write your own.)

This project has been successfully completed owing to comprehensive endurance and the support of many distinguished persons. First and foremost, we would like to thank the almighty, our family members, and friends for encouraging us to do this Mini Project work.

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$$YourDepartment$$

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TABLE OF CONTENTS

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ABSTRACT

The Knowledge Delivery Platform is a modern web application developed using the MERN Stack (MongoDB, Express.js, React.js, and Node.js). It is meticulously designed to address the pressing challenges of traditional and fragmented digital education. It achieves this by providing a centralized, scalable, and highly efficient system for managing, delivering, and tracking educational content.

Traditional methods of course delivery, often relying on disparate tools and manual processes, lead to inconsistent material distribution, significant difficulties in managing student enrollment, and inefficient, delayed tracking of learner progress. This platform overcomes these limitations by providing a single, unified solution for course creation, seamless student enrollment, real-time progress monitoring, and integrated online assessments.

The backend, architected with Node.js and Express.js, provides a robust, secure RESTful API that serves as the central nervous system for all core functionalities. For data persistence, MongoDB is utilized for its flexible, JSON-like document structure and immense scalability, allowing the platform to handle complex and evolving data models with ease. The frontend, developed with React.js, offers a dynamic, responsive, and component-based user interface that provides a tailored experience for admins, instructors, and students.

This system empowers instructors to easily create and manage courses and quizzes, while students can enroll in courses with a few clicks, visually track their completion progress, and take assessments directly within the platform. The platform's design foundationally ensures data integrity and security

through a role-based access control (RBAC) system, laying the essential groundwork for a comprehensive, secure, and modern learning environment.

LIST OF ABBREVIATIONS

Abbreviation	Description
LMS	Learning Management System
RBAC	Role-Based Access Control
API	Application Programming Interface
CRUD	Create, Read, Update, Delete
JWT	JSON Web Token
MERN	MongoDB, Express.js, React.js, Node.js
SRS	Software Requirements Specification
MVP	Minimum Viable Product
DB	Database
UI	User Interface
HTTP	Hypertext Transfer Protocol

CHAPTER 1: INTRODUCTION

1.1 Problem Statement

Education and professional training are rapidly shifting from traditional classrooms to digital platforms. While online learning offers unparalleled flexibility, accessibility, and scalability, it also presents significant challenges for institutions, instructors, and learners when there is no structured, centralized system in place.

Without a unified Knowledge Delivery Platform, the following problems arise:

- **Course Delivery Issues:** Instructors struggle to distribute materials, assignments, and quizzes consistently across different channels. This fragmentation leads to learner confusion, missed deadlines, and an inconsistent educational experience.
- **Student Enrollment & Tracking Gaps:** Institutions cannot effectively or efficiently manage which students are enrolled in which courses, leading to administrative errors and poor monitoring of

participation. This results in inaccurate reporting, difficulty in managing prerequisites, and a significant administrative burden.

- **Progress Monitoring Challenges:** Instructors find it difficult to track student progress in real-time, measure performance accurately, and provide timely interventions. As a result, at-risk students are not identified early, and learners lack the motivation that comes from clear visibility of their achievements.
- **Assessment Inefficiency:** Conducting quizzes, evaluating results, and maintaining student performance records manually is exceptionally time-consuming and highly error-prone. This delays crucial feedback to students and consumes valuable instructor time that could be spent on teaching and support.
- **Scalability Problems:** Traditional methods or fragmented digital tools do not scale efficiently. When thousands of students need simultaneous access, such as during enrollment periods or final exams, these systems often fail, creating bottlenecks that limit the institution's growth.
- **Security Concerns:** In the absence of granular, role-based access control, unauthorized users may be able to modify course content or access sensitive student performance data. This poses a significant risk of data breaches, violating student privacy and damaging the institution's reputation.

1.2 Proposed Solution

The Knowledge Delivery Platform is designed to overcome these limitations by providing a unified, secure, and scalable platform. This solution enhances learning outcomes for students and dramatically reduces administrative overhead for institutions.

The system is designed to achieve this by:

- **Providing a centralized digital platform: This acts as a 'single source of truth' for all course creation, enrollment, content delivery, and assessments. It eliminates confusion and ensures all users access the same, up-to-date information.**
- **Enabling real-time progress tracking:** The system provides instant, visual feedback on course completion and assessment scores. This empowers students with ownership of their learning journey and provides instructors with actionable data to intervene when necessary.
- **Supporting secure role-based access (RBAC):** The platform ensures only authorized users (Admin, Instructor, Student) can perform specific operations. This is critical for protecting sensitive student data and intellectual property, ensuring platform integrity.
- **Offering quiz and evaluation modules:** This automates the assessment lifecycle, from creation and delivery to grading and feedback, providing instant results to students and saving valuable administrative time.
- **Ensuring scalability and availability:** This is achieved through a modern, cloud-native architecture. The platform is designed to remain responsive and available even during peak usage, such as registration days or exam periods, ensuring a reliable experience for all users.

1.3 Components of the System

The system is architected using the MERN stack, separating concerns into distinct, manageable layers to improve maintainability and scalability:

1. **Frontend (React.js):** Hosts the interactive user interface (UI) for all stakeholders. This includes dynamic dashboards for students, comprehensive course management tools for instructors, and administrative panels for system management. It is built as a Single Page Application (SPA), which provides a fast, fluid user experience similar to a desktop application, without disruptive page reloads.
2. **Backend (Node.js & Express.js):** A server-side application that exposes RESTful API endpoints for all data and logic. It handles all business logic, data processing, request validation, and user authentication, acting as the secure bridge between the frontend and the database. This API-first design allows the same backend to serve multiple clients (e.g., a web app and a future mobile app) with consistent logic.
3. **Database (MongoDB):** A NoSQL database used to store all application data. This includes user profiles, course content, enrollment records, quiz questions, and student progress data. Its document-based model is highly flexible, allowing for varied course structures and the ability to store complex, nested data like quiz results and progress maps efficiently.
4. **Authentication & Authorization:** A critical security layer, typically implemented using JSON Web Tokens (JWT). This layer acts as a gatekeeper, first verifying a user's identity (authentication) and then checking their permissions (authorization) for every single API request, thus securing all platform resources.

1.4 Advanced Technologies

The project's technology stack was chosen specifically to build a modern, high-performance, and scalable application.

- **MERN Stack:** The core of the project, utilizing MongoDB, Express.js, React.js, and Node.js. This unified JavaScript ecosystem simplifies the development process, reduces context-switching for developers, and fosters a large, active community for support and third-party packages.
- **React.js:** A declarative, component-based library for building dynamic user interfaces. Its use of a virtual DOM allows for highly efficient UI updates by only re-rendering components that have changed, leading to a remarkably responsive and engaging user experience.
- **Node.js & Express.js:** Node.js provides the runtime environment for the backend. Its non-blocking, event-driven I/O model makes it exceptionally efficient for data-intensive, real-time applications, which is perfect for an interactive learning platform. Express.js provides a minimal, robust layer for handling routes and middleware.
- **MongoDB (with Mongoose):** A document-oriented NoSQL database that offers high performance and easy horizontal scalability. Mongoose adds a crucial layer of schema validation, business logic hooks, and query building on top of MongoDB, providing data integrity while maintaining flexibility.
- **JSON Web Tokens (JWT):** A compact, URL-safe means of representing claims to be transferred between two parties. As a stateless authentication mechanism, JWTs are server-friendly, highly scalable, and securely transmit user identity and permissions with each API request.
- **RESTful APIs:** The architectural style for communication between the frontend client and the backend server. This standardized approach, using HTTP methods (GET, POST, PUT, DELETE), simplifies development, ensures predictability, and makes the platform easy to integrate with other services in the future.

CHAPTER 2: SYSTEM ANALYSIS

2.1 Existing System

The current landscape for digital learning is fragmented. Many institutions rely on a combination of disconnected tools or legacy systems that were not designed for modern, flexible education.

- **Moodle:** An open-source LMS widely used in universities. It provides comprehensive features for course creation, quizzes, and grading. However, while powerful, its steep learning curve, complex customization, and monolithic architecture can be a significant barrier for smaller institutions or those without dedicated IT support.
- **Blackboard:** A commercial LMS used in higher education and enterprises. It offers extensive integrations, advanced assessment tools, and robust analytics. Its feature-rich environment, however, often comes with high licensing costs and a "heavy" user experience that can feel dated and cumbersome.
- **Google Classroom:** A simplified tool that excels at assignment distribution, grading, and communication, making it popular in K-12 settings. It fundamentally lacks the robust database structure, advanced RBAC, customization, and deep integration capabilities required by higher education or corporate training environments.
- **Manual/Traditional Methods:** Many smaller organizations or individual instructors still rely on a patchwork of email, shared drives (like Google Drive or Dropbox), and spreadsheets. This ad-hoc approach is highly inefficient, prone to human error, offers no real-time data, and is completely unscalable.

2.2 Drawbacks of Existing System

The existing solutions and fragmented approaches suffer from several key drawbacks that the Knowledge Delivery Platform aims to solve:

- **Lack of Centralization:** Using multiple tools for videos, documents, quizzes, and communication creates data silos. Students are forced to juggle multiple logins and platforms, leading to frustration, confusion, and disengagement.
- **Poor Progress Tracking:** It is difficult to get a real-time, consolidated view of a student's progress. Instructors cannot easily identify struggling students, and institutions cannot measure the effectiveness of their courses or learning outcomes.
- **Scalability Issues:** Legacy systems or manual methods cannot handle a large or growing number of users and courses efficiently. Performance bottlenecks during high-traffic periods (like enrollments or exams) can lead to system crashes, data loss, and a poor user experience.
- **Inefficient Assessment:** The feedback loop for students is slow, hindering the learning process. Creating, distributing, and grading assessments is often a manual process that burdens instructors with administrative work instead of teaching.
- **Security & Access Control:** Generic file-sharing systems lack the fine-grained, role-based access control needed. This lack of granularity is a major compliance risk, especially with regulations concerning student privacy, and leaves intellectual property vulnerable.

2.3 Problem Definition

The core problem is the absence of a unified, scalable, and secure platform that seamlessly integrates course delivery, student enrollment, progress tracking, and assessment. This absence leads to administrative inefficiency, a disjointed and frustrating learning experience for students, and a lack of actionable data for instructors and institutions to improve learning outcomes. This gap directly impacts student success, instructor efficiency, and an institution's ability to compete in the growing digital education market. The objective is to close this gap with a single, cohesive, and modern solution.

2.4 Proposed System

The proposed Knowledge Delivery Platform is a MERN-stack application architected as a modular, scalable, and secure system. It functions as a centralized hub for all learning activities, designed from the ground up to address the drawbacks of existing systems.

- **System Architecture:** The system is built on a modern MERN stack.
    - **Backend (Node.js/Express.js):** A core API service handles all data operations. This service-oriented architecture ensures that business logic is centralized and reusable. It includes modules for Course Management (CRUD for courses, modules), Enrollment Management (registering students), Assessment (creating/submitting quizzes), and Progress Tracking (updating/viewing completion).
    - **Database (MongoDB):** A flexible NoSQL database stores collections for `Courses`, `Users` (with roles), `Enrollments`, `Quizzes`, and `Progress`. This design choice is deliberate; it allows for storing nested data, like quiz questions within a `Quiz` document, and diverse progress metrics for each student, all in an easily queryable format that can evolve as new features are added.
    - **Frontend (React.js):** A dynamic web client that provides different dashboards based on user roles (Admin, Instructor, Student). This client-side application fetches data dynamically, meaning a student's dashboard, an instructor's grade book, and an admin's user list are all rendered from the same secure API, just with different permissions and UI components.
    - **Authentication (JWT):** A token-based system secures the API. Users log in to receive a token, which is then sent with every subsequent API request in the `Authorization` header. This allows the backend to instantly verify the user and their role before processing any data, ensuring a secure and stateless system that scales easily.

2.5 Advantages of Proposed System

The proposed system offers significant, tangible advantages over existing solutions:

- **Centralized Learning Hub:** Provides a single, reliable source of truth for all courses, materials, progress data, and assessments. This eliminates data silos and provides a consistent, branded experience for all users, building trust and simplifying the learning process.
- **Improved Efficiency:** Reduces administrative overhead for instructors by standardizing and automating course creation, student enrollment, and quiz evaluation. By automating repetitive tasks, the platform frees up valuable instructor and administrator time to focus on higher-value activities like teaching and student support.
- **Real-Time Progress Tracking:** Gives both students and instructors immediate feedback on performance and course completion. This immediate data feedback loop is a powerful motivator

for students and a critical diagnostic tool for instructors, enabling a data-driven approach to education.

- **Scalability:** The MERN stack is inherently scalable. The stateless nature of the Node.js API and the horizontal sharding capabilities of MongoDB mean the platform can be scaled out by simply adding more servers, handling thousands or even millions of users without a performance drop.
- **Secure & Role-Based:** The granular RBAC system ensures that sensitive data is protected and users only have permissions appropriate for their role. This is not just a feature but a core architectural principle, ensuring data integrity and protecting the privacy of all users.
- **Flexibility & Extensibility:** The modular, API-first design makes the platform incredibly flexible. If a mobile app is needed, a new frontend can be built to consume the existing API. If integration with a payment system is required, a new microservice can be added without disrupting the core platform.

CHAPTER 3: SYSTEM REQUIREMENTS

3.1 Hardware Requirements

Development/Server:

- **Processor:** Multi-core processor (e.g., Intel i5/i7, AMD Ryzen 5/7)
- **RAM:** 8 GB (Minimum), 16 GB (Recommended) for running the database, server, and development tools simultaneously.
- **Storage:** 256 GB SSD (Minimum) for OS, database, and code, ensuring fast read/write speeds.
- **Network:** Broadband Internet Connection

Client (User):

- **Device:** Any modern computer, tablet, or smartphone capable of running a modern web browser.
- **Network:** Stable Internet Connection (Wi-Fi, 4G/5G, or Wired) for a smooth, real-time experience.

3.2 Software Requirements

Development/Server:

- **Operating System:** Windows 10/11, macOS, or a Linux distribution (e.g., Ubuntu).
- **Database:** MongoDB Server (v5.0 or later) or MongoDB Atlas (Cloud-hosted).
- **Runtime:** Node.js (v16.x or later), which includes the `npm` package manager.
- **Package Manager:** npm (v8.x or later) or yarn.
- **Web Server:** Nginx or Apache (Recommended for production as a reverse proxy).
- **Version Control:** Git, for source code management.

Client (User):

- **Web Browser:** Google Chrome, Mozilla Firefox, Microsoft Edge, or Safari (latest stable versions).

3.3 Software Description

- **Node.js:** An asynchronous, event-driven JavaScript runtime built on Chrome's V8 engine. It is used to build the backend server, allowing for fast, scalable network applications. Its package manager, npm, also provides access to the world's largest ecosystem of open-source libraries, accelerating development.
- **Express.js:** A minimal and flexible Node.js web application framework that provides a robust set of features for building RESTful APIs. It provides a thin layer of fundamental web application features, without obscuring Node.js features, and is excellent for building lightweight, fast, and robust APIs through its routing and middleware system.
- **React.js:** A JavaScript library for building user interfaces. It allows for the creation of reusable UI components (e.g., a `Button` or `CourseCard` component can be used everywhere) and simplifies managing complex user interfaces and their state, resulting in a fast and responsive Single Page Application (SPA).
- **MongoDB:** A source-available, cross-platform, document-oriented database (NoSQL). It is ideal for this project because educational data (like user profiles and course content) is not always uniform and often evolves. MongoDB's flexible schema can adapt to these changes without costly database migrations.
- **Mongoose:** An Object Data Modeling (ODM) library for MongoDB and Node.js. It manages relationships between data, provides a powerful query API, and is used to translate between objects in code and their representation in MongoDB. Crucially, it enforces a schema at the application level, which helps prevent common data entry errors.

3.4 Frontend Specifications

The frontend is a client-side application built with React.js.

- It features component-based architecture (e.g., `CourseList`, `QuizView`, `ProgressTracker` components). This encapsulates both logic and UI, making the code more modular, reusable, and maintainable.
- It uses React Router for client-side routing, enabling navigation between different views (e.g., `/dashboard`, `/course/123`) without full page reloads, creating a seamless SPA experience.
- State management (e.g., React Context or Redux) is used to manage application-wide data, such as the logged-in user's details. This makes this information available to any component without complex 'prop-drilling'.
- It communicates with the backend API using an HTTP client like `axios` to fetch and submit data asynchronously, updating the UI without blocking user interaction.
- It provides interactive and responsive dashboards tailored for different user roles (Admin, Instructor, Student), ensuring a good experience on both desktop and mobile devices.

3.5 Backend Specifications

The backend is a RESTful API built with Node.js and Express.js.

- It provides stateless endpoints for all application functionalities (CRUD operations). "Stateless" means every request from the client contains all the information needed (like the JWT) to be processed, allowing the system to scale easily.

- It uses Express.js middleware sequentially for tasks like parsing JSON request bodies (`express.json()`), handling CORS (Cross-Origin Resource Sharing), and authenticating requests (using the JWT strategy).
- It connects to the MongoDB database via Mongoose, using asynchronous `await/async` patterns to perform non-blocking data operations efficiently.
- It implements all business logic, such as calculating quiz scores, validating enrollment, updating progress, and managing user permissions.
- It handles authentication and authorization, validating JWTs on all protected routes and checking user roles to ensure, for example, that only an 'instructor' can create a course.

CHAPTER 4: FUNCTIONAL REQUIREMENTS

This chapter outlines the specific functional capabilities of the system, aligned with the implemented API endpoints.

4.1 Detailed Requirements

1. **Add Course:**
   - **Input:** A JSON object from the request body containing course details (title, description, duration).
   - **Output:** A JSON object of the newly created course record from the database, including its unique `_id` .
   - **Role:** Restricted to 'Admin' or 'Instructor' roles.
2. **Get All Courses:**
   - **Input:** None.
   - **Output:** A JSON array containing all available course objects.
   - **Role:** All (Admin, Instructor, Student) to browse the course catalog.
3. **Enroll Student:**
   - **Input:** Course ID (from URL parameter) and Student ID/Name (from query parameter).
   - **Output:** The updated course object, with the new student's ID added to its `students` array.
   - **Role:** Admin / Instructor (to enroll students) or Student (for self-enrollment, if enabled).
4. **Update Progress:**
   - **Input:** Course ID, Student ID, and a Progress Percentage (e.g., 0-100).
   - **Output:** The updated course record, with the new progress value for that specific student.
   - **Role:** Admin / Instructor (manual override) or System (triggered automatically by module completion).
5. **Get Quiz:**
   - **Input:** Course ID (from URL parameter).
   - **Output:** The quiz details (questions, options, but *not* correct answers) associated with the course.

- **Role:** Enrolled 'Student'.

6. **Submit Quiz:**
    - **Input:** Course ID, Student ID, and the calculated Quiz Score.
    - **Output:** A confirmation message and the newly created quiz submission record.
    - **Role:** Enrolled 'Student'.

4.2 API Documentation

The following API endpoints define the contract between the frontend and backend.

Course Management

- **Add Course**
    - **Endpoint:** `POST /api/courses`
    - **Description:** Creates a new course in the database. Requires instructor or admin authentication.
    - **Request Body:**

```
{
  "title": "Data Structures",
  "description": "Learn about arrays, stacks, queues...",
  "duration": 10
}
```

    - **Response:** `201 Created` with the new course object.
- **Get All Courses**
    - **Endpoint:** `GET /api/courses`
    - **Description:** Retrieves a list of all courses available on the platform.
    - **Response:** `200 OK` with an array of course objects.

Enrollment & Progress

- **Enroll Student**
    - **Endpoint:** `PUT /api/courses/:id/enroll?student=Alice`
    - **Description:** Enrolls a student named 'Alice' into the course with the specified `:id`. This is an idempotent `PUT` request.
    - **Response:** `200 OK` with the updated course object.
- **Update Progress**
    - **Endpoint:** `PUT /api/courses/:id/progress?student=Alice&progress=70`
    - **Description:** Updates the progress map within the course document for 'Alice' in the specified course to 70%.
    - **Response:** `200 OK` with the updated course object.

Assessment (Quizzes)

- **Get Quiz**

- **Endpoint:** `GET /api/courses/:id/quiz`
- **Description:** Retrieves the quiz questions and options for a specific course.
- **Response:** `200 OK` with the quiz JSON object for that course.

- **Submit Quiz**
  - **Endpoint:** `POST /api/courses/:id/quiz?student=Alice&score=85`
  - **Description:** Submits a score of 85 for 'Alice'. This creates a new `Submission` document in the database, linking the student, course, and score.
  - **Response:** `200 OK` with a success confirmation.

CHAPTER 5: SYSTEM DESIGN

5.1 Module Description

The system is logically divided into several key modules, primarily on the backend, to ensure separation of concerns, reusability, and maintainability.

- **Course Management Module:**
  - **Responsibility:** Handles all CRUD (Create, Read, Update, Delete) operations related to courses. This includes not only the course metadata (title, description) but also embedding or referencing modules, lessons, and resources associated with that course.
  - **Components:** `Course` model (Mongoose schema), `courseController` (business logic), and `courseRoutes` (API endpoints).
  - **Functions:** `createCourse()`, `getAllCourses()`, `getCourseById()`, `updateCourse()`, `deleteCourse()`.
- **User & Authentication Module:**
  - **Responsibility:** Manages user registration, login, and role-based access control (RBAC). This module is the gateway to the application.
  - **Components:** `User` model (with roles like 'student', 'instructor', 'admin'), `authController`.
  - **Functions:** `registerUser()`, `loginUser()`, `protect()` (a core middleware for checking JWT), `restrictTo()` (middleware for checking user roles, e.g., `restrictTo('admin')`).
- **Enrollment Module:**
  - **Responsibility:** Manages the relationship between students and courses. This logic is critical as it creates the link between a user and a course.
  - **Components:** Logic is embedded within the `courseController` and `userController` (e.g., an `enrollStudent` function).
  - **Functions:** `enrollStudent()` (adds a student ID to a course's `students` array and a course ID to a user's `enrolledCourses` array, ensuring data is synchronized).
- **Progress Tracking Module:**
  - **Responsibility:** Records and retrieves student progress for courses and modules. This module might be triggered by other events, such as a student completing a quiz (via the Assessment Module) or marking a lesson as 'complete'.

- **Components:** This logic is often part of the `Course` model (e.g., a map of student IDs to progress percentages).
- **Functions:** `updateProgress()`.

- **Assessment (Quiz) Module:**
  - **Responsibility:** Manages the creation, retrieval, and submission of quizzes. This module is responsible for both serving quiz questions to students and accepting their submissions.
  - **Components:** `Quiz` model (stores questions, options, answers), `Submission` model (stores results), `quizController`.
  - **Functions:** `getQuizByCourseId()`, `submitQuiz()` (which includes calculating the score and persisting the result for an instructor to review).

5.2 Data Flow Diagram (Description)

A Data Flow Diagram (DFD) for this system would illustrate the flow of information. As a textual description:

1. **User (Student/Instructor)** interacts with the **React Frontend** in their browser.
2. To perform an action (e.g., "Add Course"), the **React Frontend** bundles the form data into a JSON object and sends an `Authorization` header containing the user's JWT along with the `POST /api/courses` request to the **Backend API (Node.js/Express)**.
3. The **Express Router**, acting as a traffic controller, matches the endpoint and passes the request, first through authentication middleware, then to the relevant **Controller** (e.g., `courseController.createCourse`).
4. The **Controller** validates the input data. If valid, it interacts with the **Mongoose Model** (e.g., `Course.create(...)`) to prepare a database query.
5. **Mongoose** translates this command into a low-level BSON query that the **MongoDB Database** understands. This translation from a high-level JavaScript function is a key part of the ODM's role.
6. The **Database** executes the query (e.g., inserts the new course document) and returns the result to **Mongoose**.
7. **Mongoose** returns the data (now formatted as a JavaScript object) to the **Controller**.
8. The **Controller** formats a JSON response (e.g., `{ status: 'success', data: newCourse }`) and sends it back to the **React Frontend**.
9. The **React Frontend** receives the response, updates its local state (e.g., adding the new course to its `courses` array), which triggers React to automatically re-render the UI and display the new course in the list, all without a full page refresh.

5.3 Entity Relationship Diagram

The system uses a NoSQL database, so relationships are managed at the application level through referencing (using ObjectIDs) or embedding. The primary entities are:

- **User:**
  - `_id` (ObjectID, Primary Key)
  - `name` (String)

- `email` (String, Unique)
- `password` (String, Hashed)
- `role` (String: 'student', 'instructor', 'admin')
- `enrolled_courses` (Array of `Course` ObjectIDs)

$$Relationship to Course$$

- **Course:**
  - `_id` (ObjectID, Primary Key)
  - `title` (String)
  - `description` (String)
  - `duration` (Number)
  - `instructor` (ObjectID, maps to `User`)

$$Relationship to User$$

  - `students` (Array of `User` ObjectIDs)

$$Relationship to User$$

  - `quizzes` (Array of `Quiz` ObjectIDs)

$$Relationship to Quiz$$

  - `progress` (Map: `student_id -> percentage`)

$$Embedded Relationship$$

- **Quiz:**
  - `_id` (ObjectID, Primary Key)
  - `course_id` (ObjectID, maps to `Course`)

$$Relationship to Course$$

  - `title` (String)
  - `questions` (Array of objects: `{ questionText, options, correctAnswer }`)

$$Embedded Data$$

- **Submission (Quiz Result):**
  - `_id` (ObjectID, Primary Key)
  - `quiz_id` (ObjectID, maps to `Quiz`)

$$Relationship to Quiz$$

- `student_id` (ObjectID, maps to `User`)

$$Relationship to User$$

- `course_id` (ObjectID, maps to `Course`)

$$Relationship to Course$$

- `score` (Number)

Relationships:

- A **User (Instructor)** can create one-to-many **Courses**.
- A **User (Student)** can enroll in many-to-many **Courses** (managed by the `enrolled_courses` and `students` arrays).
- A **Course** can have one-to-many **Quizzes**.
- A **User (Student)** can have one-to-many **Submissions** for a **Quiz**. This normalized structure is better for analytics.

5.4 Sequence Diagram (Description)

A sequence diagram for the **"Student Submits Quiz"** workflow:

1. **Student (Actor)** clicks "Submit" on the quiz page in the **ReactClient**.
2. **ReactClient** sends a `POST /api/courses/:id/quiz` request (with student ID and score in the query) to the **APIServer (Express.js)**.
3. **APIServer**'s `quizRoute` receives the request.
4. `quizRoute` first calls the `authMiddleware` to verify the student's JWT. This middleware decodes the token from the `Authorization` header to verify identity.
5. `authMiddleware` validates the token and attaches the user's details (e.g., `req.user`) to the request.
6. `quizRoute` calls the `quizController.submitQuiz` function.
7. `quizController` creates a new `Submission` document (e.g., `Submission.create({ studentId, quizId, score })`). This action is asynchronous.
8. `quizController` sends this command to the **MongoDB** database.
9. **MongoDB** saves the submission and returns a success message/document.
10. `quizController` (optionally) `await`s a call to `courseController.updateProgress` to update the student's progress for that course based on the quiz score. This shows inter-module communication.
11. `quizController` sends a `200 OK` JSON response back to the **ReactClient**.
12. **ReactClient** displays a "Submission Successful" message to the **Student**.

5.5 Architecture Diagram (Description)

The system follows a modern **3-Tier Architecture (MERN)**, which decouples the major concerns of the application.

1. **Presentation Tier (Client):**
    - This is the user's web browser running the **React.js** application.
    - It is responsible for rendering the UI and handling all user interactions. It maintains its own state and logic for the UI.
    - It is completely decoupled from the backend and communicates only via the REST API. It doesn't know *how* the backend works, it only knows the API 'contract' (the endpoints and data structures).
2. **Application Tier (Server):**
    - This is the **Node.js** runtime executing the **Express.js** application.
    - It contains all the business logic, controllers, and API routes.
    - It handles requests from the client, processes data, and interacts with the database. It also manages authentication and authorization.
    - This tier is **stateless**; it does not store any session information. All state is managed by the client (in the JWT) or in the database. This is key to horizontal scalability.
3. **Data Tier (Database):**
    - This is the **MongoDB** database server (either self-hosted or on a cloud service like Atlas).
    - It is responsible for persistently storing and retrieving all application data.
    - It is secured and (in production) runs on a separate server or cluster, accessible only by the Application Tier, not the public internet.

This architecture allows each tier to be developed, deployed, scaled, and maintained independently.

CHAPTER 6: TESTING

A comprehensive testing strategy is essential to ensure the reliability, security, and performance of the Knowledge Delivery Platform. The testing pyramid model is applied.

6.1 Unit Testing

- **Objective:** To test the smallest individual functions, components, and modules of the application in isolation.
- **Backend (Node.js/Express.js):**
    - **Tools:** `Jest` or `Mocha` (as test runners), `Chai` (for assertions), `Sinon` (for mocks).
    - **Description:** Individual controller functions, utility functions (e.An_G_e., a score calculator), and Mongoose model validations are tested. Database and external API calls are "mocked" or "stubbed" to ensure the test only focuses on the unit's logic. For example, testing that a Mongoose `pre-save` hook correctly hashes a password.
- **Frontend (React.js):**
    - **Tools:** `Jest` and `React Testing Library`.

- **Description:** Individual React components are rendered in a virtual DOM. Tests check that the component renders correctly given specific `props`, that it handles user events (like button clicks), and that it displays the correct information. For example, a test could check that when a user types into an input field, the component's state updates correctly.

6.2 Integration Testing

- **Objective:** To test the interaction and data flow between different modules of the application.
- **Backend (API Testing):**
  - **Tools:** `Supertest` (integrated with Jest).
  - **Description:** This involves spinning up the entire backend application and making real HTTP requests to its API endpoints. A dedicated test database is used. Tests verify that the API endpoints behave as expected, that they correctly interact with the database (e.g., a `POST` request actually creates a document), and that the correct HTTP status codes and JSON responses are returned. For example, a test would `POST` a new user to `/api/register`, then use the returned token to `POST` a new course to `/api/courses`, and finally `GET` `/api/courses` to verify the new course is in the list. This tests the integration of the `User` and `Course` modules, including the `auth` middleware.
- **Frontend-Backend Integration:**
  - **Description:** These tests (often run with `Cypress` or `React Testing Library` with `msw`) confirm that the React frontend can successfully `fetch` data from and `POST` data to a mocked or real backend API, and that it correctly handles the responses (both success and error states).

6.3 End-to-End (E2E) Testing

- **Objective:** To simulate a real user's workflow from start to finish, testing the entire application stack as a whole.
- **Tools:** `Cypress` or `Selenium`.
- **Description:** E2E tests run the entire application (both frontend and backend). An automated browser script performs a complete user journey. These tests are the ultimate verification of the system's health. They are designed to be 'brittle'—they break if anything in the user flow changes—which is their strength. They catch issues related to CSS, browser quirks, and asynchronous timing that other tests miss.
- **Example Journey:**
  1. Navigating to the login page.
  2. Typing in instructor credentials and logging in.
  3. Navigating to the "Create Course" page.
  4. Filling out the form and submitting it.
  5. Verifying that the new course appears in the course list.
  6. Logging out.

CHAPTER 7: SCREENSHOTS

(This section is a placeholder. Please capture screenshots of your running application and insert them here. You can add captions to describe each image.)

(Screenshot 1: Home Page or Login Page) *Caption: The main landing page or login screen for the Knowledge Delivery Platform.*

(Screenshot 2: Student Dashboard) *Caption: The student's view, showing enrolled courses and progress.*

(Screenshot 3: Instructor Course Management Page) *Caption: The instructor's view, showing options to add, edit, or delete courses.*

(Screenshot 4: Add Course Form) *Caption: The form used by instructors to create a new course.*

(Screenshot 5: Quiz/Assessment View) *Caption: The student's view while taking a quiz.*

CHAPTER 8: FUTURE WORK

The current Minimum Viable Product (MVP) provides a solid foundation for the Knowledge Delivery Platform. The following features are identified as "Out of Scope" for the current version but represent high-priority enhancements for future iterations to make the platform more robust and feature-complete.

- **Full User Accounts & Authentication:**
  - Implement a complete user registration, login, and profile management system using JWT and password hashing (e.g., `bcrypt.js`). This is the top priority as it enables personalization and lays the foundation for all other user-specific features.
  - Develop a "Forgot Password" / "Reset Password" email-based workflow.
- **Advanced Role-Based Access Control (RBAC):**
  - Flesh out the permissions for different roles (e.g., only Instructors can update *their own* courses, Admins can manage all courses and users). This is critical for enterprise or institutional adoption, where complex permission hierarchies are a firm requirement.
- **Certificates & Badges:**
  - Automatically generate and award digital certificates (e.g., as PDFs) or badges to students upon successful completion of a course. This gamification and credentialing feature significantly boosts student motivation and a sense of accomplishment.
- **Search, Filters & Pagination:**
  - Implement advanced search functionality for the course catalog.
  - Add filters (e.g., by category, instructor) and pagination to handle large numbers of courses efficiently. These are essential usability features, as the platform will become unusable with a large catalog without them.
- **Notifications:**

    - Add a notification system (in-app or via email) to alert students about new course announcements, assignment deadlines, or quiz results. This proactive communication tool keeps users engaged and ensures they stay on top of their learning commitments.

- **Payments & Monetization:**
    - Integrate a payment gateway (like Stripe or Razorpay) to allow for paid courses, subscriptions, and refund management. This directly transforms the platform from an internal institutional tool into a potential commercial product (SaaS), opening up new business models.
- **Advanced Quiz Engine:**
    - Expand the quiz module to support different question types (e.g., true/false, fill-in-the-blank), question pools, randomized questions, and time limits. This enhances the platform's pedagogical value, allowing instructors to create more nuanced assessments.
- **Analytics Dashboard:**
    - Create an analytics dashboard for instructors and admins to view reports on student performance, course popularity, and enrollment trends. This provides the "big data" insights that institutions need to understand learner behavior and improve the quality of education.

CHAPTER 9: CONCLUSION

The **Knowledge Delivery Platform** project successfully demonstrates the power and flexibility of the MERN stack in building a modern, scalable, and effective e-learning solution. By thoughtfully addressing the core problems of fragmented course delivery, inefficient progress tracking, and the lack