# DESIGN AND IMPLEMENTATION FOR

# Kaiju Academy

**Version 1.1**


**Prepared by**
**Group A2**

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# Contents

# Document Revision History

| Version | Revised By | Revision Date | Comments |
|---|---|---|---|
| 0.1 | Group A2 | 2025-02-27 | Added:<br>–Initial document structure<br>–Basic content outline |
| 1.0 | Group A2 | 2025-03-11 | Updated:<br>–Final review and integration |
| 1.1 | C. W. Leung | 2025-04-23 | Updated:<br>–Pruned and updated per requirements in meeting1.docx |

# 1. Introduction

Kaiju Academy is a **web-based e-learning platform** designed to make learning programming accessible and engaging. It combines modern Learning Management System (LMS) capabilities with interactive coding features, enabling users to learn at their own pace.

## 1.1 Summary of Requirements

Kaiju Academy includes:

- **User Management & Authentication:** Role-based access control for users (student), teachers (educator), and admins, with secure authentication and optional MFA.
- **Course Creation & Management:** Tools for creating, updating, and organizing courses with videos, PDFs, quizzes, and coding assessments.
- **Interactive Learning:** Real-time code execution and automated grading via an online code editor.
- **Profile and Progress:** User and educator profiles, progress tracking, recommended and registered courses.
- **Monetization:** Course credit system for payment and buying credits to unlock courses.

## 1.2 Quality Goals

| Goal | Description |
|---|---|
| **Performance** | - Response time <2 seconds for 95% of users.<br>- Code execution results in <5 seconds for 99% of submissions. |
| **Scalability** | - Support 10,000 concurrent users.<br>- Horizontal scaling via AWS Lambda and SurrealDB sharding. |
| **Reliability** | - 99.9% uptime with automatic failover.<br>- Recovery from failures within 5 minutes. |
| **Security** | - AES-256 encryption for data at rest.<br>- TLS 1.2+ for data in transit.<br>- Role-based permissions and MFA. |

**Table 1.1:** Quality Goals for Kaiju Academy

## 1.3 Stakeholders

| Stakeholder | Role & Responsibilities |
|---|---|
| **Admin** | - Manage system health, user roles, and platform configurations.<br>- Enforce security policies. |
| **User (Student)** | - Enroll in courses, complete assessments, and track progress. |
| **Teacher (Educator)** | - Create and update course content.<br>- Grade submissions and provide feedback. |

**Table 1.2:** Stakeholders and Their Roles

### 1.3.1 Acknowledgments

This document was prepared with the assistance of AI tools (e.g., ChatGPT 4.1) for drafting and review.

# 2. System Architecture

## 2.1 Major Components

**Frontend Application:** A React application providing the user interface across all devices.

**Backend Services:** Rust-based AWS Lambda functions for service logic.

**SurrealDB:** Primary database for persistent data.

**AWS Services:** API Gateway, Lambda, Cognito (auth/MFA), S3 (media), CloudFront (CDN), Fargate (code execution).

## 2.2 Component Relationships

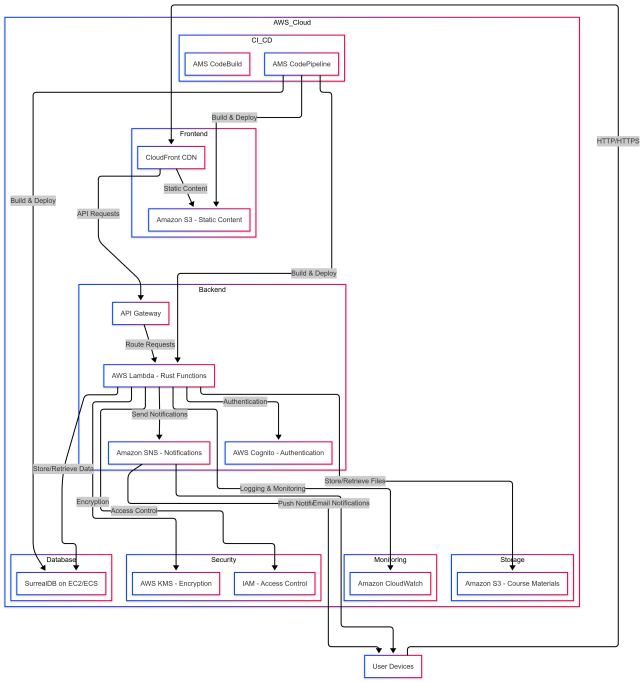



**Figure 2.1:** AWS Serverless Deployment Architecture

- Users access via browsers, routed through CloudFront CDN and API Gateway.
- Lambda functions handle business logic, SurrealDB stores data.
- Cognito manages authentication and optional MFA.
- S3 stores learning materials.

## 2.3 Database

SurrealDB's multi-model database supports course, user, credit/payment, progress, and assessment data.

## 2.4 Security

- AWS-managed VPC and IAM boundaries.
- AES-256 encryption at rest, TLS 1.2+ in transit.
- JWT for stateless API authentication, MFA support via Cognito.

## 2.5 User Authentication and Authorization

- Email/password registration and login, MFA if supported.
- JWT tokens for session management.
- Roles: user (student), teacher (educator), admin.

## 2.6 Testability

- Automated unit and integration tests in Rust.
- CI/CD pipeline with test coverage enforcement.

# 3. Data Models

## 3.1 Database Schema

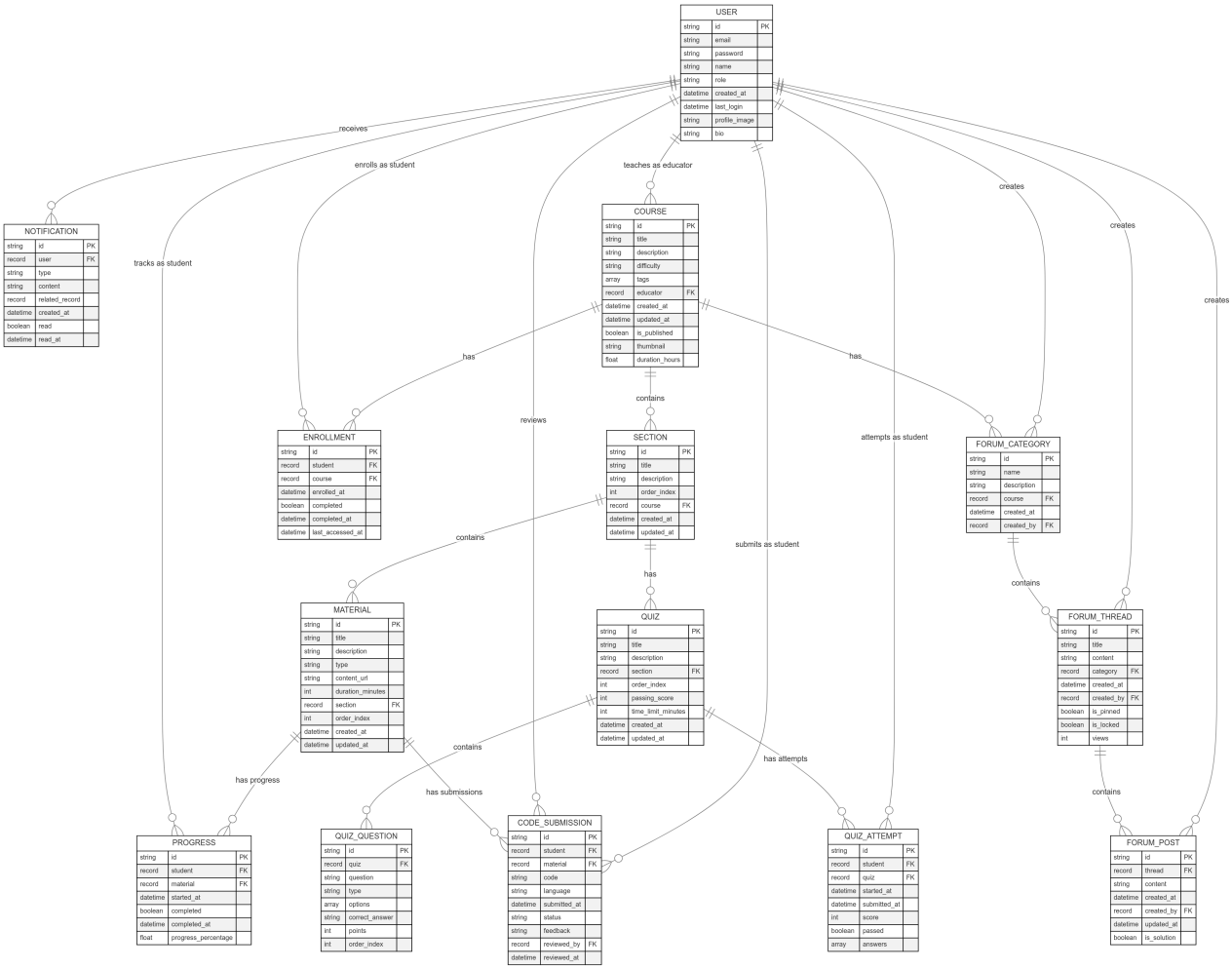



**Figure 3.1:** Database Schema

## 3.2 Request and Response Structure

```
let response = ApiGatewayProxyResponse {
    status_code: 200,
    headers: std::collections::HashMap::new(),
    multi_value_headers: std::collections::HashMap::new(),
    body: Some(json!({ "message": "Hello from Kaiju Academy API!" }).
        to_string()),
    is_base64_encoded: Some(false),
};
Ok(response)
```

## 3.3 Data Flow Sequence

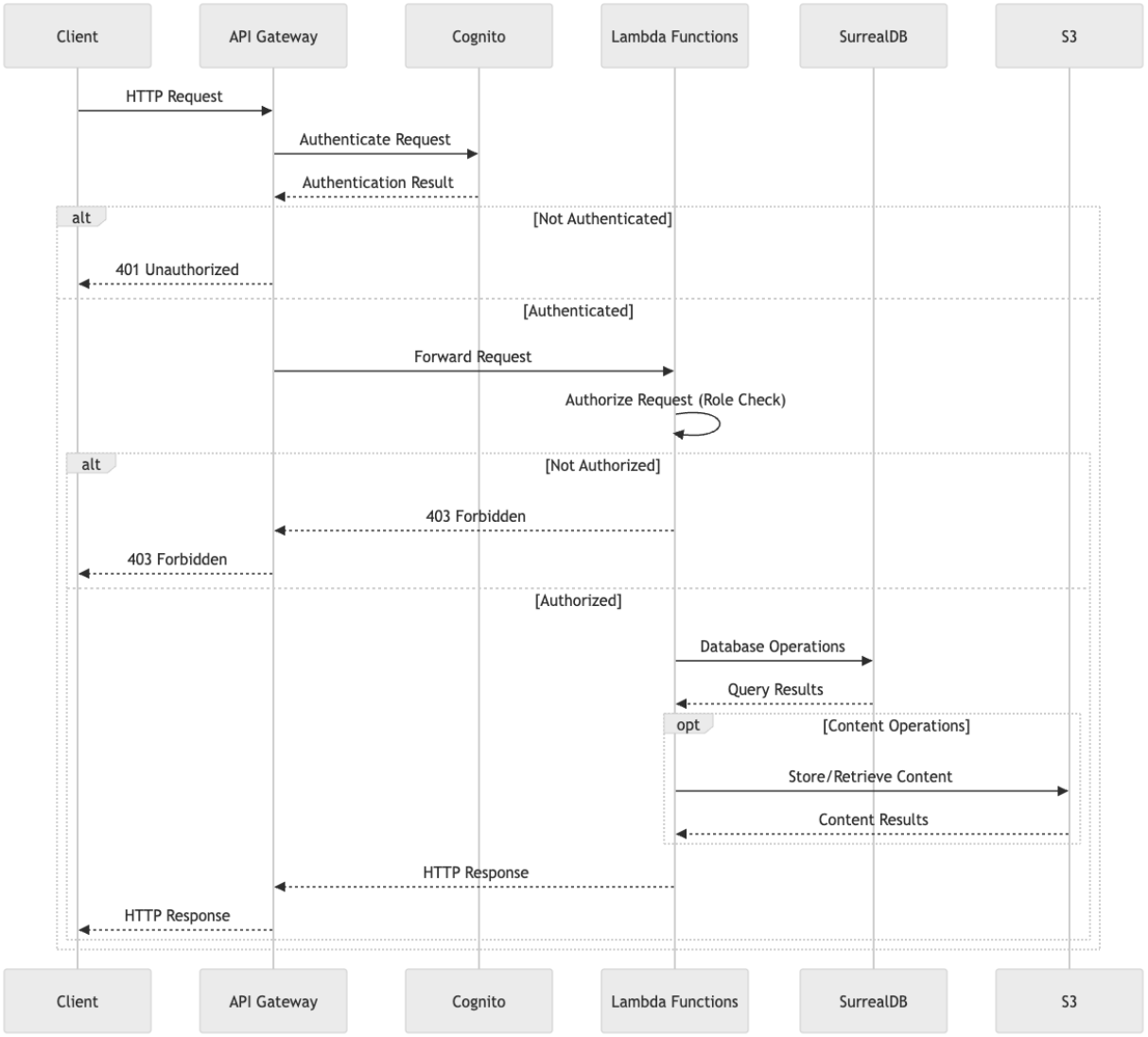



**Figure 3.2:** Data Flow Sequence Diagram

# 4. Interface Design

## 4.1 User Registration and Authentication

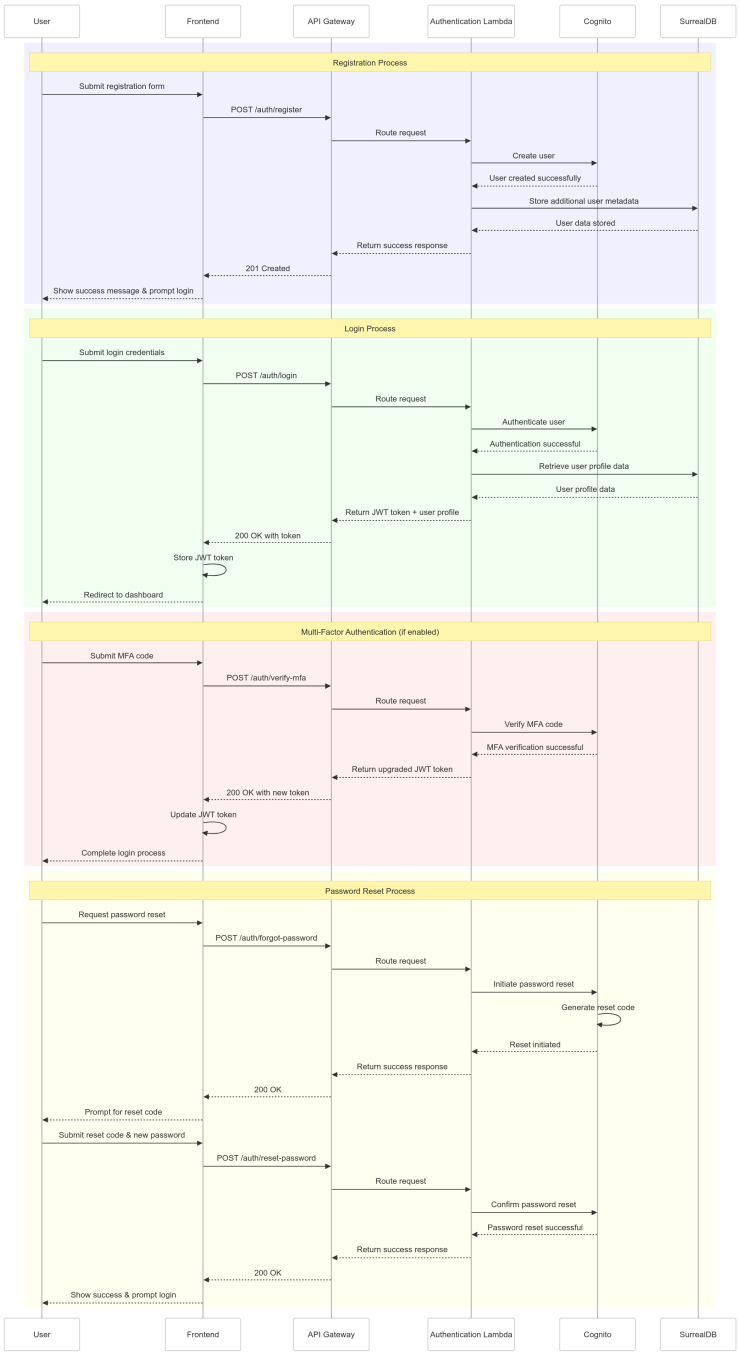



**Figure 4.1:** User Authentication Workflow

1. User submits registration/login with optional MFA.
2. API Gateway routes to Authentication Lambda.
3. Lambda creates/validates user in Cognito and SurrealDB.
4. JWT token returned for session.

### 4.1.1 Course Management

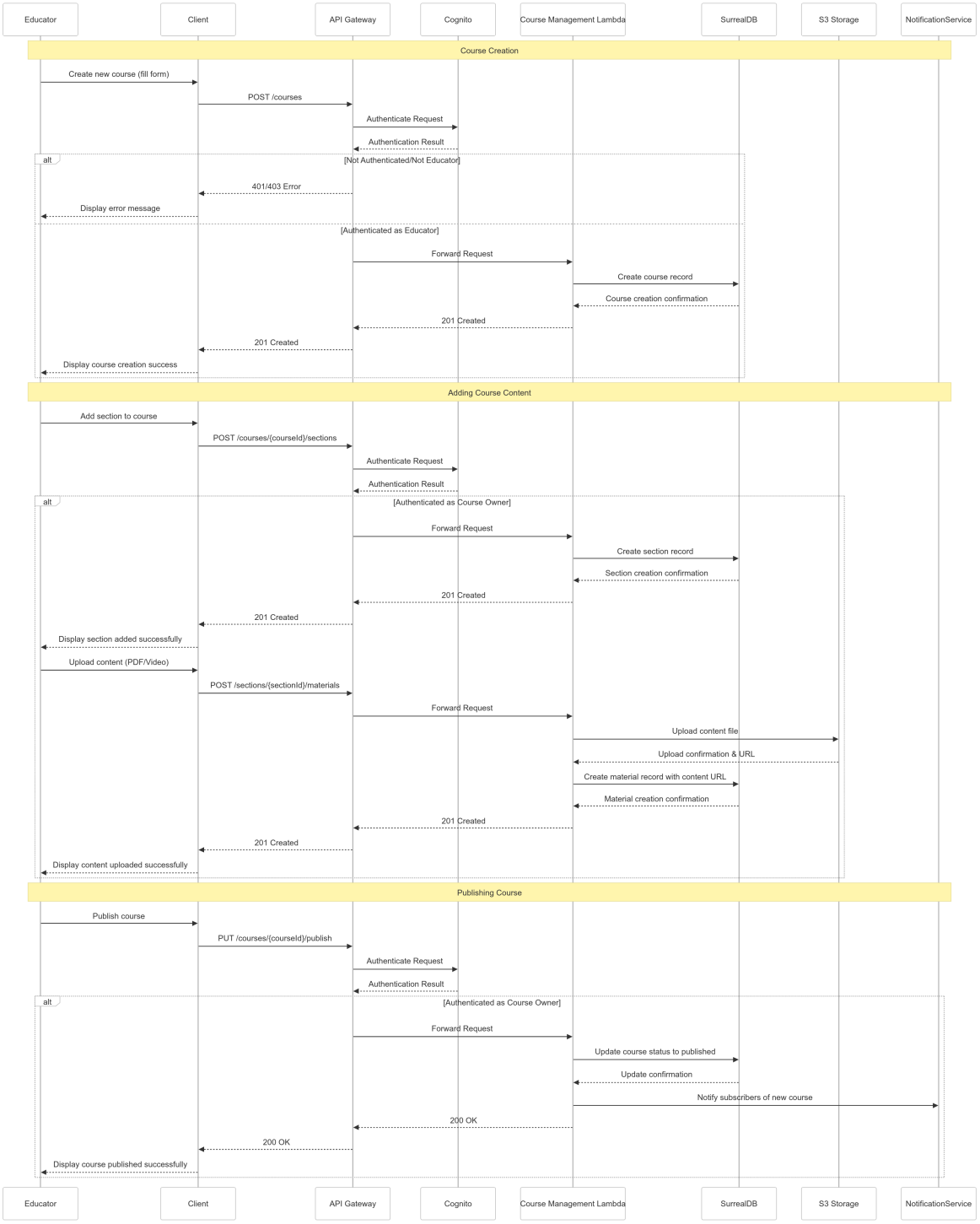



**Figure 4.2:** Course Management Workflow

1. Educator manages course structure and modules.
2. Materials uploaded to S3.
3. Changes stored in SurrealDB.

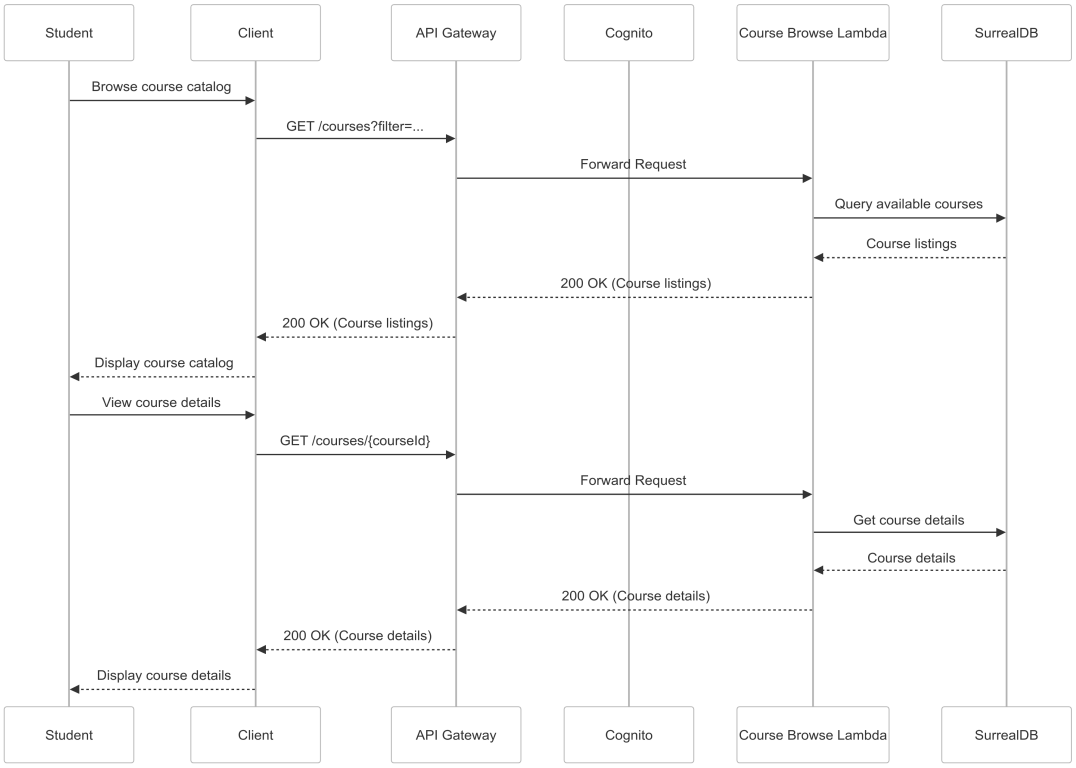



**Figure 4.3:** Course Access Workflow

### 4.1.2 Course Access

### 4.1.3 Code Assessment and Grading

**Sample code assessment editor (simplified):**

```
// Code Assessment Editor (conceptual)
fn CodeEditor() {
    let code = "// Write your code here";
    fn run_code() {
        // send code to backend, display result
    }
    // Renders a textarea and Run button
}
```

## 4.2 Service Communication

- RESTful APIs with JSON payloads.
- Rate limiting per user/IP.
- Batch operations and pagination.

## 4.3 Security Implementation

- Multi-factor Authentication (MFA) optional for all users.
- OAuth2 integration for social login.
- JWT for API authentication.
- AES-256 encryption for sensitive data.

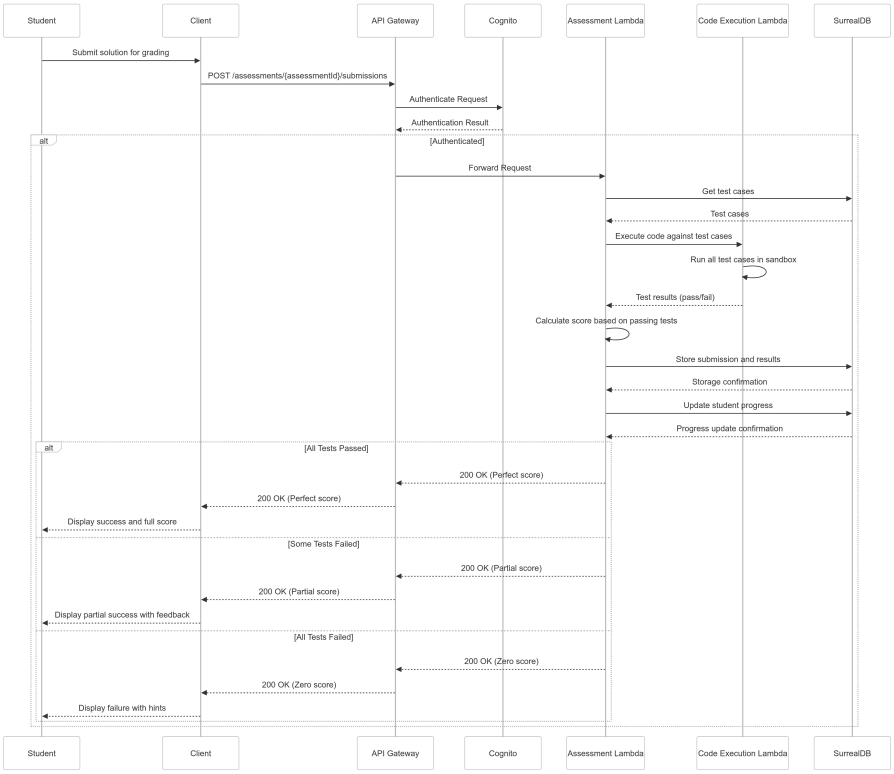



**Figure 4.4:** Code Auto-grading Workflow

## 4.4 Exception Handling

### 4.4.1 Expected Exceptions

- Authentication errors (401)
- Authorization errors (403)
- Validation errors (400)
- Not found errors (404)
- Database errors (500)
- Internal server errors (500)
- External service errors (502)
- Rate limit errors (429)

### 4.4.2 Error Handling Example

```
impl From<AppError> for ApiGatewayProxyResponse {
    fn from(error: AppError) -> Self {
        let (status_code, error_type) = match &error {
            AppError::Authentication(_) => (401, "Authentication Error"),
            AppError::Authorization(_) => (403, "Authorization Error"),
            AppError::NotFound(_) => (404, "Not Found"),
            AppError::Validation(_) => (400, "Validation Error"),
            AppError::Database(_) => (500, "Database Error"),
            AppError::Internal(_) => (500, "Internal Server Error"),
            AppError::ExternalService(_) => (502, "External Service Error"),
            AppError::RateLimit(_) => (429, "Rate Limit Exceeded"),
        };
        // Response body omitted for brevity
        ApiGatewayProxyResponse { ... }
    }
}
```

### 4.4.3 Credit Purchase and Payment Flow

**Overview:**
Kaiju Academy uses a credit-based payment system. Users buy credits through an integrated payment gateway and spend credits to unlock/register for courses. This system decouples payment from course registration and supports flexible monetization.

### 4.4.4 Credit Purchase and Course Enrollment Flow

1. User navigates to the "Buy Credits" page from the profile or course page.
2. User selects a credit package (e.g., 100 credits, 200 credits).
3. User is redirected to a third-party payment gateway (e.g., Stripe) to complete the transaction.
4. Upon successful payment, the backend updates the user's credit balance.
5. User can now browse courses; when enrolling in a paid course, the platform checks credit balance:
   - If sufficient, deducts credits and confirms registration.
   - If insufficient, prompts the user to buy more credits.
6. All transactions are logged for auditing and user transparency.

**Security Note:** All payment processing is handled via a PCI-compliant gateway. No sensitive payment data is stored on Kaiju Academy servers.

### 4.4.5 Credit Purchase and Enrollment Logic (Mermaid Diagram)

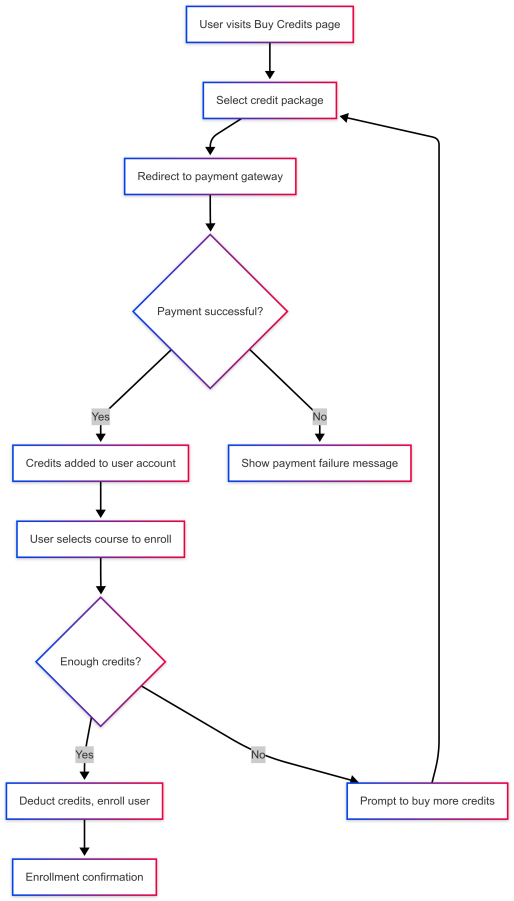



**Figure 4.5:** Credit Purchase and Course Enrollment Flow

## 4.5 Licence Key Verification

**Overview:**
Upon first login or before accessing any main features, users must enter a valid licence key. The backend validates the key against a list (hardcoded or stored in the database). If the key is valid, access is granted; otherwise, the user is denied access and prompted again.

1. After successful login, the user is prompted for a licence key.
2. The entered key is sent to the backend for validation.
3. If valid, the session is marked as "licenced" and the user proceeds.
4. If invalid, an error message is displayed and access is denied.

**Minimal Implementation Note:**
If time is limited, licence management may be implemented as a stub or described as future work, but the design must be documented.
**Security Note:**
Licence keys must not be predictable and should be stored securely.

# 5. Component Design

## 5.1 Frontend Components

### 5.1.1 Navbar Component

- **Intention:** Provides navigation links and user profile access.
- **Input:** User interactions (clicks), authentication state.
- **Output:** Navigation actions, profile dropdown.

### 5.1.2 Code Editor Component

- **Intention:** Provides syntax highlighting, code execution, and result display.
- **Input:** User code, language, test cases.
- **Output:** Code submission to backend, execution result.

## 5.2 Backend Components

### 5.2.1 Authentication Service

- **Intention:** Registration, login, MFA, token management.
- **Input:** Credentials, MFA codes.
- **Output:** JWT tokens, authentication status, error messages.

### 5.2.2 Course Management Service

- **Intention:** Course/module creation, update, and deletion.
- **Input:** Course objects, materials.
- **Output:** Course IDs, content structures.

### 5.2.3 Assessment Service

- **Intention:** Executes user code, grades submissions, provides feedback.
- **Input:** User code, language, test cases.
- **Output:** Execution results, scores, feedback.

# 6. User Interface Design

## 6.1 Design Principles

- **Consistency:** Unified design language
- **Accessibility:** WCAG 2.1 AA compliance
- **Responsiveness:** Mobile friendly
- **Feedback:** Clear system status for all actions

## 6.2 User-wise Navigation Flow

### 6.2.1 Student

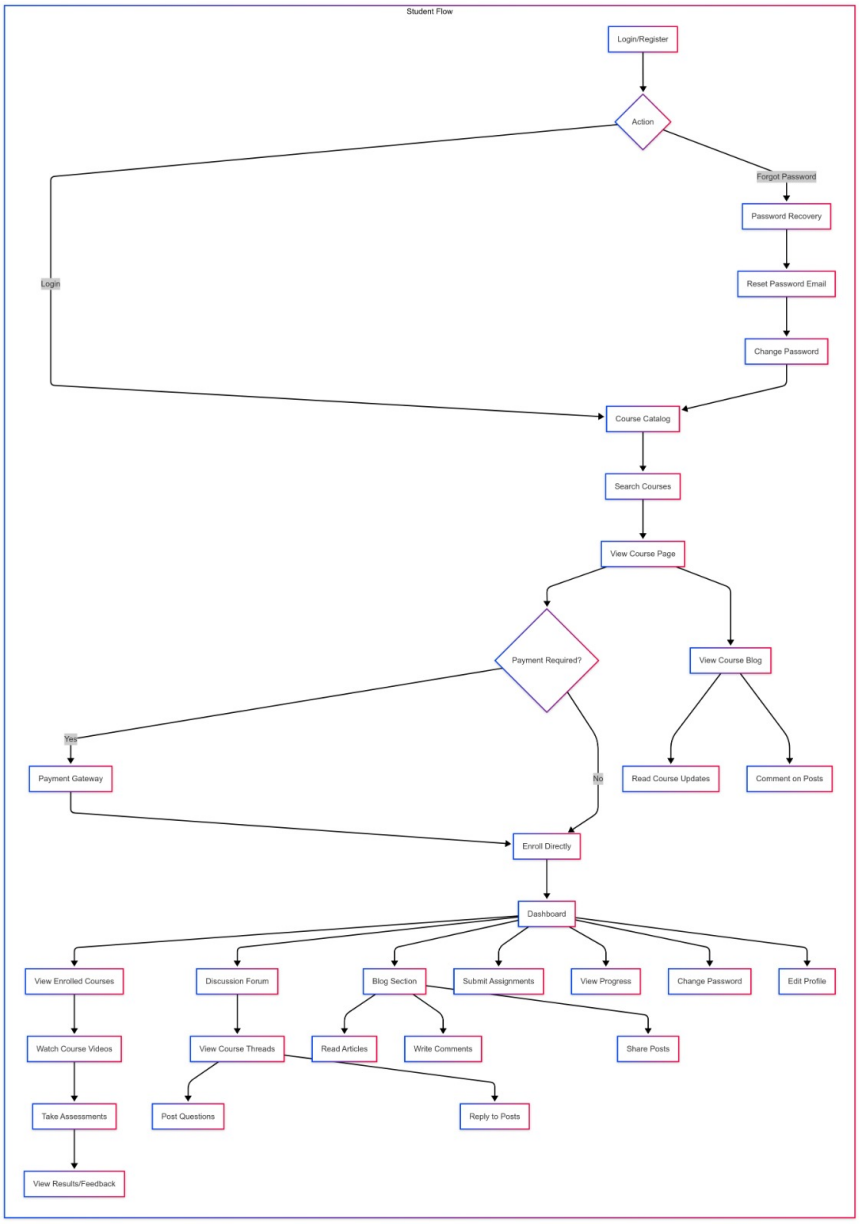



**Figure 6.1:** Student Navigation Flow

### 6.2.2 Educator

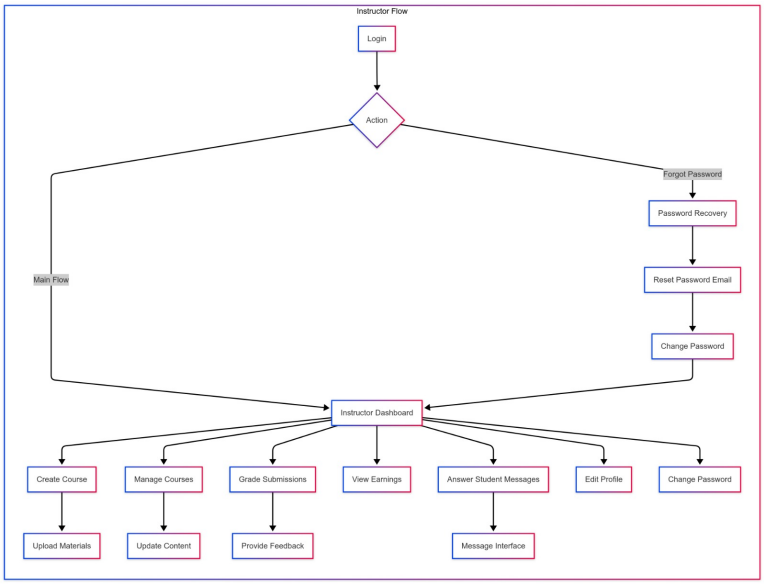
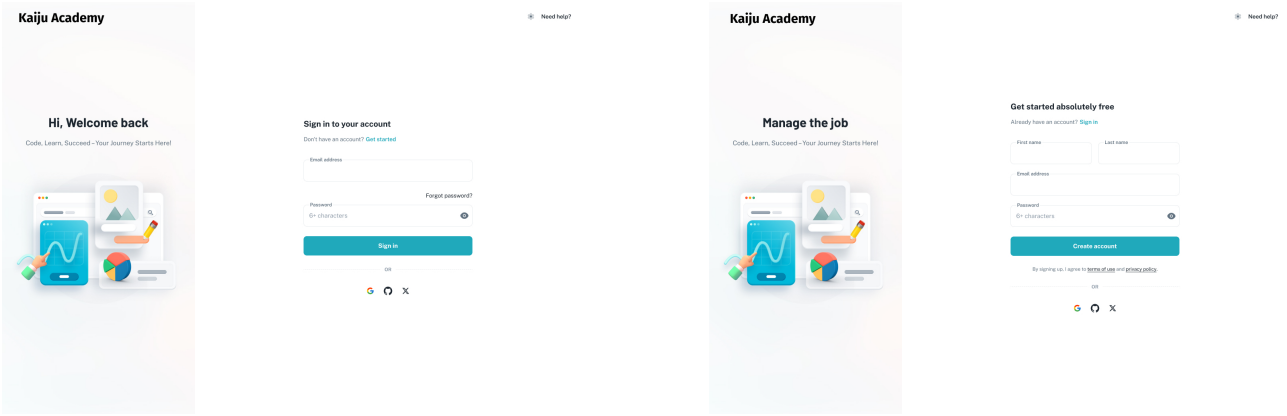



**Figure 6.2:** Educator Navigation Flow

## 6.3 Interface Storyboards

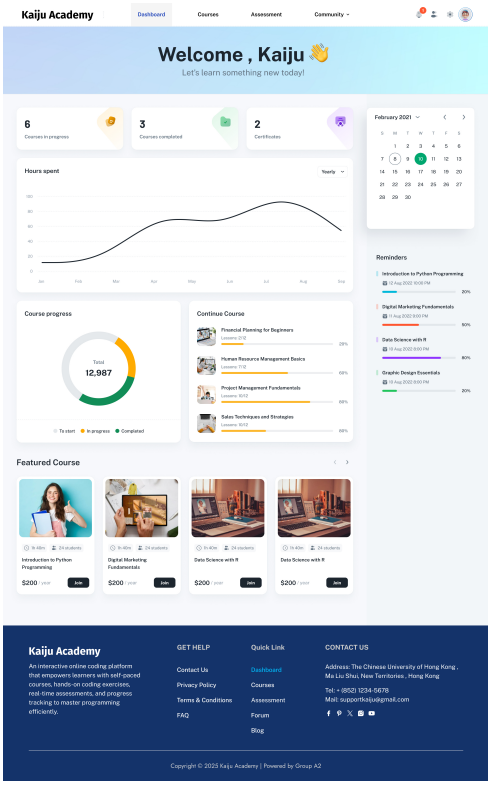
### 6.3.1 Authentication Flow



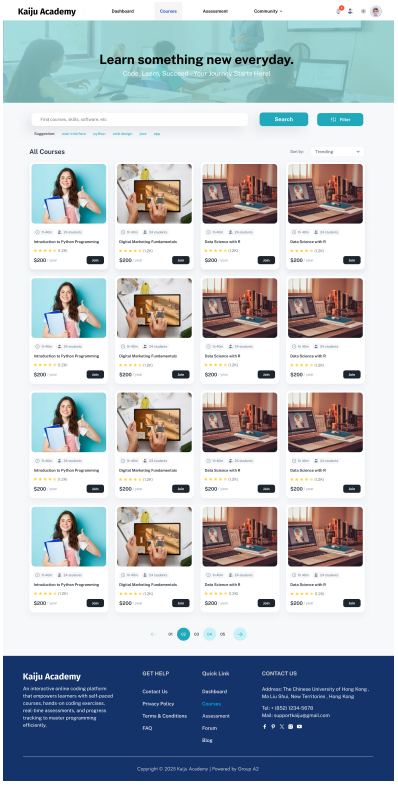

**(a)** Sign In Screen **(b)** Sign Up Screen

**Figure 6.3:** Authentication Screens

### 6.3.2 Student Learning Journey




**(a)** Student Dashboard




**(b)** Course Catalog

**Figure 6.4:** Student courses view

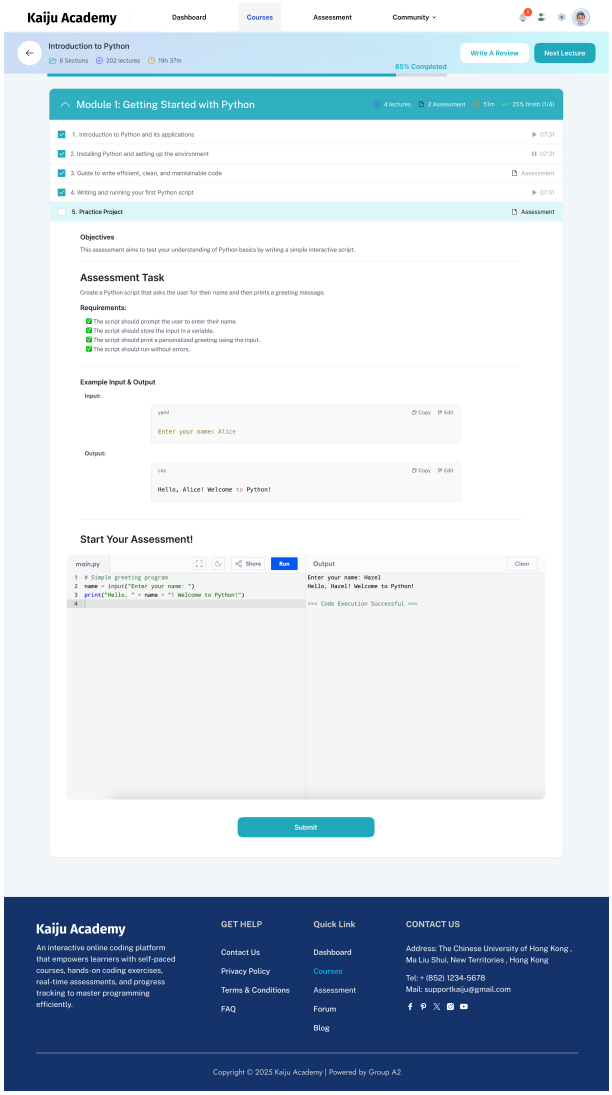
### 6.3.3 Learning Environment

## 6.4 Accessibility Considerations

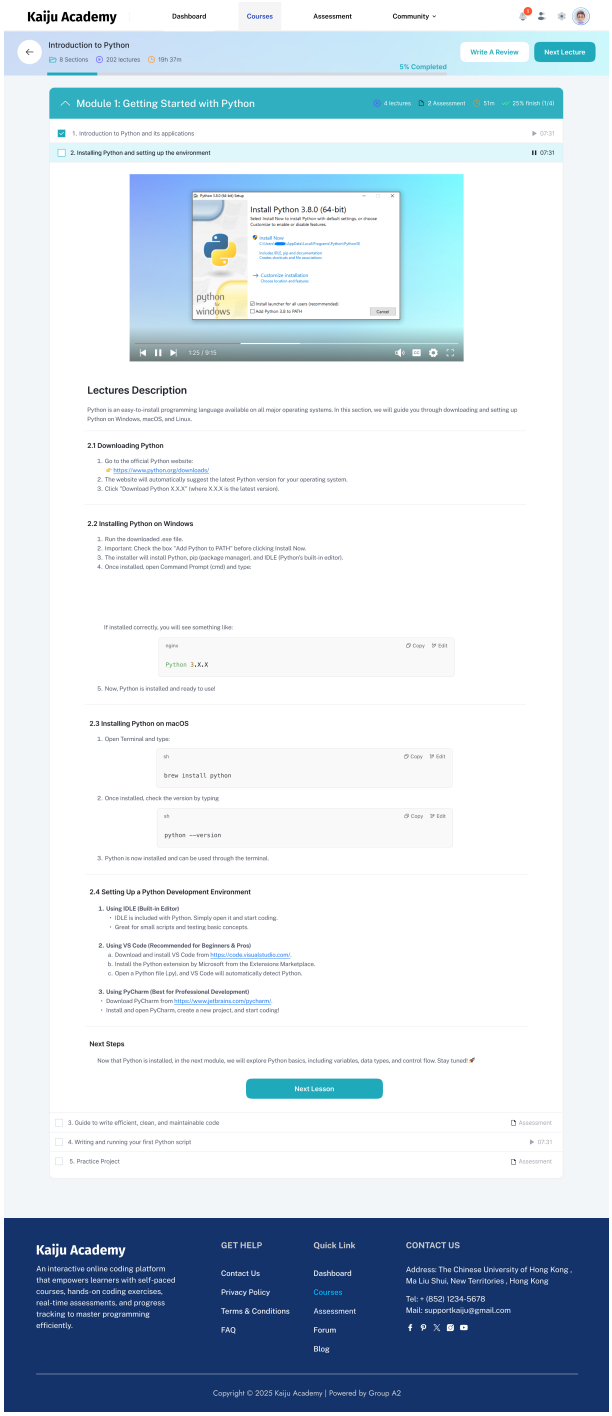
- **Screen Reader Support:** Proper ARIA labels and semantic HTML
- **Text Resize:** Interface remains functional when text is enlarged 200%
- **Motion Control:** Animations can be disabled
- **Alternative Text:** All images include descriptive alt text
- **Light/Dark Mode:** Option to switch between light and dark themes
- **Font Size Adjustment:** Users can easily change font size

## 6.5 Responsive Design

- **Breakpoints:** 480px, 768px, 1024px, and 1440px
- **Layout:**
  - Single column on mobile
  - Sidebar overlay on small screens
  - Multi-column on larger screens
- **Touch Targets:** Minimum 44×44px for all interactives




**(a)** Assessment Interface




**(b)** During Course Interface

**Figure 6.5:** Learning and Assessment Interface

# 7. Assumptions

## 7.1 Technical Constraints

### 7.1.1 Hardware Constraints

- At least 4GB RAM, 320px width, 5 Mbps internet
- AWS cloud deployment, serverless Lambda, horizontal scaling

### 7.1.2 Software Constraints

- Modern browsers (Chrome, Firefox, Safari, Edge, latest 2 versions)
- HTML5 and JavaScript required
- Responsive web (no native app initially)

## 7.2 Operational Assumptions

- Peak: 10,000 code submissions/minute
- 80/20 read/write database
- Code execution max 5 seconds
- CI/CD pipeline with automated testing
- 99.9% uptime excluding maintenance, daily backups

## 7.3 Dependencies

### 7.3.1 Third-Party Services

- Authentication via OAuth providers (Google, GitHub, Microsoft)
- Payment processing for course credits
- Email delivery through Amazon SNS
- CDN via CloudFront
- Media transcoding via AWS MediaConvert