

# **Software Requirements Specification (SRS)**

## **AI-Powered Personalized Learning Path Generator**

**Problem Statement ID:** 25199

**Organization:** Ministry of Skill Development and Entrepreneurship (MSDE)

**Department:** MSDE in association with NCVET

**Version:** 1.0

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## **1. Introduction**

### **1.1 Purpose**

This document specifies the software requirements for developing an AI-powered Personalized Learning Path Generator system for India's vocational education and training ecosystem. The system aims to provide customized training pathways to learners based on their profiles, aspirations, and real-time labor market demands.

### **1.2 Scope**

The system will serve as an intelligent career navigator and skilling assistant that analyzes learner profiles, maps career aspirations with industry requirements, and generates adaptive training pathways aligned with the National Skills Qualifications Framework (NSQF). It will continuously update recommendations based on learner progress and evolving job market trends.

### **1.3 Definitions, Acronyms, and Abbreviations**

- **NCVET:** National Council for Vocational Education and Training
- **NSQF:** National Skills Qualifications Framework
- **MSDE:** Ministry of Skill Development and Entrepreneurship
- **AI/ML:** Artificial Intelligence/Machine Learning
- **LMI:** Labour Market Intelligence
- **API:** Application Programming Interface
- **SRS:** Software Requirements Specification
- **NQR:** National Qualifications Register

## **1.4 References**

- National Skills Qualifications Framework (NSQF) guidelines
- NCVET qualification standards and frameworks
- Data privacy and security norms (IT Act, 2000 and amendments)
- Accessibility standards (GIGW - Guidelines for Indian Government Websites)

## **1.5 Overview**

This document is organized into sections covering overall system description, specific functional and non-functional requirements, system interfaces, and constraints.

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## **2. Overall Description**

### **2.1 Product Perspective**

The AI-Powered Personalized Learning Path Generator is a standalone yet integrable system that connects with existing NCVET infrastructure, training provider databases, and labor market intelligence platforms. It serves as the central recommendation engine for vocational training pathways in India.

### **2.2 Product Functions**

The system shall provide the following core functions:

1. Learner profile creation and analysis
2. Career aspiration mapping with industry requirements
3. Personalized training pathway generation
4. Adaptive learning recommendations
5. Progress tracking and pathway adjustment
6. Labor market intelligence integration
7. Multi-stakeholder dashboard interfaces
8. Reporting and analytics

### **2.3 User Classes and Characteristics**

#### **2.3.1 Learners**

- Primary users seeking vocational training guidance
- Diverse backgrounds: academic qualifications, socio-economic contexts

- Age range: 15-60 years
- Varying digital literacy levels
- Multiple language preferences

### **2.3.2 Training Providers**

- Vocational training institutes
- Industrial Training Institutes (ITIs)
- Skill Development Centers
- Corporate training programs

### **2.3.3 Career Counselors/Trainers**

- Government career counselors
- Educational institution counselors
- Industry mentors

### **2.3.4 Policymakers and Administrators**

- NCVET officials
- MSDE personnel
- State skill development mission teams

### **2.3.5 Employers/Industry Representatives**

- HR managers seeking skilled workforce
- Industry associations providing skill requirements

## **2.4 Operating Environment**

- **Platform:** Web-based application with mobile responsiveness
- **Server Environment:** Cloud-based infrastructure (AWS/Azure/GCP)
- **Client Devices:** Desktop, laptop, tablet, smartphone
- **Browsers:** Chrome, Firefox, Safari, Edge (latest versions)
- **Mobile OS:** Android 8.0+, iOS 12.0+
- **Connectivity:** Online with offline data caching capability

## **2.5 Design and Implementation Constraints**

- Compliance with Indian data privacy laws and regulations
- Adherence to NCVET qualification frameworks and NSQF alignment
- Multilingual support (minimum 12 Indian languages + English)
- Accessibility compliance (WCAG 2.1 Level AA)
- Scalability to serve millions of concurrent users
- Integration capabilities with existing government systems (DigiLocker, Aadhaar, etc.)

## 2.6 Assumptions and Dependencies

- Availability of updated NCVET qualification database
  - Access to real-time or periodic labor market intelligence data
  - Internet connectivity for primary functionality
  - User consent for data collection and processing
  - Training provider data integration and cooperation
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# 3. Specific Requirements

## 3.1 Functional Requirements

### 3.1.1 Learner Profile Management

#### FR-1.1: User Registration

- The system shall allow learners to register using mobile number, email, or government ID integration (Aadhaar/DigiLocker)
- The system shall support multi-factor authentication
- The system shall verify user identity through OTP or biometric authentication

#### FR-1.2: Profile Creation

- The system shall collect learner information including:
  - Personal details (name, age, gender, location)
  - Educational background (highest qualification, subjects, marks)
  - Prior work experience and skills
  - Socio-economic context (family background, income level, special categories)
  - Learning preferences (pace, mode, language)

- Career aspirations and interests
- The system shall allow profile completion in multiple sessions
- The system shall provide an intuitive step-by-step profile creation wizard

#### **FR-1.3: Skill Assessment**

- The system shall provide AI-driven skill assessment tests
- The system shall support adaptive testing based on learner responses
- The system shall generate a comprehensive skill profile from assessment results
- The system shall identify skill gaps against target career paths

#### **FR-1.4: Profile Updates**

- The system shall allow learners to update their profiles at any time
- The system shall automatically trigger pathway recalibration upon significant profile changes

### **3.1.2 Career Aspiration and Goal Setting**

#### **FR-2.1: Career Interest Analysis**

- The system shall use psychometric assessments to identify career interests
- The system shall map career interests to NSQF-aligned job roles
- The system shall provide career exploration tools with industry insights

#### **FR-2.2: Goal Definition**

- The system shall allow learners to set short-term and long-term career goals
- The system shall validate goals against learner's current profile and market feasibility
- The system shall provide goal templates for common career trajectories

#### **FR-2.3: Aspiration-Industry Mapping**

- The system shall map learner aspirations with current and projected industry demands
- The system shall highlight high-demand skills and emerging opportunities
- The system shall provide realistic career pathway options with success probability indicators

### **3.1.3 AI-Powered Recommendation Engine**

#### **FR-3.1: Pathway Generation Algorithm**

- The system shall use machine learning algorithms to generate personalized learning pathways
- The system shall consider multiple factors:
  - Current skill level and knowledge gaps
  - Career aspirations and target job roles
  - Learning pace and time availability
  - Geographic constraints and training center proximity
  - Financial constraints and funding availability
  - Industry demand and employment probability
- The system shall generate multiple pathway options ranked by suitability

### **FR-3.2: NSQF Alignment**

- The system shall map all recommendations to NSQF levels (1-10)
- The system shall ensure progressive skill building across NSQF levels
- The system shall identify stackable credentials and micro-credentials

### **FR-3.3: Course Recommendation**

- The system shall recommend specific courses from NCVET-approved training providers
- The system shall suggest sequence and duration for each course
- The system shall recommend complementary courses for holistic skill development

### **FR-3.4: Certification Pathway**

- The system shall outline certification requirements and examination preparation
- The system shall recommend recognized certifications aligned with career goals
- The system shall track certification validity and renewal requirements

### **FR-3.5: On-the-Job Training**

- The system shall recommend apprenticeship and on-the-job training opportunities
- The system shall match learners with potential employers based on location and industry

## **3.1.4 Adaptive Learning and Continuous Updates**

### **FR-4.1: Progress Tracking**

- The system shall track learner progress across courses and certifications

- The system shall update skill profiles as learners complete training modules
- The system shall maintain a comprehensive learning history

#### **FR-4.2: Dynamic Pathway Adjustment**

- The system shall automatically adjust recommendations based on:
  - Learner progress and performance
  - Changes in career goals
  - Evolving labor market trends
  - New qualification offerings
- The system shall notify learners of pathway changes with explanations

#### **FR-4.3: Feedback Integration**

- The system shall collect learner feedback on recommendations and outcomes
- The system shall use feedback to refine recommendation algorithms
- The system shall implement continuous learning mechanisms to improve accuracy

### **3.1.5 Labour Market Intelligence Integration**

#### **FR-5.1: Real-Time Market Data**

- The system shall integrate with labor market intelligence platforms
- The system shall access real-time data on:
  - Job openings and demand by sector
  - Salary trends and compensation data
  - Skill requirements and emerging technologies
  - Geographic employment hotspots
  - Future skill predictions

#### **FR-5.2: Industry Alignment**

- The system shall prioritize pathways aligned with high-demand industries
- The system shall provide employment probability scores for each pathway
- The system shall highlight future-ready skills and technologies

#### **FR-5.3: Market Trend Analysis**

- The system shall analyze historical and current market trends

- The system shall predict future skill demands using predictive analytics
- The system shall generate market insight reports for different sectors

### **3.1.6 Dashboard and User Interfaces**

#### **FR-6.1: Learner Dashboard**

- The system shall provide a personalized dashboard showing:
  - Current learning pathway and progress
  - Recommended next steps
  - Upcoming courses and deadlines
  - Certification status
  - Employment opportunities
  - Skill gap analysis
- The system shall support customizable dashboard widgets

#### **FR-6.2: Trainer/Counselor Dashboard**

- The system shall provide tools for career counselors to:
  - View multiple learner profiles
  - Provide manual pathway adjustments
  - Add notes and recommendations
  - Track counseling effectiveness
- The system shall enable batch learner management

#### **FR-6.3: Policymaker Dashboard**

- The system shall provide analytics and insights including:
  - Aggregated learner demographics and trends
  - Popular career pathways and skills
  - Training provider performance metrics
  - Labor market alignment statistics
  - System usage and adoption metrics
- The system shall support custom report generation

#### **FR-6.4: Training Provider Interface**

- The system shall allow training providers to:
  - Register and manage course offerings
  - View learner referrals
  - Update course schedules and availability
  - Report learner outcomes

### **3.1.7 Multilingual and Accessibility Features**

#### **FR-7.1: Language Support**

- The system shall support at least 12 Indian languages plus English
- The system shall allow language switching at any point
- The system shall provide complete translation of all user-facing content
- The system shall support voice input and text-to-speech in multiple languages

#### **FR-7.2: Accessibility Compliance**

- The system shall comply with WCAG 2.1 Level AA standards
- The system shall support screen readers and assistive technologies
- The system shall provide keyboard navigation for all functions
- The system shall offer high-contrast and adjustable font size options

#### **FR-7.3: Digital Literacy Support**

- The system shall provide tutorial videos and help guides
- The system shall offer chatbot assistance for common queries
- The system shall support simplified interface mode for low digital literacy users

### **3.1.8 Integration and Interoperability**

#### **FR-8.1: NCVET System Integration**

- The system shall integrate with NCVET's National Qualifications Register (NQR)
- The system shall sync with NCVET's assessment and certification systems
- The system shall access updated qualification standards and frameworks

#### **FR-8.2: Training Provider Integration**

- The system shall provide APIs for training providers to integrate course catalogs

- The system shall support automated enrollment and progress reporting
- The system shall enable single sign-on for integrated systems

### **FR-8.3: Government System Integration**

- The system shall integrate with DigiLocker for credential verification
- The system shall support Aadhaar-based authentication
- The system shall connect with employment exchange databases

### **FR-8.4: Third-Party Integrations**

- The system shall integrate with job portals for employment opportunities
- The system shall connect with scholarship and funding databases
- The system shall support payment gateway integration for course fees

## **3.1.9 Reporting and Analytics**

### **FR-9.1: Learner Reports**

- The system shall generate individual progress reports
- The system shall provide skill certification and achievement records
- The system shall create downloadable/printable pathway roadmaps

### **FR-9.2: Administrative Reports**

- The system shall generate usage statistics and adoption metrics
- The system shall provide training provider performance reports
- The system shall create labor market alignment reports
- The system shall support custom report parameters and filters

### **FR-9.3: Predictive Analytics**

- The system shall use AI to predict learner success probabilities
- The system shall identify at-risk learners requiring intervention
- The system shall forecast training demand by sector and region

## **3.2 Non-Functional Requirements**

### **3.2.1 Performance Requirements**

### **NFR-1.1: Response Time**

- The system shall load pages within 3 seconds under normal conditions
- The system shall generate pathway recommendations within 10 seconds
- The system shall process skill assessments in real-time with results within 5 seconds

### **NFR-1.2: Scalability**

- The system shall support at least 10 million registered users
- The system shall handle 100,000 concurrent active users
- The system shall process 1 million pathway generation requests per day

### **NFR-1.3: Throughput**

- The system shall process at least 1,000 transactions per second
- The system shall support batch processing of reports for 50,000+ learners

## **3.2.2 Security Requirements**

### **NFR-2.1: Authentication and Authorization**

- The system shall implement role-based access control (RBAC)
- The system shall enforce strong password policies (minimum 8 characters, complexity requirements)
- The system shall support multi-factor authentication for sensitive operations
- The system shall implement session timeout after 30 minutes of inactivity

### **NFR-2.2: Data Protection**

- The system shall encrypt all data in transit using TLS 1.3 or higher
- The system shall encrypt sensitive data at rest using AES-256 encryption
- The system shall implement secure API authentication using OAuth 2.0 or JWT
- The system shall mask sensitive personal information in logs and reports

### **NFR-2.3: Privacy Compliance**

- The system shall comply with IT Act, 2000 and amendments
- The system shall implement consent management for data collection
- The system shall provide data portability and right to erasure functionality
- The system shall conduct regular privacy impact assessments

## **NFR-2.4: Audit and Logging**

- The system shall log all user authentication attempts
- The system shall track all data modifications with user attribution
- The system shall maintain audit trails for at least 7 years
- The system shall implement intrusion detection and prevention systems

### **3.2.3 Reliability and Availability**

#### **NFR-3.1: Uptime**

- The system shall maintain 99.9% uptime (excluding scheduled maintenance)
- The system shall schedule maintenance during off-peak hours with advance notice

#### **NFR-3.2: Fault Tolerance**

- The system shall implement automatic failover mechanisms
- The system shall continue partial operations during component failures
- The system shall provide graceful degradation of services

#### **NFR-3.3: Backup and Recovery**

- The system shall perform automated daily backups of all data
- The system shall enable point-in-time recovery for the past 30 days
- The system shall achieve Recovery Time Objective (RTO) of 4 hours
- The system shall achieve Recovery Point Objective (RPO) of 1 hour

### **3.2.4 Maintainability**

#### **NFR-4.1: Code Quality**

- The system shall follow industry-standard coding practices and style guides
- The system shall maintain code documentation and comments
- The system shall achieve minimum 80% unit test coverage
- The system shall use version control for all code repositories

#### **NFR-4.2: Modularity**

- The system shall implement microservices architecture for independent component updates
- The system shall use API-first design for integration flexibility

- The system shall support hot-deployment of non-critical updates

### **NFR-4.3: Monitoring**

- The system shall implement comprehensive application performance monitoring
- The system shall provide real-time dashboards for system health metrics
- The system shall send automated alerts for critical errors and threshold breaches

### **3.2.5 Usability**

#### **NFR-5.1: User Experience**

- The system shall provide intuitive navigation requiring minimal training
- The system shall complete common tasks within 5 clicks from the home page
- The system shall provide contextual help and tooltips throughout the interface

#### **NFR-5.2: Responsiveness**

- The system shall be fully responsive across devices (desktop, tablet, mobile)
- The system shall adapt layouts automatically based on screen size
- The system shall maintain functionality on devices with screen sizes from 320px to 2560px width

#### **NFR-5.3: Error Handling**

- The system shall provide clear, actionable error messages
- The system shall guide users to resolve common errors
- The system shall log errors for technical support and resolution

### **3.2.6 Portability**

#### **NFR-6.1: Platform Independence**

- The system shall run on multiple cloud platforms (AWS, Azure, GCP)
- The system shall support containerization using Docker/Kubernetes
- The system shall use database abstraction for multiple database backends

#### **NFR-6.2: Data Migration**

- The system shall provide tools for data import from legacy systems
- The system shall support standard data export formats (CSV, JSON, XML)

- The system shall enable bulk data operations through APIs

### **3.2.7 Compliance and Standards**

#### **NFR-7.1: Regulatory Compliance**

- The system shall comply with MEITY guidelines for government applications
- The system shall follow GIGW (Guidelines for Indian Government Websites)
- The system shall implement National Informatics Centre (NIC) security guidelines

#### **NFR-7.2: Accessibility Standards**

- The system shall conform to WCAG 2.1 Level AA
- The system shall pass automated accessibility testing tools
- The system shall support assistive technologies including JAWS, NVDA

#### **NFR-7.3: Data Standards**

- The system shall use standard classification systems (NCO, NIC codes)
  - The system shall implement NSQF level mapping standards
  - The system shall follow ISO/IEC 27001 for information security management
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## **4. System Features and Use Cases**

### **4.1 Learner Pathway Generation**

#### **Use Case UC-1: New Learner Registration and Pathway Creation**

**Actors:** Learner, System

**Preconditions:** User has internet access and valid mobile number/email

**Main Flow:**

1. Learner accesses the registration page
2. System presents registration form with language selection
3. Learner enters basic details and verification method
4. System sends OTP for verification
5. Learner completes verification
6. System creates user account

7. Learner completes profile wizard (education, skills, aspirations, preferences)
8. System conducts skill assessment
9. System analyzes profile using AI algorithms
10. System generates personalized learning pathways
11. System presents pathway options with visualizations
12. Learner selects preferred pathway
13. System creates learner dashboard with selected pathway

**Postconditions:** Learner has a personalized learning pathway and active dashboard

**Alternative Flows:**

- If verification fails, system allows retry up to 3 times
- If learner exits during profile creation, system saves progress for later completion
- If no suitable pathway found, system recommends foundational courses

## 4.2 Progress Tracking and Pathway Adjustment

### Use Case UC-2: Course Completion and Pathway Update

**Actors:** Learner, Training Provider System, AI Engine

**Preconditions:** Learner is enrolled in a course as per pathway

**Main Flow:**

1. Learner completes course at training provider
2. Training provider system updates completion status via API
3. System receives completion notification
4. System updates learner's skill profile
5. AI engine analyzes updated profile
6. System recalibrates remaining pathway
7. System checks for new opportunities based on updated skills
8. System notifies learner of pathway updates and new recommendations
9. Learner reviews updated pathway
10. System presents next recommended courses

**Postconditions:** Learner pathway is updated reflecting new skills and adjusted recommendations

## **4.3 Career Counselor Intervention**

### **Use Case UC-3: Manual Pathway Adjustment by Counselor**

**Actors:** Career Counselor, Learner, System

**Preconditions:** Counselor has access rights and learner has consented to counselor access

#### **Main Flow:**

1. Counselor logs into counselor dashboard
2. Counselor searches for and selects learner profile
3. System displays learner's current pathway and progress
4. Counselor reviews AI-generated recommendations
5. Counselor conducts personal assessment or interview
6. Counselor manually adjusts pathway based on additional insights
7. Counselor adds notes explaining adjustments
8. System validates manual changes against NSQF alignment
9. System updates learner pathway with counselor recommendations
10. System notifies learner of counselor-adjusted pathway
11. Learner reviews and accepts adjustments

**Postconditions:** Learner pathway includes counselor expertise alongside AI recommendations

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## **5. External Interface Requirements**

### **5.1 User Interfaces**

#### **UI-1: Responsive Web Interface**

- Clean, modern design following government web standards
- Support for portrait and landscape orientations
- Touch-friendly interface elements (minimum 44x44px touch targets)
- Consistent navigation across all pages
- Visual hierarchy emphasizing primary actions

#### **UI-2: Mobile Application (Optional Enhancement)**

- Native or hybrid mobile apps for Android and iOS

- Offline capability for viewing pathway and progress
- Push notifications for updates and reminders
- Mobile-optimized data entry forms

### **UI-3: Dashboard Visualizations**

- Interactive pathway visualization (flowchart/roadmap)
- Progress bars and completion indicators
- Skill radar charts showing current vs. target skills
- Labor market demand graphs and trends
- Gamification elements (badges, achievements)

## **5.2 Hardware Interfaces**

### **HI-1: Server Infrastructure**

- Cloud-based virtual servers (minimum 16 vCPU, 32GB RAM for production)
- Load balancers for traffic distribution
- Database servers with master-slave replication
- Storage systems for documents and media

### **HI-2: Client Devices**

- Support for standard input devices (keyboard, mouse, touchscreen)
- Camera access for document uploads and video assessments
- Microphone access for voice input

## **5.3 Software Interfaces**

### **SI-1: NCVET Systems**

- API integration with National Qualifications Register
- Real-time sync with qualification standards database
- Integration with NCVET assessment and certification platforms

### **SI-2: Training Provider Systems**

- RESTful APIs for course catalog integration
- Webhook support for enrollment and completion notifications

- Standard data exchange formats (JSON, XML)

### **SI-3: Labor Market Intelligence**

- Integration with job portals (Naukri, LinkedIn, government job exchanges)
- API connections to industry skill demand databases
- Integration with labor statistics platforms

### **SI-4: Government Systems**

- DigiLocker API for credential storage and retrieval
- Aadhaar-based authentication (using UIDAI APIs)
- Integration with Skill India Portal

### **SI-5: Payment Gateways**

- Support for UPI, credit/debit cards, net banking
- Integration with government subsidy and scholarship systems

### **SI-6: Communication Services**

- SMS gateway for notifications and OTPs
- Email service for communications
- WhatsApp Business API for updates (optional)

## **5.4 Communication Interfaces**

### **CI-1: Network Protocols**

- HTTPS for all web communications
- WebSocket for real-time updates
- SMTP for email communications
- REST and GraphQL APIs for system integrations

### **CI-2: Data Formats**

- JSON for API data exchange
- PDF for reports and certificates
- CSV/Excel for data import/export
- XML for legacy system compatibility

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## **6. Data Requirements**

### **6.1 Data Models**

#### **DM-1: Learner Profile Data**

- Personal information (name, DOB, gender, contact, address)
- Educational qualifications (degrees, marks, institutions)
- Work experience (employers, roles, duration, skills gained)
- Socio-economic data (family background, income bracket, category)
- Preferences (learning mode, pace, language, location)
- Career aspirations (target roles, industries, salary expectations)
- Assessment scores and skill ratings
- Learning history and achievements

#### **DM-2: Qualification and Course Data**

- NSQF level and qualification code
- Course title, description, duration
- Prerequisites and eligibility criteria
- Learning outcomes and competencies
- Assessment methods and certification
- Training provider details
- Cost and funding options
- Enrollment capacity and schedules

#### **DM-3: Labor Market Data**

- Job role titles and descriptions
- Required skills and qualifications
- Industry and sector classification
- Geographic demand distribution
- Salary ranges and growth projections
- Emerging skill trends
- Employment statistics

## **DM-4: Pathway Data**

- Sequence of courses and certifications
- Estimated timeline and milestones
- Stackable credential structure
- Progress tracking metrics
- Success probability scores
- Alternative pathway options

## **6.2 Data Storage**

### **DS-1: Database Requirements**

- Relational database for structured data (PostgreSQL/MySQL)
- NoSQL database for unstructured data (MongoDB)
- Data warehouse for analytics (Redshift/BigQuery)
- Caching layer for performance (Redis/Memcached)

### **DS-2: Data Volume Estimates**

- 10 million learner profiles (approx. 10TB)
- 50,000 qualification/course records (approx. 500GB)
- 1 billion assessment records (approx. 2TB)
- Labor market data and analytics (approx. 5TB)

### **DS-3: Data Retention**

- Active learner data: Indefinite (with consent)
- Inactive learner data: 7 years after last activity
- Assessment records: 10 years
- Audit logs: 7 years
- Analytics data: 5 years aggregated, 2 years detailed

## **6.3 Data Security and Privacy**

### **DSP-1: Sensitive Data Identification**

- Personally Identifiable Information (PII)

- Educational credentials and certificates
- Assessment scores and performance data
- Socio-economic information
- Financial information

### **DSP-2: Access Control**

- Row-level security for learner data
- Role-based data access restrictions
- Anonymization for research and analytics
- Consent-based data sharing with third parties

### **DSP-3: Data Anonymization**

- Remove PII from analytics datasets
  - Use pseudonymization for research data
  - Aggregate data for public reporting
  - k-anonymity for statistical disclosure control
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## **7. AI/ML Model Requirements**

### **7.1 Recommendation Algorithm**

#### **ML-1: Learner Profiling Model**

- Input: Learner demographic, educational, and assessment data
- Output: Multi-dimensional learner profile vector
- Technique: Deep learning embeddings, clustering algorithms
- Accuracy Target: 90%+ profile classification accuracy

#### **ML-2: Pathway Generation Model**

- Input: Learner profile, career goals, market data, NSQF qualifications
- Output: Ranked list of personalized pathways with confidence scores
- Technique: Collaborative filtering, content-based recommendation, hybrid approach
- Evaluation Metrics: Precision@k, Recall@k, NDCG, learner satisfaction score
- Target: 85%+ learner acceptance rate for top-3 recommendations

### **ML-3: Career Aspiration Matching**

- Input: Learner interests, aptitude scores, career descriptions
- Output: Matched career options with fit scores
- Technique: Natural language processing, semantic similarity, classification
- Accuracy Target: 80%+ match satisfaction

### **ML-4: Adaptive Learning Model**

- Input: Learner progress, performance, engagement metrics
- Output: Adjusted difficulty, pace, and content recommendations
- Technique: Reinforcement learning, Bayesian knowledge tracing
- Target: 20%+ improvement in course completion rates

## **7.2 Predictive Analytics**

### **PA-1: Demand Forecasting Model**

- Input: Historical labor market data, economic indicators, technology trends
- Output: Predicted skill demand by sector and region
- Technique: Time series forecasting (ARIMA, LSTM), regression analysis
- Accuracy Target: 75%+ forecast accuracy for 1-year horizon

### **PA-2: Success Prediction Model**

- Input: Learner profile, pathway characteristics, historical outcomes
- Output: Probability of pathway completion and employment
- Technique: Gradient boosting, random forests, neural networks
- Evaluation: AUC-ROC > 0.80, F1-score > 0.75

### **PA-3: Dropout Risk Identification**

- Input: Engagement metrics, progress patterns, external factors
- Output: Risk score for learner dropout
- Technique: Logistic regression, survival analysis
- Target: Identify 80%+ of at-risk learners for intervention

## **7.3 Natural Language Processing**

### **NLP-1: Multilingual Content Processing**

- Support for understanding queries in 12+ Indian languages
- Translation of course descriptions and recommendations
- Sentiment analysis of learner feedback
- Chatbot for learner assistance

### **NLP-2: Skill Extraction**

- Extract skills from job descriptions and course content
- Map skills to NSQF competencies
- Identify skill synonyms and related concepts

## **7.4 Model Training and Maintenance**

### **MM-1: Training Data Requirements**

- Historical learner pathways and outcomes (minimum 100,000 records)
- Labor market data spanning 5+ years
- NCVET qualification database
- User feedback and satisfaction scores

### **MM-2: Model Update Frequency**

- Recommendation models: Monthly retraining
- Predictive models: Quarterly updates
- Labor market models: Weekly data refresh
- A/B testing for model improvements

### **MM-3: Model Monitoring**

- Real-time performance tracking
  - Drift detection for data and model quality
  - Bias and fairness audits
  - Explainability and interpretability tools
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## 8. System Architecture

### 8.1 Architecture Overview

- **Pattern:** Microservices architecture with API gateway
- **Deployment:** Cloud-native containerized deployment
- **Scalability:** Horizontal scaling with auto-scaling policies
- **High Availability:** Multi-region deployment with failover

### 8.2 Key Components

#### Component 1: API Gateway

- Request routing and load balancing
- Authentication and authorization
- Rate limiting and throttling
- API versioning

#### Component 2: User Service

- User registration and authentication
- Profile management
- Access control and permissions

#### Component 3: Recommendation Engine

- AI/ML model serving
- Pathway generation logic
- Real-time personalization
- A/B testing framework

#### Component 4: Data Integration Service

- NCVET system integration
- Training provider APIs
- Labor market data ingestion
- Third-party integrations

#### Component 5: Analytics Service

- Data processing and aggregation
- Report generation
- Predictive analytics
- Dashboard metrics

### **Component 6: Notification Service**

- SMS, email, and push notifications
- Scheduled reminders
- Event-driven alerts

### **Component 7: Content Management**

- Course catalog management
- Qualification database
- Multimedia content storage

## **8.3 Technology Stack (Recommended)**

### **Frontend:**

- React.js or Vue.js for web interface
- React Native or Flutter for mobile apps
- Bootstrap or Material-UI for UI components

### **Backend:**

- Python (Django/Flask) or Node.js (Express) for API services
- Java/Spring Boot for enterprise integrations
- GraphQL for flexible data queries

### **AI/ML:**

- Python (TensorFlow, PyTorch, Scikit-learn)
- MLflow for model management
- Apache Spark for large-scale data processing

### **Database:**

- PostgreSQL for relational data
- MongoDB for document storage
- Redis for caching
- Elasticsearch for search functionality

## **Cloud & DevOps:**

- Kubernetes for container orchestration
  - Docker for containerization
  - Jenkins/GitLab CI for CI/CD
  - Terraform for infrastructure as code
  - Prometheus and Grafana for monitoring
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## **9. Testing Requirements**

### **9.1 Functional Testing**

- Unit testing for all components (80%+ code coverage)
- Integration testing for API endpoints
- End-to-end testing for critical user journeys
- User acceptance testing with representative learner groups

### **9.2 Performance Testing**

- Load testing (100,000 concurrent users)
- Stress testing (system breaking point)
- Spike testing (sudden traffic sur