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Revolutionizing Learning Management Systems: Architecture of an AI-Based LMS with Instructor-driven Personalized Content Generation

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Abstract
The increasing advancement of machine learning (ML) and artificial intelligence (AI) technologies forces the modern practice of e-learning platforms to provide advanced services for their users. E-learning is no longer focused only on delivering high-quality learning resources, but also requires an advanced Learning Management System that is capable of understanding specific user needs. This paper introduces a new design for an AI-enhanced Learning Management System (LMS) that includes an automated content generation, translation, and personalization feature, significantly enhancing the core educational characteristics of such systems.

Keywords: Learning Management System, Artificial Intelligence, e-Learning, Machine Learning, Personalized Learning

1. Introduction

E-learning tools like Learning Management Systems (LMSs) help in making, distributing, and organizing educational content on the Internet. These systems have transformed education by offering a flexible and convenient method for students to obtain information. However, the rapid growth of education and the worldwide availability of information on the web have brought challenges to LMS. Today, most LMS platforms support either standalone content module deployment or web integration of content deployment. In both cases, the delivery of the same content to every learner does not accommodate for information overload and cognitive differences among learners. It also overlooks the fact that learners have different needs and preferences for knowledge, which results in different expectations from the LMS and the learning content. Personalization is often the answer to handling these problems [2].

Artificial Intelligence (AI) is transforming the educational landscape through the introduction of novel artificial intelligence (AI)-assisted Learning Management Systems (LMS). These systems, called AI-assisted LMS in short, offer innovative architectures for current LMSs and are examined from different perspectives: 1) automatic personalized content creation with Automatic Natural Language Generation (NLG) and text-to-speech systems use to adaptive audio-visual processing, 2) content translation with a statistical machine translation and automatic discrete tone generation use to adaptive multi-lingual processing, and 3) adjunctive pedagogically-motivated tutoring with a combination of machine learning algorithms and NLG based automata dialogue systems use to adaptive pedagogical processing. All approaches exhibit the potential benefits as well as foreseeable challenges of their implementation in education [3].

2. Evolution of Learning Management Systems (LMSs)

The term “Learning Management System” (LMS) is used for different hardware and software solutions that are capable of recording educational activities. In this, traditional SCORM-conformant systems utilize a so-called “reporting” methodology to keep a log of educational activities, e.g. how many times, and how long a user has opened a specific course/module. This reporting allows the creation of different overview statistics for these educational activities along with still-frame reports. Learning platforms based on modern educational IT-ecosystems are seen as systems for organizing, securing, and providing further services of recorded educational/learning activities, information, and knowledge of users, groups, and things on the Internet. Therefore, LMSs are required to record not only the static information of the educational courses, but also the

dynamics of user interactions that lead to an educational result, i.e. to acquire knowledge. Accordingly, switching from static courses to dynamic educational/learning services [4] is a crucial point of this new platforming educational era.

The evolution of LMSs involves a landmark shift of education and pedagogy from traditional face-to-face approaches based on common group studying toward advanced and modern educational social web-related approaches that provide possibilities for personalized and self-oriented educational networking within the whole world. In this shift LMSs play a crucial role as the core element of newly arising (global) educational platforms, as they provide services for off-line and on-line educational communication/networking between users and educational contents, objects, ITs, and achievements. Such a paradigm of advanced networked, platform-based, technology-enhanced education poses a number of challenges for LMSs which cope with both technological and methodological shifts. Current technological trends of improvement of the affordability and speed of computing and networking as well as the emergence of global consensus standards of web, data bases, ontologies, programming tools, etc. are analyzed regarding the technological development of LMSs. Use of LMS-based environment as digital platforms of educational networking provides opportunities along with significant challenges for pedagogical re-engineering of the existing approaches to teaching and educational activity assessment at universities and educational institutions [4].

3. Benefits of AI in Education

AI has caused an unprecedented change in the realm of IT and communication in the past three decades. Its incorporation into different areas, such as social media platforms and the healthcare sector, has become an essential and irreplaceable aspect of our quickly changing society. One major advancement in artificial intelligence is the development and application of chatbots capable of conversing like humans. This notable accomplishment has significant consequences for the field of education. Despite the importance of LMSs in education, it is crucial to recognize that they impose limitations as well. Yet, AI assistance can address these obstacles and lead to a groundbreaking and inventive learning journey. AI has the ability to tailor the learning experience by taking into account the individual requirements and likes of every student. Using this method, AI facilitates the development of a customized learning journey for each individual, fostering optimal growth and improvement. Moreover, AI can provide immediate feedback to students, changing the way in which they are guided and supported. We no longer have to wait for assignments to be graded or only seek help during office hours. AI enables students to get immediate feedback, aiding them in engaging more in their studies and making prompt modifications. Continual and immediate feedback fosters a better learning environment and motivates students to take ownership of their academic progress.

Moreover, AI serves as a beneficial tool for teachers, simplifying their paperwork and allowing them to focus on the core of teaching. Currently, artificial intelligence technology is able to efficiently handle tasks such as keeping records, grading, and organizing materials. Avoiding boring and time-consuming tasks enables teachers to concentrate on cultivating strong connections with their students, generating new lesson concepts, and offering personalized assistance to those in need. Educators can enhance their ability to address each student's individual needs by adjusting their teaching methods and harnessing AI for gathering important data insights. AI has the ability to transform education by making learning more available, interesting, and customized for every student, regardless of their individual situations or histories. Through integrating AI in education, each student's capabilities can be unlocked, guiding them towards a limitless future filled with opportunities and accomplishments [6].

4. Key Components of AI-Assisted LMS

The key components that make up an AI-assisted learning management system may include the **knowledge base** containing academic materials such as courses, topics, exercises, assessment questions, and vocabulary items in multiple forms (e.g., text, proper and inappropriate use examples, images, audio, video, etc.), **student profiles** including properly designed knowledge, proficiency, skills, interests, preferred materials, habits, mood, and affect, educator profiles designed as for students but with other contents, **text mining sub-systems** to extract diverse data about materials, students, and educators, **educational chatbot** to interact with students and educators in a natural language, **text-to-audio sub-systems** to enable learners to access course material in an audio format and **authoring sub-systems** to create new educational materials from scratch, or to adapt existing materials automatically [2]. Additionally, they may include **machine translation sub-systems** to translate didactic materials to the languages preferred by students and educators, **personalization sub-systems** to select or compose personalized materials for each student or educator automatically from the knowledge base, **learning and teaching synergy sub-systems** to construct complementary materials for students and educators automatically, **knowledge and proficiency improvement sub-systems** to adapt materials to the level of their difficulty automatically, **recommendation sub-systems** to suggest relevant didactic materials to students and educators, **analytics sub-systems** to conduct diverse analyses of educational processes, and **automated grading** to provide precise and timely assessment grading based on pre-established criteria.

The most important features in an AI-assisted Learning Management System (LMS), as detailed in Fig 1, encompass a range of functionalities essential for delivering effective and efficient learning experiences [8].

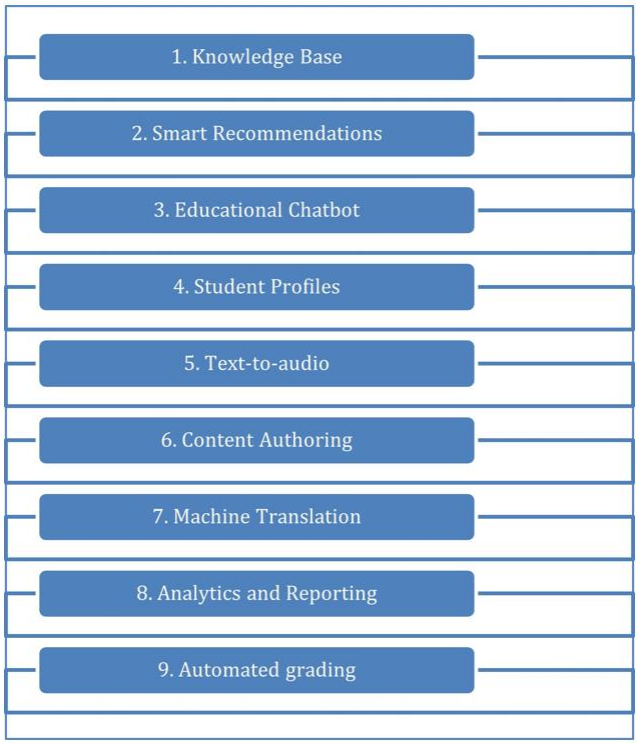

Fig 1: Most important features in an AI-assisted LMS

5. Case Studies of AI-Enhanced LMS Implementations

This section presents two case studies of AI-enhanced Learning Management Systems that focus on the use of artificial intelligence for automatic personalized content creation and automatic translation of content to improve content experience. The chosen cases provide insight from novel AI-based LMS applications developed by both educational institutions and developers. Additionally, they represent a mix of successful implementations and ongoing attempts, making them valuable learning opportunities for others aspiring to integrate AI into their LMS.

Akhter *et al.* [1] describe the development of SAMCares, an AI-enabled adaptive learning hub, by the University of Business and Technology in Saudi Arabia. A pilot implementation of SAMCares is currently being conducted in collaboration with the university's School of Computer Science. The results of this study will offer a real-world example of how to integrate AI into an existing LMS. SAMCares provides personalized content recommendations and interactive content creation support for instructors. The case study also goes over the intended roadmap of further SAMCares implementations in the institution after the pilot runs successfully. A close evaluation of the pilot study results will help other institutions analyze the practical challenges that can arise during AI-enhanced LMS implementations and how to overcome them.

The case of CogniLMS, a privately developed AI-based LMS deployed at academic institutions in Serbia, Bosnia, and Montenegro, is presented by Adamu and Awwalu [2]. The LMS is integrated with OpenAI's ChatGPT API, enabling AI-assisted content generation and translation capabilities for lesson materials. The case study dives deep into how these features were developed, offering insightful technical implementation knowledge. Additionally, it discusses the challenges faced during implementation and presents early usage metrics and feedback from both instructors and students. Integrating AI-infused capabilities into an LMS that is already used by students provides an interesting angle on AI-enhanced Learning Management Systems.

6. The Proposed Architecture and Design

AI technologies offer new opportunities to support adaptive personalized educational environments. There is an increasing interest in the automatic generation of fully personalized educational content. However, the automatic transformation of an educational resource into alternative forms in which the content is adapted to the particular needs of learners is still a challenge [1]. Furthermore, there is research and development on tools and systems for adaptive educational hypermedia but hardly any for the adaptive personalization of Learning Management Systems (LMS). Here, an LMS aims to support all stages of pedagogical educational processes and is also an important part of blended learning environments that use a combination of traditional face-to-face classroom activities supported by online resources and activities.

In this section, we introduce an innovative architecture for an AI-assisted LMS, which leverages advanced artificial intelligence technologies to enhance educational experiences. The proposed architecture is designed to smoothly incorporate into current LMS platforms, such as Moodle [9], offering additional features like evaluation of learners' skill levels, automatic content creation led by teachers, and content translation.

At the core of this design is **"MoodleSense"**, which serves as the central AI engine coordinating these components. This central hub integrates the functionalities, allowing for seamless interaction and data flow between modules. The design underscores the collaboration of AI with traditional LMS features, focusing on the ways AI can improve the personalization, accessibility, and effectiveness of learning settings.

Through the use of AI-powered data analysis, the system can adjust to the specific needs of each learner by providing personalized content that fits their learning preferences, speed, and style. Furthermore, the design includes adaptive evaluation instruments that modify the level of difficulty of tasks based on the student's performance, leading to a more efficient and captivating educational setting. The incorporation of AI enables the efficient handling of administrative responsibilities like grading and progress monitoring, allowing educators to concentrate on instructional design and interacting with students. The integration of AI also facilitates efficient management of administrative tasks, such as grading and progress tracking, allowing educators to focus more on instructional design and student interaction. Overall, this innovative architecture represents a significant advancement in the development of intelligent e-learning systems, fostering a more responsive and personalized educational landscape.

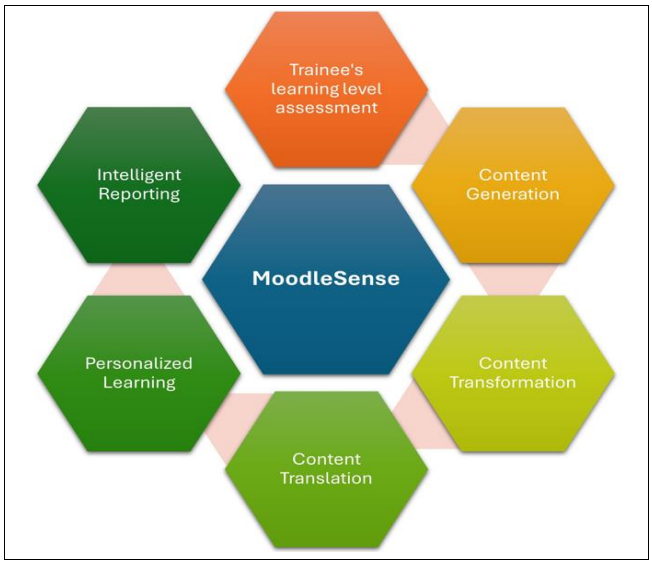

Fig 2: MoodleSense Design and Architecture

The key components of the MoodleSense architecture and design are the following:

1. **Trainee's Learning Level Assessment:** AI is utilized for assessing trainees' current skills and knowledge, allowing the LMS to personalize learning journeys based on individual requirements. It ensures that the content given to students is appropriately challenging and manageable.
2. **Content Generation:** Automatic creation of educational content is achieved through the use of machine learning and natural language processing algorithms. It has the ability to generate quizzes, assignments, and complete courses dynamically, according to curriculum needs and student advancement. The created content is entirely instructor-led and sourced from particular websites, documents, PDFs, texts, and other materials to guarantee that it is accurate, reliable and appropriate for the students.
3. **Content Transformation:** This module allows for the alteration of existing educational materials into different media and styles. It can convert text content into interactive simulations, infographics, or videos, in order to enhance learner engagement and cater to various learning preferences.
4. **Content Translation:** This feature ensures accessibility for a worldwide audience by automatically translating educational materials into a variety of languages. AI-powered translation technologies guarantee that the context and accuracy of the translated content are maintained.
5. **Personalized Learning:** This component offers customized learning chances based on the distinct preferences, strengths, and weaknesses of each learner through the examination of user interactions. It provides suggestions for content, adjusts difficulty levels, and gives instant feedback.
6. **Intelligent Reporting:** Teachers and educators can utilize this tool to monitor grading, and growth, pinpoint areas for enhancement, and make decisions based on data. It provides advanced capabilities for reporting and analytics. AI algorithms are able to forecast patterns and recommend actions to enhance learning results.

7. Conclusion and Recommendations

The exploration of innovative architectures for AI-assisted learning management systems with a focus on automatic personalized content creation and translation has revealed the potential of utilizing advanced machine learning and artificial intelligence technologies. Generative Pre-trained Transformers (GPTs), in combination with Large Language Models (LLMs), Self-Supervised Learning (SSL), and multi-modal analyzers, can be leveraged to develop powerful tools for generating and tailoring educational content, transcending the language barrier, and enhancing learning accessibility and engagement. The proposed architecture exhibits great promise in creating teacher-led personalized content, paraphrasing and restructuring content, and translating content to better match learners' backgrounds, learning preferences, and cognitive capacities. Moreover, the exploration of our architecture demonstrates an innovative approach to maintain the contextual and topical relevance of content and its translation, while developing a wider pool of suitable content across various languages.

There are significant gaps, limitations, opportunities, and suggested solutions for future research and development based on its findings. Continuous advancements in machine learning and artificial intelligence will expand the pool of technologies available for educational content creation that can be adopted by institutions. However, institutions might not employ the right set of technologies to meet their objectives, which could lead to content and translation mismatch [7]. Therefore, beyond the architecture itself, it is suggested that research into how the proposed technologies can be integrated within institutions, including the selection of the right technologies, the technical and human infrastructures required, the best practices for implementation, etc., is conducted. Additionally, any architecture for automatic content creation requires a sufficient repository of suitable content across all languages to sustain its performance while maintaining the same level of contextual and topical relevance, which is not guaranteed. Therefore, future research should explore how suitable and reliable content can be produced across languages to better train and equip institutions with educational content creation methodologies.

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