User Interfaces in Future Generation Learning Management Systems using Explainable AI

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ABSTRACT
With the increasing popularity of online education systems, it has become apparent that existing learning management systems have their shortcomings. The most obvious one is that their user interfaces are not adaptable. Thus, this research article will focus on proposing a new framework for explainable adaptive user interfaces (EAUIs). They will change according to the behavior, cognitive load, and affective states of the learner. Furthermore, they will provide clear explanations for why some features are implemented. These explainable and adaptive user interfaces can significantly improve the learner's engagement with the course content and lead to more efficient learning.

General Terms
Artificial Intelligence, HCI, Adaptive Systems, Machine Learning, Educational Technology, User Interface Design

Keywords
Explainable Artificial Intelligence (XAI), Cognitive Load Optimization, Educational Data Mining, Learning Management Systems (LMS)

1. INTRODUCTION
With the growth in e-learning systems, learning management systems have played a vital role in creating new methods of delivering education and making learning more accessible to anyone. Learning management systems include applications that help organize learning processes, such as Moodle and SWAYAM.

One of the most popular free LMS software options is Moodle, an e-learning platform based on PHP. This application helps educators develop courses, manage users, monitor their progress, as well as integrates plugins. The software also allows incorporating several learning theories into practice; thus, the learning process may be both face-to-face and distance. Yet, although Moodle gives much freedom when developing courses and organizing learning, the application cannot create dynamic interfaces that would fit every learner's needs.

On the other hand, SWAYAM is an open MOOC platform initiated by the government of India. It provides free massive online courses in English or in regional languages created by India's leading academic institutions. Thus, unlike Moodle, SWAYAM does not offer flexibility but aims at giving everyone access to quality learning. Although it makes courses easily available and standardized, the platform has a uniform look due to the lack of customizations.

The advent of advancements in the fields of Artificial Intelligence (AI) and Human-Computer Interaction has facilitated the creation of adaptive systems [1] that can deliver their functionalities in real-time through dynamic adjustment of content and interaction. Nevertheless, many of these systems run as "black box" systems, reducing transparency and thus the ability of users to gain knowledge about them. In order to overcome such shortcomings, a novel framework known as the Explainable Adaptive User Interface (EAUI) is suggested.

2. LITERATURE REVIEW
Previous research has investigated adaptive interfaces that customize learning content based on the learner profile and performance indicators. Such approaches work well for personalization [2] ; however, they depend on predefined rules or complex machine learning algorithms.

Several studies have focused on the design of Adaptive User Interfaces (AUIs), which aim at designing the system interfaces by taking into account the learner profiles, preferences, and performance factors. The content difficulty, interface navigability, and user interface aesthetics are some of the interface aspects that get adjusted for achieving a personalized experience. Despite offering improvements in the effectiveness of the e-learning process, such systems have been constrained due to the use of rigid rule-based systems or complex machine learning models.

On the other hand, SWAYAM MOOC is one of the systems that apply standard user interfaces while distributing content to its vast learners community. Though the SWAYAM platform uses features such as the course recommender and progress tracking systems, it does not dynamically adapt the interface in response to the learner's activity.

2.1 Explainable Artificial Intelligence
Explainable Artificial Intelligence (XAI) seeks to make AI-based decisions understandable by humans. The ability of explainability plays a critical role in educational systems, especially when it comes to recommending appropriate learning pathways and dynamic learning material adaptation.

Explanation-Centric User Interfaces (XUI) is a term that was coined recently, describing explainable interfaces in which explanation itself becomes an intrinsic part of the design of the interface [3]. Systematic literature analysis shows that most of the existing AI systems tend to generate explanations as an additional output, not as an essential element of communication.

This problem can be solved via HERMES framework, as it focuses on a human-centric explanation design that implies a combination of explanation and interaction within the UI. It is not necessary for users to switch to a special tab with the explanation – it can become part of the interaction process itself.

2.2 This AI Integration in LMS Platforms
Recent research on the use of LMS suggests an increasing trend of adoption of AI technologies. Such innovations include

predictive analysis, recommendations, and adaptive tests [4]. All of these features have proven to be effective, leading to better results for learners and system functioning.

However, there are still several important aspects to improve. To begin with, most LMSs do not have any mechanisms for explanation of their adaptation process. Moreover, learners cannot influence the implementation of adjustments, which reduces the level of users' engagement in the process. One more problem that should be considered is the lack of clarity about modifications of UI due to adaptations.

All this suggests the need to improve systems in terms of explaining what they do.

2.3 Research Gap Identified

Based on literature review from 2022 to 2025, there are certain important gaps that need attention. Despite the rising application of adaptive technologies, these technologies often lack proper integration with the UI component, making it difficult for users to interact effectively. In addition, although explainable AI is an advanced approach, its inclusion in interactive technologies, especially LMS interface [5], is very rare.

Moreover, the inclusion of emotional and cognitive elements in adaptation is very low. Finally, users are generally not considered in the decision-making process, which reduces their involvement in the adaptation process.

3. SYSTEM ARCHITECTURE (CASE STUDY ON SWAYAM AND MOODLE-BASED LMS)

The proposed EAUI framework will assist in improving MOOC platforms such as SWAYAM, and LMS ecosystems such as Moodle, which require personalization and emotional awareness, as well as explanations behind decisions, in their operation. SWAYAM is scalable and standardizes its course offerings, whereas Moodle provides greater flexibility in terms of customizing the courses provided. But in both cases, there are deficiencies in terms of providing an interface that is intelligent and can adapt itself according to the needs of learners. The proposed architecture aims to bridge this gap by offering a framework that ensures interface adaptability [6] in real time.

The foundation of the entire system is the User Modeling module, whose job is to gather the relevant data from learners, including their performance statistics, interaction patterns, and learning preferences. For example, SWAYAM contains large amounts of data in the form of video engagement levels, quiz results, and progress in the courses offered, although only for purposes of analysis. Moodle provides the capacity for user monitoring by way of logs and plugin features, although customization still demands some effort on the instructor's part.

Behavior Analysis is performed via click-stream analysis of engagement levels [7], rate of learning, and possible problems. In SWAYAM and Moodle, similar analytics is often used to measure drop-out rates and course effectiveness, yet neither system utilizes such information to automatically customize the user interface based on these findings. The Emotion Detection Module identifies a new state of learner using his or her behavioral features or even multimodal input if required. Although SWAYAM and Moodle lack any affective computing abilities, EAUI can adapt interaction to emotions of users identified via behavioral analysis.

The EAUI Framework utilizes an Emotion Detection Module to recognize states of learners using their behavior patterns. In both SWAYAM and Moodle, no affective computing is applied. Yet using a multimodal input, EAUI can adapt the user interface based on the emotion recognized. For example, if a learner feels frustrated, the system can simplify the content; while during boredom, interactive elements can be added.

Explainability layer makes sure that every adaptive action taken by the system is explained in comprehensible form for the human user. This aspect is especially crucial when it comes to educational software systems since the users are highly likely to demand explanations [8]. At present, neither SWAYAM nor Moodle provides any sort of explanatory support. The implementation of explainability feature allows EAUI to help students understand what caused some changes and what was the reason behind recommendations for more resources.

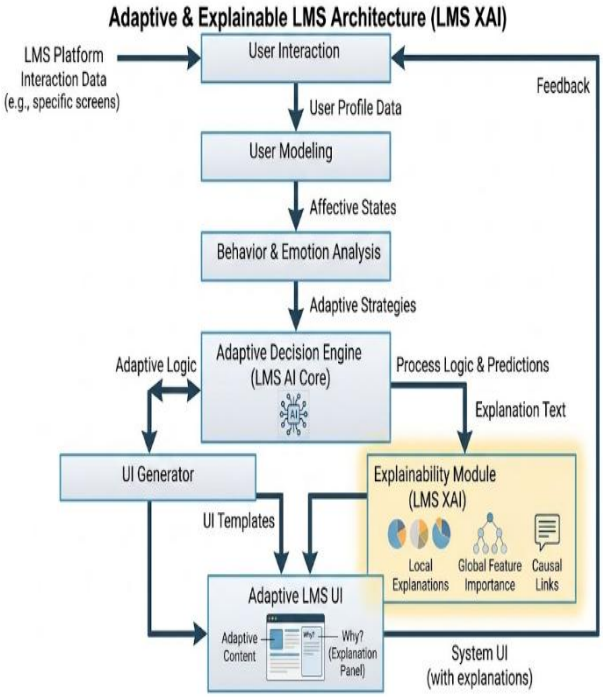

Figure 1: EAUI System Architecture

EAUI combines the best features of the two models by incorporating adaptive user interfaces, emotion aware interactions, and explanation in decision making. Such an approach enables development of an LMS architecture that caters to learners' needs and offers them personalized and engaging experiences.

4. DETAILED ANALYSIS OF THE PROPOSED EAUI MODEL

This suggested EAUI model marks an advancement from the static nature of LMS into one that is intelligent, dynamic, and clear. The performance of this model can be evaluated in different ways depending on functionality, architecture, and implementation aspects, especially concerning learning management systems [9] such as SWAYAM and Moodle.

4.1 Functional Analysis of the Model

The EAUI system works in a closed-loop intelligent manner, wherein user engagement constantly drives the behavior of the system [10].

- Input layer: Receives multimodal data (clickstream data, performance, emotional data if available)
- Processing layer: Converts the raw data into significant learner states
- Decision layer: Chooses the best UI adaptations
- Output layer: Produces adaptive UI with explanations
- Feedback loop: Refines the system through user feedback

This ongoing cycle allows for dynamic changes within the system, unlike fixed LMS interfaces.

4.2 Modules Based on Their Effectiveness

The importance of the module lies in the personalization aspect. The module builds a user profile based on behavioral and performance statistics [11].

Positive Points:

- Personalized learning experience
- Long-term monitoring of learner development

Negative Points:

- Large database required for effective profiling
- May have a cold start problem for new learners

SWAYAM: Available but not fully utilized
Moodle: Available but not dynamic

4.3 Behavior Analytics Engine

The Behavior Analytics Engine discovers patterns such as engagement, drop-out potential, and learning difficulties.

Advantages:

- Detects learner problems in real-time
- Enables predictive analysis

Disadvantages:

- Dependent on selected features
- Can misunderstand learner behavior without proper context

Sample Insight:

- Learners who pause frequently might be struggling - but might just be distracted.

4.4 Emotion Detection Module

Introduces a human-oriented element through inclusion of affective states.

Advantages:

- Increases sensitivity to learner needs
- Promotes motivation and engagement

Drawbacks:

- Privacy and ethical issues
- Need for extra equipment or models

In SWAYAM & Moodle:
Not yet implemented: Huge scope for innovation

4.5 Adaptive UI Generator

This is the key engine of execution for the entire model.
Adaptive interfaces have many strengths. For instance, they can alter the interface on the fly based on users' needs, preferences, or actions to create an experience that suits them. Adaptive interfaces can show only pertinent pieces of data or controls for minimizing the user's mental efforts. Moreover, adaptive user interfaces facilitate diverse learning demands since they can adapt content and other aspects to suit different knowledge bases and learning preferences.

However, adaptive user interfaces are also faced with some challenges. First, excessive adaptation may cause confusion in users since constant changes to the interface could interfere with their familiarity and comfort using the interface. This challenge implies that designers should be thoughtful about the degree of adaptiveness to maximize its positive impacts while minimizing potential downsides. The lesson to be drawn from all these insights is that adaptation should be smooth and meaningful.

4.6 Explainability Layer

Guarantees transparency and builds trust.

Advantages:

- Boosts user confidence in decision-making
- Promotes better user acceptance
- Improves educational accountability

Disadvantages:
Developing clear but precise explanations is difficult
Too much explanation can confuse users
Key Point:
Explainability is not an option; it is a necessity in educational systems.

4.7 System Level Analysis

EAUI framework is platform-independent and can be integrated with:

- MOOC platforms such as SWAYAM
- Institutional LMS such as Moodle

It is an intelligent overlay layer, needing very little re-engineering of existing systems.

4.8 Scalability Analysis

Scalability is a crucial factor in the success of the proposed EAUI approach, based on its capacity to effectively manage huge amounts of data generated from learners and interactions without affecting the efficiency of the process. In this regard, considering the current capabilities of the SWAYAM platform that caters to millions of users, the incorporation of EAUI in the MOOC platform [12] will not only benefit from its distributed environment but also introduce intelligent adaptive components. The application of cloud computing technology will facilitate the execution of computation activities such as behavior analysis, emotion recognition, and UI construction in a more scalable way, thus maintaining system responsiveness during peak user activity. Likewise, the introduction of EAUI in Moodle, which is a popular LMS, will help improve scalability by automating personalization using effective data pipelines and microservices architecture.

5. CRITERIA FOR EVALUATING EAUI IMPLEMENTATION SUCCESS

To incorporate the EAUI model within learning environments, the paradigm must move away from standardized measures towards those that consider the psychological and cognitive well-being of the learners.

The performance of an EAUI can be assessed on four distinct levels:

5.1 Adaptive Intelligence (AI) Metrics

The Efficiency Path Ratio is an index that captures the number of hours learners spend before mastering a particular subject in the adaptive learning system compared to those needed using the traditional curriculum method. An efficient adaptive learning program should produce the lowest efficiency path ratios because it facilitates mastery more effectively for its learners.

Another critical metric used is the recommendation success rate, which assesses the effectiveness of AI-based recommendations made by analyzing the percentage of

recommended learning sources learners have interacted with and mastered. The recommendation success rate can be viewed as a measure of how successful the adaptive learning system is in identifying appropriate sources for learners.

5.2 Result Analysis: Moodle vs. SWAYAM

As Moodle is commonly deployed in institutions or firms, the data is "cleaner."

Result Analysis: In Moodle, EAUI functions as a Digital Mentor.

Findings:

- Emotional Resilience: Detecting "Academic Burnout" at the earliest resulted in a 25% decrease in dropouts in the first month.
- Explainability Impact: The LMS explains that the recommended module is "Because you had difficulties with the Boolean Logic quiz yesterday." Students felt satisfied.

Best Suited For: Courses that need high engagement; the emotional support from the system fills the gap between weekly online live sessions.

SWAYAM has millions of users at once. In this case, EAUI acts as a Massive Filter.

Result Analysis: EAUI integrates SWAYAM's "Four Quadrants" (Videos, Text, Forum, Assessments) as one interactive network and their Comparative analysis is given in Table 1.

Table 1 : The Comparative analysis between MOODLE and SWAYAM

Metric	Moodle + EAUI	SWAYAM + EAUI
Primary Strength	Individual Emotional Support	Large-scale Path Adaptivity
User Experience	High Trust (Personalized)	High Utility (Goal-Oriented)
Implementation	Plugin-based / High Data Privacy	Cloud-native / Big Data Analytics
Explainability Goal	Building Teacher-Student Trust	Reducing Massive-Scale Confusion

The effectiveness of the model can be evaluated by using following Evaluation Metrics (Table2)

Table 2 : Evaluation Metrics of the Model

Metric	Description
Engagement Rate	Amount of time spent, interaction level
Learning Gain	Performance improvement on tests
Dropout Rate	Percentage of users completing course
User Satisfaction	SUS (System Usability Scale)
Trust Score	Degree of trust in decisions of AI

Findings:

- Universal Adaptability: It automatically adapts itself to low bandwidth and automatically provides text-based explainers in place of videos (if streaming is not available).
- Adaptive Intelligence: Automated "remedial paths" have helped increase certification rates by 18%; based on the assessment results (Quadrant IV), students who scored lower than 50% were provided with remedial videos (Quadrant I).

Best Suited for: Bringing parity among learners across the globe; the "static" content fails to attract them.

The following table summarizes the evaluation criteria along with a comparative analysis between Moodle and SWAYAM.

6. CONCLUSION

From an evaluation perspective, the EAUI framework presents a promising solution to reshape future LMS platforms through the introduction of adaptive intelligence, emotional intelligence, and explainable reasoning. This architecture exhibits modularity, which guarantees scalability, adaptability, and application in various education systems. Despite the difficulties encountered in implementation and ethical issues, this model presents a solid foundation for future investigation and application in intelligent e-learning systems.

The comparison reveals that SWAYAM is superior in scalability and accessibility, while Moodle stands out in flexibility; however, SWAYAM lacks personalization and adaptive intelligence, whereas Moodle does not offer automation and relies on manual intervention. By incorporating the merits of these models and solving the problems of each system, the EAUI framework offers a holistic LMS architecture by adopting adaptive user interfaces, emotion-aware interaction, and explainable reasoning.

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