

# Ph.D. Research Proposal

## Title

### **Intelligent Tutoring System for Mobile Platforms Using Reinforcement Learning-Based Adaptive Learning Paths**

## Introduction

The field of education is rapidly evolving with the integration of Artificial Intelligence (AI), especially in personalized and adaptive learning systems. Traditional e-learning platforms often provide static content, failing to accommodate individual differences in learning pace, background knowledge, and cognitive ability. This proposal presents the development of an **Intelligent Tutoring System (ITS)** tailored for **mobile platforms**, which utilizes **Reinforcement Learning (RL)** to dynamically adapt educational content in real-time, optimizing the learning path for each student based on performance, behavior, and engagement. With the increasing penetration of smartphones and mobile internet, mobile-based learning solutions provide an ideal medium for scalable, accessible, and individualized education. The proposed system aims to fill the gap between static content delivery and personalized learning by incorporating advanced machine learning techniques, particularly **RL algorithms such as Deep Q-Network (DQN) or Proximal Policy Optimization (PPO)**.

## Objectives

The primary objective of this research is to design and implement a **mobile-based ITS** that utilizes **RL-based adaptive learning paths** to enhance student engagement, retention, and academic performance.

### Sub-objectives:

1. To develop a student model that profiles individual learners using real-time interaction data.
2. To apply reinforcement learning algorithms to dynamically adjust the learning content and sequence.
3. To track and analyse student behaviour for continuous improvement of the adaptive learning strategy.
4. To evaluate the effectiveness of the proposed system through quantitative and qualitative metrics.
5. To design an intuitive mobile interface that ensures high user engagement and ease of use.

## Problem Statement

Conventional mobile learning systems are limited in personalization and adaptability. They do not adequately cater to individual learners' strengths, weaknesses, and pace, resulting in suboptimal learning outcomes. There is a need for an intelligent system that:

- Continuously learns from user behaviour,
- Dynamically adjusts the content,
- Operates efficiently on mobile platforms.

## Methodology

### System Architecture Overview

- **Frontend:** A mobile app (Android/iOS) with a clean UI to facilitate user interaction.
- **Backend:** A cloud-based server with a database and AI engine for analytics and adaptation.
- **AI Engine:** Reinforcement Learning models that dynamically select content based on user state.

### Step-by-Step Functional Flow

1. **Authentication & Profile Setup**
  - User logs in (Google/Facebook/Email).
  - Profile is created or loaded from cloud storage.
2. **Initial Assessment**
  - Baseline knowledge assessment for new users.
  - Previous history loaded for returning users.
3. **RL-Based Learning Path Generation**
  - State space: Learner profile (knowledge level, engagement, accuracy).
  - Action space: Available learning modules.
  - Reward: Improvement in accuracy, engagement, completion time.
4. **Content Delivery & Interaction**
  - Lessons, quizzes, and interactive modules presented.
  - Performance and engagement tracked in real-time.
5. **Feedback and Adaptation**
  - Immediate feedback is given post interaction.
  - RL model updates policy based on reward and transitions.
6. **Recommendation System**
  - Personalized suggestions based on performance and behavior.
  - Notifications to guide and motivate learners.
7. **Evaluation**
  - Continuous analysis of learning outcomes and algorithm performance.
  - User satisfaction and system usability assessments.

### Algorithms & Technical Stack

- **Algorithms:**
  - Deep Q-Network (DQN)
  - Proximal Policy Optimization (PPO)
  - Bandit Algorithms for exploration-exploitation balance
- **Technologies:**
  - **Mobile:** Flutter/React Native
  - **Backend:** Python (FastAPI), Firebase/Node.js
  - **Database:** MongoDB or Firebase Realtime DB
  - **AI/ML:** TensorFlow, PyTorch
  - **Analytics:** Google Analytics, Mixpanel

## Expected Outcomes

- A fully functional mobile ITS app with adaptive learning capabilities.
- Enhanced learning outcomes due to personalized content delivery.
- A robust RL framework capable of real-time decision-making.
- A scalable model for broader educational deployment.

## Evaluation Plan

- **Quantitative Evaluation:**
  - Learning gains (pre-test vs post-test)
  - Engagement metrics (session duration, frequency)
  - Retention and completion rates
- **Qualitative Evaluation:**
  - User feedback surveys
  - Usability testing (SUS score)
  - Educator feedback on learning path quality

## Conclusion

This research aims to revolutionize mobile learning by introducing a **Reinforcement Learning-powered Intelligent Tutoring System** that adapts in real-time to individual learners' needs. By continuously monitoring and responding to student behavior, this system has the potential to bridge learning gaps, increase engagement, and personalize education on a truly scalable platform.