Adaptive General Knowledge Quiz System

Revolutionizing education through personalized learning experiences powered by AI and machine learning.

Introduction to Adaptive Learning

Adaptive learning systems use AI and machine learning to personalize education, dynamically adjusting content based on real-time learner performance and preferences. This approach addresses the limitations of traditional one-size-fits-all models.

Learner Model

Captures knowledge, preferences, and performance history.

Domain Model

Structured knowledge base of subject matter.

Pedagogical Model

Governs teaching strategies and adaptive algorithms.

AI in Education & System Overview

AI, including machine learning and NLP, enables intelligent tutoring systems to provide personalized instruction at scale. Our system integrates multiple AI models via OpenRouter API for robust question generation.

Key AI Integrations

- Proximal Policy Optimization (PPO) agent for difficulty adjustment.
- Advanced language models for question generation.
- Comprehensive history to prevent repetition.

Challenges in Traditional Learning

Traditional systems are static, offering uniform content and delayed feedback, hindering personalized learning and scalability.

1

Static Content

Same questions for all, leading to disengagement.

2

Delayed Feedback

Missed opportunities for immediate correction.

3

Lack of Scalability

Limited individualized attention for large groups.

4

Assessment Authenticity

Fails to capture full knowledge spectrum.

Project Objectives

Our system aims to overcome traditional limitations by developing an adaptive, AI-powered quiz platform.

Adaptive Algorithm

Real-time difficulty adjustment using reinforcement learning.

Question Generation

High-quality, diverse questions across topics.

Intuitive UI

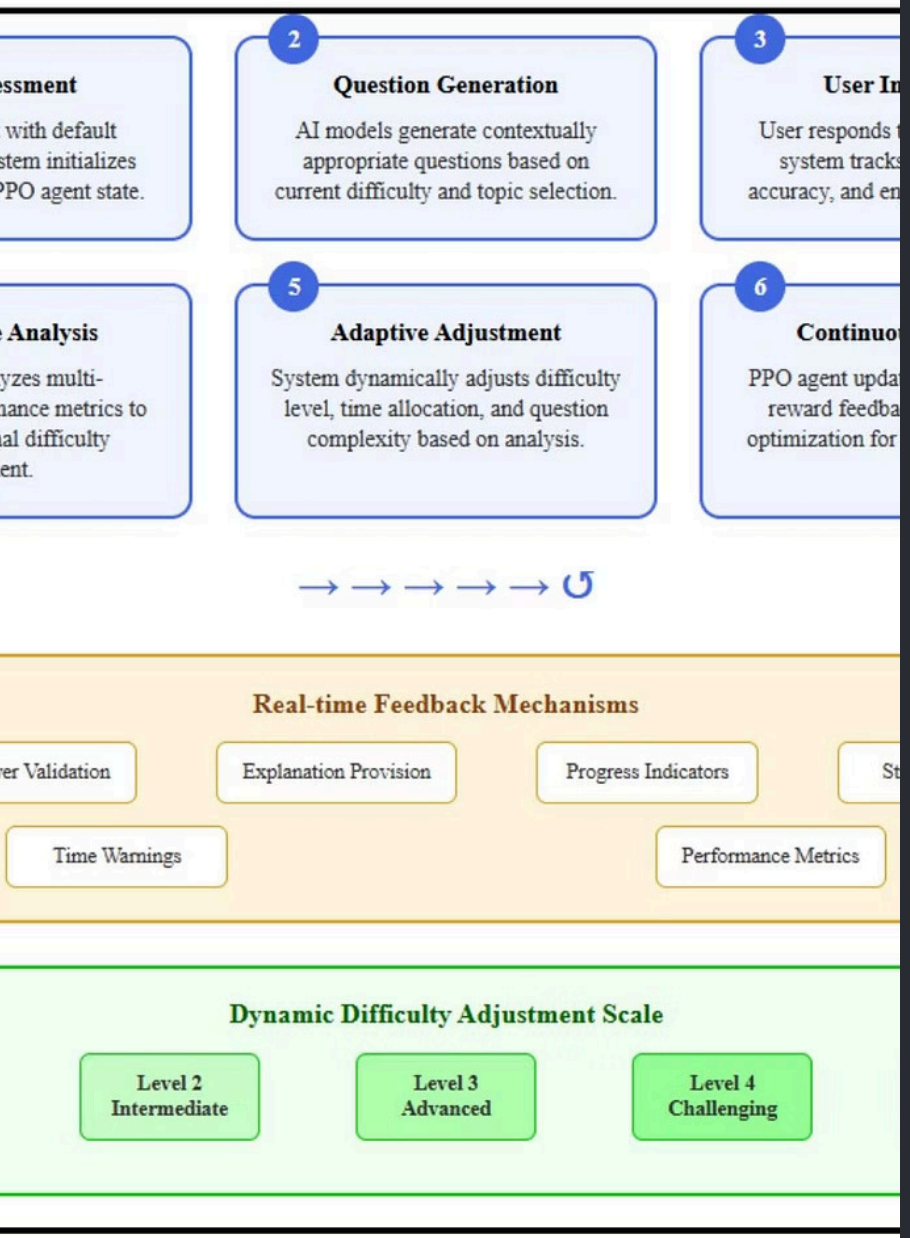
Engaging interface with clear feedback and progress visualization.

Data Analytics

Insights into learning patterns and progress trends.

Robust Architecture

Scalable, reliable, and maintainable system.



System Architecture

The system uses a full-stack web application with React/TypeScript frontend and Supabase backend, integrating AI models via OpenRouter API.

The PPO agent continuously analyzes user performance to optimize the learning experience.

Experimental Results

A 30-question simulation with a "true skill" 3.5 user demonstrated the system's adaptive capabilities.

Overall User Performance

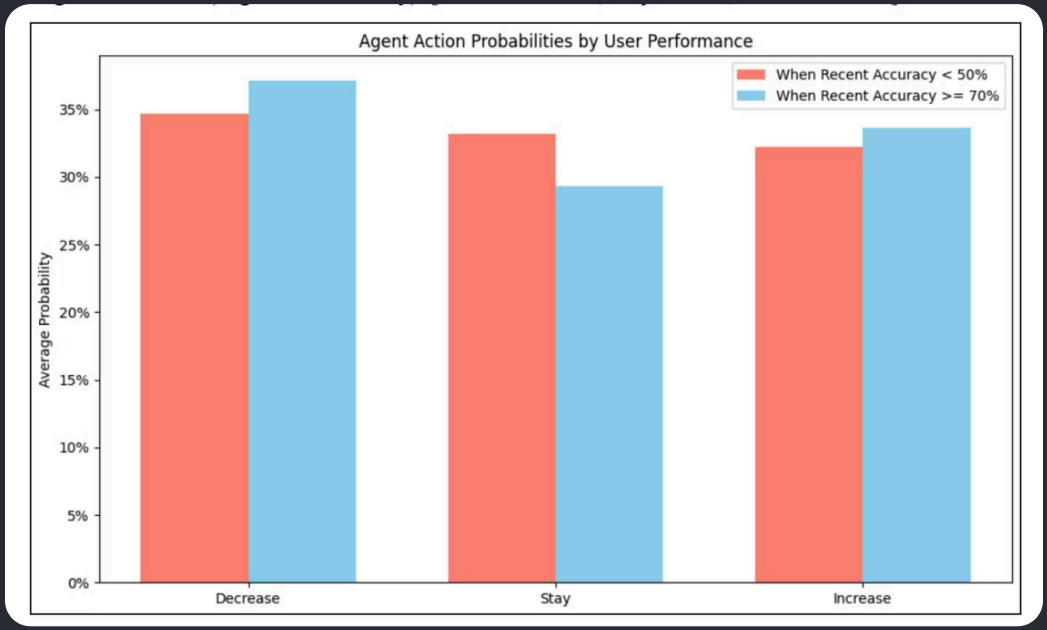
Total Questions	30
Correct Answers	19
Overall Accuracy	63.3%

Adaptive System Dynamics

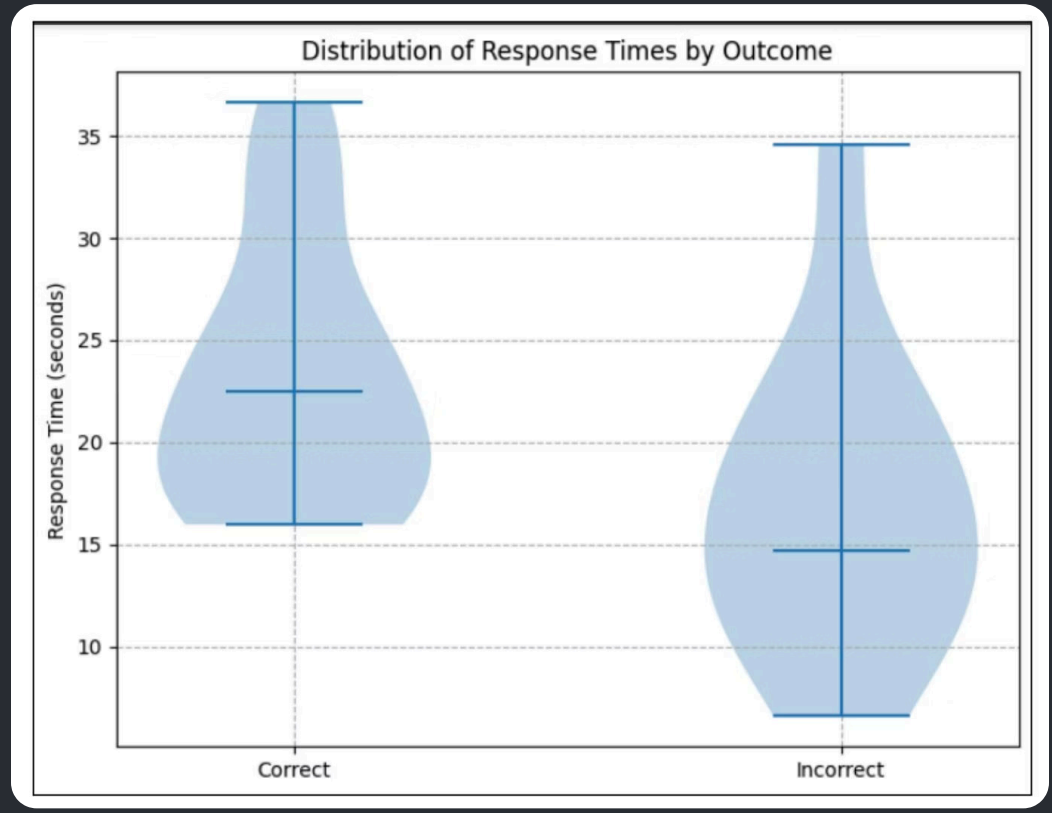
Initial Difficulty	2.00
Final Difficulty	4.20
Avg. Reward	0.770

Analysis of Results

The system successfully adapted difficulty, converging to the user's skill level. However, the PPO policy's decision-making was suboptimal, relying heavily on heuristic rules.



Agent's action probabilities were nearly random, indicating underdeveloped policy.



Incorrect answers were faster (16.99s) than correct ones (23.14s), suggesting rushing or guessing.

Key Findings & Implications

The system demonstrates successful macro-level adaptation and high stability, validating the architectural concept. The hybrid heuristic-RL model provides robustness despite the PPO's current limitations.

Macro-Level Adaptation

System successfully adjusted difficulty to user performance.

Hybrid Model Robustness

Heuristics ensure sensible behavior even with underdeveloped AI policy.

High Stability

Smooth, gradual difficulty adjustments for positive UX.

Diagnostic Tool

Reveals user behavior patterns beyond simple scores.

Conclusion & Future Work

The PPO-based hybrid system effectively personalizes learning, though the PPO agent needs further tuning. Future work includes hyperparameter tuning, state representation refinement, and live A/B testing.

1

Agent Enhancement

Tune PPO hyperparameters and refine state representation.

2

UX Expansion

Add Explainable AI, multi-topic adaptation, and adaptive feedback.

3

Evaluation & Deployment

Conduct live A/B testing and longitudinal tracking.