

# Adaptive Learning Revolution with AI-Driven Personalization and Gamified Real-Time Interaction

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**Abstract** - As cutting-edge technologies like artificial intelligence, machine learning, cloud computing, OpenAI, LLM, generative AI, augmented reality (AR), virtual reality (VR), mixed reality (MR), extended reality (XR), and big data become more prevalent, it is helpful from an educational point of view to analyze the AI-enabled Adaptive Learning Platform with Gamified Personalized System and Real-Time Recommendations. This will allow learners to take full advantage of these new technologies. The literature review and their research on the Adaptive Learning Model are conducted from this point of view. This study assesses the potential of cutting-edge technologies for adaptive learning platforms, addressing the proliferation of personalized with recommendations & gamified educational approaches. Since 2012, numerous studies have been conducted to this extent. Also, the perspective of current going on studies is crucial to provide advanced and accurate solutions in the realm of education which can transform the complete educational & research field. This paper synthesizes the guide for future research and studies on how to better platforms design AI-Based Adaptive Learning Platform with Dynamic Content Delivery, Real-Time Feedback, Student Engagement, Competency-Based Education, Supervised Association Rules, Dynamic System Models, Open Educational Resources (OERs), Reinforcement Learning, Advanced Analytics & Visualization, Scalability, Low Latency. These advancements highlight the potential for AI and machine learning to strengthen personalized learning & gamification, improve student engagement and optimize educational results.

**Keywords**— Adaptive Learning, Gamification, Personalized Learning, Real-Time Feedback, Reinforcement Learning.

## I. INTRODUCTION

Emerging technologies such as artificial intelligence (AI), machine learning, cloud computing, augmented reality (AR), virtual reality (VR), OpenAI, and large language models have transformed conventional learning models and created new opportunities for personalized learning. To improve educational experiences, create an AI-powered adaptive learning system that incorporates gamification, personalization, and real-time feedback. Current adaptive learning systems have several problems, including a one-size-fits-all approach, a lack of real-time feedback mechanisms, inconsistent application of gamified elements, difficulties with scalability and responsiveness, limited content adaptation, and the crucial but challenging task of maintaining strong data privacy and security [1]. With a one-size-fits-all approach, traditional educational systems have limits that these technologies help address. In today's context

it is now possible for personalized learning environments to optimize learning paths, offer content dynamically, and give real-time feedback [2][3]. The necessity for flexible systems that can meet the varied demands of students has been highlighted by the COVID-19 epidemic, which has sped up the transition to online and hybrid learning [4], [5]. Real-time feedback, gamified elements, and dynamic content alterations are frequently not fully integrated into current adaptive learning systems [4]. The potential of AI and machine learning to transform education is nevertheless constrained by issues like scalability, real-time responsiveness, and the capacity to adapt information to the needs of a wide range of learners[6]. In order to improve student engagement, achievement, and the learning process overall, this project intends to create an AI-powered adaptive learning system that offers personalized, gamified, and real-time learning experiences. In-memory architecture design and development, gamification to increase engagement, scalability and efficiency for large-scale deployment, integrating generative AI for personalized content creation, and incorporating real-time feedback mechanisms are among the goals [7], [8]. The study also looks at how machine learning and data analytics can be used to provide competency-based, individualized instruction while maintaining scalability and low latency [9]. By combining gamification, real-time recommendations, and AI-driven adaptive learning systems, the project seeks to improve student engagement, achievement, and retention [10]. To enable students to advance at their own pace and acquire the skills they need, a framework for gamified learning, dynamic content distribution, and real-time recommendations will be created. Additionally, the research investigates the importance of integrating Open Educational Resources (OERs), scalability, and low-latency performance [7].

Through personalized, dynamic, and gamified experiences, the study demonstrates how AI-powered adaptive learning platforms have the potential to completely transform education. It offers guidance for future developments in adaptive learning systems and offers insights into developing scalable, efficient learning environments that meet the demands of diverse learners. This research attempts to create a more efficient and inclusive educational ecosystem by providing an evidence-based framework for creating AI- powered adaptive learning platforms [8].

## II. RELATED WORK

The swift expansion of e-learning platforms has made it necessary to create scalable, adaptive, and personalized systems that can meet the various needs of students. This field has evolved significantly in recent years, as seen by studies that combine artificial intelligence, machine learning, and big data to create more engaging and dynamic learning environments. Research shows how big data, and deep learning can be used to create tailored suggestions in MOOC systems, improving learner outcomes and engagement [4]. Furthermore, it has been demonstrated that dynamic game mechanisms in adaptive gamification increase student engagement [11]. The significance of adaptive learning systems is further supported by studies that highlight the beneficial effects of personalized adaptive learning on academic achievement and engagement [12]. These results highlight how important new technologies are to convert e-learning into a more effective, interactive, and customized teaching approach. To overcome the drawbacks of conventional e-learning systems and eventually improve student outcomes, AI-driven platforms must be integrated with immersive technologies, dynamic material delivery, and real-time feedback

### A. Integration of AI and Machine Learning

Modern adaptive learning systems rely significantly on AI and machine learning. A lot of research is being done on the combination of dynamic content delivery through algorithms, reinforcement learning, and personalized learning [7], [13]. These technologies enable systems to provide real-time feedback and tailored material recommendations by adjusting to the demands and learning preferences of each individual learner.

### B. Student Engagement and Gamification

One important tactic to boost engagement is gamified learning, especially in adaptive learning settings. Research like [11], [14] examine how adaptive gamification can boost student motivation and performance. Platforms encourage increased student involvement as they get more entertaining and interactive.

### C. AR and VR Immersion Technologies

The use of immersive technologies (including AR, VR, MR and XR) is changing how students engage with course materials. For instance, immersive e-learning systems can produce captivating and interactive experiences that greatly enhance learning outcomes, as demonstrated by [15], [16].

### D. Feedback in real time and scalability

Two of the most important issues facing adaptive learning systems are scalability and low latency. In addition to efficiently delivering individualized content, systems must be able to manage high consumption. The goal of studies like [17], [18] is to make sure that adaptive systems can grow without sacrificing the Caliber of real-time input

Future studies will probably concentrate on improving AI-driven systems to increase their predictive power, context awareness, and ability to provide more detailed levels of customization. Big data and advanced analytics will also be

used more frequently, providing more individualized and accurate learning opportunities

## III. METHODOLOGY RESEARCH

The process of data collection and literature carried out by using a range of resources, including IEEE Xplore, ScienceDirect, ResearchGate, ACM libraries, Google Scholar, and some non-scholarly resources to identify relevant information that needs to be obtained from publications. In the survey several terms related to literature analysis, such as Learner Modelling, Machine Learning Techniques, Learner's Learning Styles, Systematic analysis, and Web-based Learning, to guarantee thorough coverage is used. During the introduction & literature review part, it already stated that the proposed work is defining the existing problem and providing the solution as the anticipated result is an AI-powered platform that offers interactive experiences, real-time feedback, and individualized learning pathways, enhancing student achievement, closing educational gaps, and encouraging the use of AI in the classroom.

### A. Proposed Model

Several crucial steps are involved in the adaptive learning system such as frontend constructed Bootstrap, HTML/CSS, and JavaScript for responsiveness and interaction, while the backend is developed with Python and Django. While reinforcement learning algorithms adjust learning paths in real-time, OpenAI's GPT models create personalized learning content based on user performance and preferences. The diagram below shows the complete flow of work methodology in two parts, figure 1, 2 & 3 since during study we clearly found that how Requirement Analysis, System Design, AI Integration, Development, Training the Models, Testing & Integration, Deployment, Maintenance & Updates takes place to provide the desired frontend, backend and visualization part of the Adaptive Learning Revolution with AI-Driven Personalization and Gamified Real-Time Engagement.

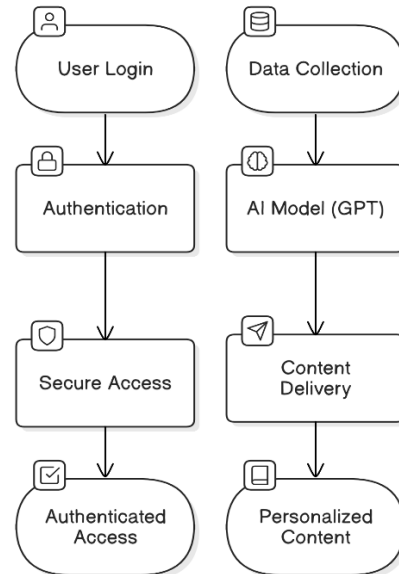


Fig. 1: Methodological Prospect.

In Fig. 1 depicts the overall technique, which begins with user login and continues with authentication to ensure secure

access. Parallely, data collection begins, followed by AI Model (GPT) processing and content delivery. Finally, users receive Authenticated Access and Personalized Content, demonstrating the integration of AI models with safe access mechanisms.

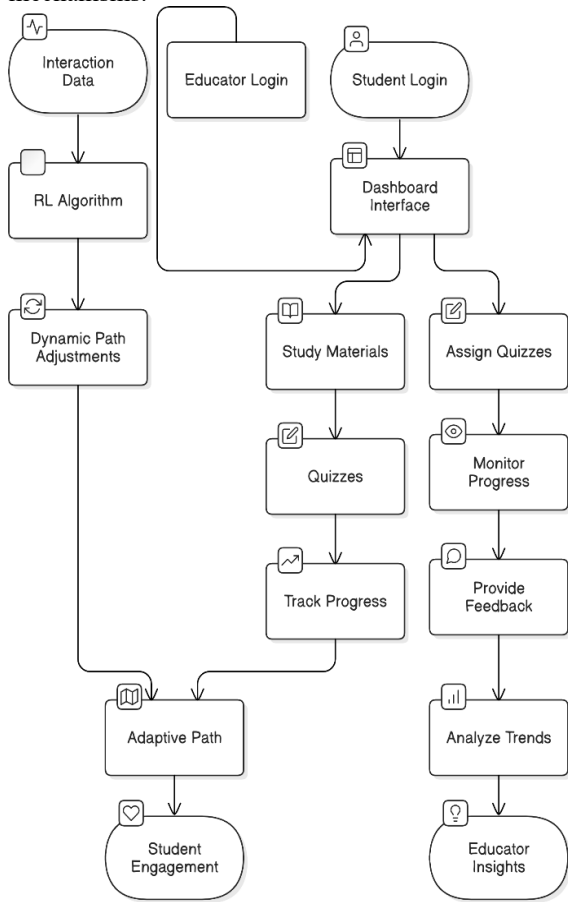


Fig. 2: AI-Driven Adaptive Learning Model

In Fig. 2 students are organized into groups based on common needs, allowing for more tailored learning paths. The system's in-memory architecture provides great performance and scalability, which are critical for real-time feedback and dynamic content delivery. Secure API connectivity, SSL/TLS encryption, and Django authentication ensure solid security. Using advanced analytics and data visualization technologies, educators obtain information about student performance, allowing them to make wiser decisions. The combination of AI and machine learning enables dynamic, engaging learning experiences while protecting data privacy and system efficiency. The graphic depicts the workflow, which includes student authentication, clustering based on shared needs, in-memory processing, secure data handling, personalized content delivery, real-time feedback, and interactive learning. This creates a dynamic, educator-friendly platform that improves student engagement and achievement.

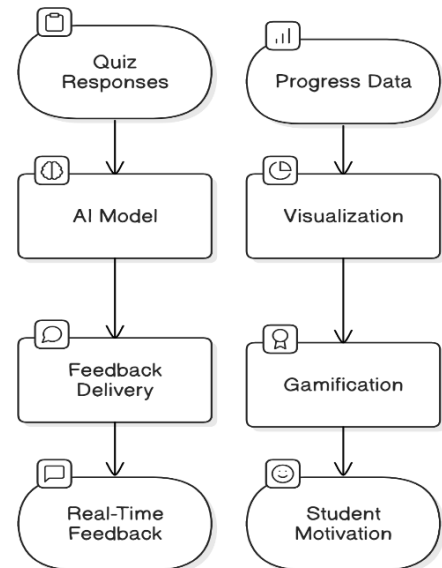


Fig. 3: Visualization and Gamified Interaction Models

In Fig. 3 visualization section presents progress data, improving the visual appeal of gamification aspects and increasing student motivation and engagement. The AI model analyses quiz responses and progress data to give individualized learning experiences and real-time feedback.

### B. Reinforcement Learning's (RL) Function in Adaptive Learning System

Reinforcement Learning (RL) is an important component of adaptive learning systems since it dynamically adjusts learning paths based on individual performance and engagement measures. The RL algorithm uses real-time feedback to continuously optimize educational content delivery to each learner's specific needs. Key steps include user authentication, clustering, real-time content delivery, and feedback mechanisms, all of which contribute to a personalized and engaging learning experience. While RL techniques like as Q-Learning and DQN are widely used, the algorithm specially created for this proposed model is described below:

Here, RL-inspired Adaptive Learning Model Optimizer (ALMO) algorithm demonstrates how Reinforcement Learning adapts learning experiences according on performance data and real-time student interactions.

**Step I:** Initialize Model Argument (Learning\_Rate  $\alpha$ , Discount\_Factor  $\Gamma$ , Exploration\_Rate  $\epsilon$ ).

**Step II:** Loop - Student Interaction.

- i. Monitor the student's actions (quiz response, time spent and engagement).
- ii. Update the student performance matrix.
- iii. Determine the initial reward depending on performance and interaction:
  - A positive incentive for right answers, fast completion, and high engagement.
  - Negative reinforcement for inaccurate responses, delays, and low engagement.
- iv. Update Q-values with the following formula:  $Q(S, A) \leftarrow Q(S, A) + \alpha [r + \Gamma \max_{A'} Q(S', A') - Q(S, A)]$

Where,  $Q(S, A)$  represents the Q-value for the current state (S)-action (A) pair,  $r$  represents the reward and  $S'$  is the next state

- v. Adapt the learning path depending on updated Q-values:
  - Choose material that maximizes potential rewards.
  - Adjust the assignment, timing, and resources accordingly.
- f. Keep track of real-time feedback and adjust model parameters accordingly.

### Step III. STOP.

**Step IV:** Use visual progress statistics and real-time feedback to increase student motivation and engagement.

**Step V:** Return to Step 2 for continuous improvement.

## Significant to Key Findings:

**Personalization:** By grouping students based on similar needs and dynamically changing learning paths, Adaptive Learning Model Optimizer (ALMO) tailors' material to individual learners, increasing student engagement and performance.

**Scalability and Real-Time Feedback:** The in- memory design and safe data handling enable excellent performance and scalability while also providing real-time feedback, which is crucial for adaptive learning.

**Student Motivation and Gamification:** Integrating gamification features with AI-powered feedback systems keeps students motivated and engaged, resulting in higher learning results.

**Educator Insights:** Advanced analytics and data visualization technologies let educators gain practical insights into student progress and system effectiveness.

The Adaptive Learning Model Optimizer (ALMO) algorithm is useful in AI-Driven adaptive learning platforms, seamlessly merging personalization, real- time feedback, and dynamic content delivery to improve educational experience

## IV. DISCUSSION

Prior to diving into the suggested model analysis, the discussion above outlines the need for gamified suggestions in personalized adaptive systems as well as the integration of MOOCs and Open Educational Resources (OERs). The proposed work and analysis presented above demonstrate the transformative potential of adaptive learning systems in education. These systems use AI to provide tailored learning paths, real-time feedback, and gamified aspects, all of which dramatically improve student engagement and learning outcomes.

### A. Personalized and AI-driven adaptive learning systems

The ALS heavily rely on reinforcement learning (RL) models and clustering algorithms to customize instructional content. Students are grouped according to shared needs, such as learning styles and performance data, allowing for personalized learning routes. The RL algorithm continuously optimizes these courses based on real-time feedback, ensuring that the educational experience is dynamic and tailored to individual needs. This approach has been proven in several studies, all of which emphasize the wide application of AI approaches in adaptive learning systems.

#### 1) Personalized Learning and Involvement:

By using clustering algorithms and Reinforcement Learning (RL) models, the adaptive learning system under discussion greatly improves the personalization of educational materials. The system provides information that is suited to a variety of learning styles and performance indicators by grouping students according to common needs and dynamically modifying learning pathways. By giving real-time input, the RL algorithms continuously improve these pathways, producing more efficient and interesting learning opportunities.

#### 2) Clustering approaches:

To ensure that students receive tailored content that meets their individual needs, the system groups students with similar learning styles and needs using clustering approaches. By ensuring that every student's learning experience is customized to meet their unique needs, this method raises student engagement and improves academic results [19].

#### 3) Real-Time Feedback:

A crucial element of personalized learning is real-time feedback. The system helps students comprehend their faults and learn effectively by instantaneously assessing performance data and offering prompt corrective measures. This customized feedback loop guarantees ongoing development and supports students' motivation for progress [7], [13].

### B. Scalability and Real-Time Interaction

The platform's in-memory architecture, which offers fast data access and great performance, is essential for managing large-scale installations. The system's scalability guarantees that it can support a sizable user base at once without sacrificing functionality. Students can learn more effectively and quickly with the support of real-time feedback mechanisms, which provide prompt remedial activities. SSL/TLS encryption, Django authentication, and secure API connectivity all support the system's resilience and security while preserving data privacy and system integrity [17].

#### 1) High Performance and Scalability:

Even with a huge user base, the platform's in-memory architecture guarantees that learning resources are supplied quickly and effectively. Maintaining system performance and providing real-time feedback to a large user base depend on its scalability [14].

## 2) *Data Security:*

The system's strong security features, such as SSL/TLS encryption, Django authentication, and secure API connectivity, guarantee that user data is safeguarded and privacy is upheld. These characteristics are essential for maintaining the integrity of the adaptive learning platform and fostering trust

## C. *Integration of Generative AI*

Personalized quizzes and study materials that are catered to the individual learning requirements of every student are made possible by generative AI, which is fueled by OpenAI's GPT models. The AI creates challenging and pertinent content by evaluating user performance and interaction, which keeps students engaged with learning. The platform's ability to deliver a steady flow of new and tailored information is ensured by this incorporation of generative AI, which improves the educational process as a whole [7], [16], [20].

### 1) *AI-Driven Personalization:*

By leveraging OpenAI's GPT models, dynamic and customized learning materials, such as study guides and quizzes, can be produced. The platform may continuously update and show pertinent material based on student performance and preferences by utilizing generative AI.

### 2) *Content Relevance:*

Personalized content guarantees that educational resources stay interesting and demanding, resulting in a better learning environment. Effective learning is encouraged and student engagement is sustained through ongoing adaption based on real-time data [21].

## D. *Gamification and Enhanced Motivation*

Integrating gamified features into the adaptive learning platform increases the motivation and engagement of learners. Learning becomes joyful and satisfying when progress visualization and interactive feedback are used to foster a sense of accomplishment. Gamification allows students to monitor their progress and create customized objectives, which enhances retention and cultivates a love of learning. The effectiveness of gamification in establishing attractive learning environments has been demonstrated by research [9], [11].

1) *Engagement through Gamification:* By offering measurable objectives and incentives, the platform's gamified features—such as challenges, leaderboards, and badges—increase student motivation. These impacts are further amplified by visualization tools like dashboards and progress charts, which highlight accomplishments and promote ongoing participation.

2) *Positive Learning Environment:* Gamification turns the educational process into an engaging and entertaining experience that encourages a proactive attitude toward learning and a sense of accomplishment. It has been demonstrated that this strategy improves overall experience and student retention.

## E. *Educator insights and advanced analytics*

Educators can gain helpful insights about student performance using sophisticated analytics tools and data visualization strategies. Educators can adjust their teaching methods to suit students' needs by monitoring progress and pinpointing areas for development. In order to improve the educational process, educators can make well-informed judgments by using comparative analytics and heatmaps to analyze learning patterns in depth [20], [22].

1) *Analytics and Visualization:* The platform uses comparative analytics and heatmaps to visualize performance data, as well as advanced analytics to monitor student growth. These resources assist educators in seeing patterns, comprehending student conduct, and modifying their pedagogical approaches accordingly.

2) *Actionable Insights:* The platform enables educators the ability to make data-driven decisions by offering comprehensive progress reports and performance metrics. This guarantees that teaching methods are continuously improved to improve the learning outcomes of students

## F. *System Security and Performance*

The platform's in-memory architecture's high performance and low latency guarantee the timely and effective delivery of educational materials. For large-scale deployment, this scalability is crucial since it keeps the system operating effectively even when there are a lot of users. User data is safeguarded, preserving privacy and system integrity thanks to Django authentication, SSL/TLS encryption, and secure API connectivity [17].

1) *In-Memory Architecture:* The platform scales effectively because of its high-performance, in-memory processing, which also offers low latency and seamless data access. Supporting large-scale deployments while preserving quick data processing speeds requires this design.

2) *Security Measures:* User data is protected by the system's sophisticated security features, which include SSL/TLS encryption, secure APIs, and strong authentication procedures. In a digital learning environment, these precautions are crucial for preserving data privacy and safeguarding sensitive information.

## G. *Combining AI with Adaptive Learning Paths*

The system's core algorithm, the Adaptive Learning Model Optimizer (ALMO), uses reinforcement learning to generate adaptive learning patterns. Each student is guaranteed a customized learning experience based on their performance and engagement metrics according to the algorithm's constant updating and improvement of these pathways in response to real-time feedback. Numerous studies that emphasize the value of AI in improving educational results have backed this adaptive strategy [12].

1) *ALMO Algorithm:* Based on ongoing feedback, the ALMO algorithm dynamically modifies learning routes by applying reinforcement learning techniques. By ensuring that every learner's experience is specifically catered to their needs, this adaptive strategy greatly improves performance and engagement.

2) *Strengths of Adaptive Learning*: The platform guarantees that students obtain the most pertinent and efficient instructional materials by constantly improving and customizing learning pathways. Higher levels of student satisfaction and improved learning outcomes are fostered by this dynamic adjustment

System integrity in adaptive learning systems depends on data confidentiality and privacy. Regular monitoring is essential. By improving scalability, including cutting-edge AI models, and extending capacities to suit different learning styles, future research must improve algorithms like ALMO and address a range of educational demands. This platform, which uses AI-driven solutions to revolutionize education, promises gamification, real-time feedback, and personalized learning.

## V. CONCLUSION

This paper highlights the revolutionary possibilities of an AI-driven adaptive learning system. To provide real-time feedback, personalize learning paths, and add gamified elements—all of which greatly improve student engagement and learning outcomes—the system makes use of Reinforcement Learning (RL) models, clustering algorithms, and Generative AI. The platform's strong frontend and backend enable it to dynamically modify material according to user preferences and performance, guaranteeing a customized learning environment. By grouping learners with comparable needs, clustering approaches offer personalized educational paths. The in-memory design facilitates scalability and real-time communication through providing fast data access and high performance. Data security and privacy are preserved by Django authentication, SSL/TLS encryption, and secure API connectivity. Generative AI creates study guides and customized tests, enhancing the relevance and interest of the content. Leaderboards and badges are examples of gamified elements that increase motivation and retention. Educators can customize their teaching methods with the help of actionable insights from advanced analytics

This adaptive learning platform highlights the revolutionary influence of AI-driven personalization and real-time engagement in education while addressing the shortcomings of traditional education and providing a dynamic and captivating learning environment

## ACKNOWLEDGMENT

I would like to express my heartfelt gratitude to my project guide, Dr. Sessaiah Merikapudi, for his invaluable support, insightful guidance, and constructive feedback throughout the research process, including reviews, recommendations, and continuous encouragement

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