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Investigating AI-Powered Tutoring Systems that Adapt to Individual Student Needs, Providing Personalized Guidance and Assessments

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Abstract: This comprehensive literature review seeks to assess the potential of AI-powered tutoring systems that are able to adapt and provide personalized guidance tailored to individual student needs. As Artificial Intelligence (AI) technologies continue to progress at a rapid rate, there is ever increasing interest in leveraging these capabilities for educational purposes. By offering customized instruction based on each student's strengths, weaknesses, and learning style preferences, AI-powered tutoring systems may revolutionize how students learn. The review will examine various studies and research papers exploring the design, implementation techniques as well as effectiveness of such innovative solutions. This includes delving into algorithms like machine learning, natural language processing or data mining which enable these systems to adjust their interactions according to students' requirements. Moreover, it will investigate any positive impacts such personalized teaching has had on academic performance levels in addition to engagement motivation amongst learners. Additionally, this study shall look into existing challenges faced when using AI-powered tutoring systems; from ethical concerns about privacy issues thought too effective teacher -student communication. After taking all findings from available literature into account we can then identify areas where more work is needed, offer suggestions for future improvements or studies within this field. In conclusion, with our synthesis of insights gathered during our investigation we hope improve awareness & understandings around utilizing AI technology for educational purposes so that teachers & students alike can benefit from personalized adaptive educations experiences.

Keywords: AI-powered tutoring systems, Adaptive learning, Machine learning

Introduction

Higher education institutions (HEIs) are increasingly embracing technology, which is significantly changing the educational landscape. The traditional educational system has changed due to innovations such as enhanced learning structures and virtual reality classrooms. Through a variety of tools, resources, and the direction of teachers and mentors, technology-supported learning enables students to improve their knowledge and abilities (Gros, 2016).

Technology can expand curricula and offer students more exciting learning opportunities, according to information technology and information systems educators (Pappas & Giannakos, 2021). However, issues with the rigidity of online learning platforms have been raised. To correctly solve this problem, complex learning algorithms have been created in response. A game-changer in the educational system is using cutting-edge data analytics and artificial intelligence (AI) methods. In order to adapt educational content and make it relevant to specific student needs, modern learning platforms use historical data from prior users (Hasanov et al., 2019). Intelligent tutors and learning analytics are only two examples of AI-enabled learning systems that provide personalized feedback and direction to students, significantly increasing their learning experience.

Numerous AI-enabled learning systems, including intelligent tutors and learning analytics, have emerged due to advancements in AI research. These developments have been helpful in education because they give pupils personalized feedback and guidance, which promotes a more efficient learning process (Moreno Guerrero et al.,

n.d.). Technology improves students' educational experiences and gives teachers the tools to design engaging, adaptable learning environments. Artificial intelligence in education allows teachers to modify their lesson plans to accommodate different types of learners, improving both student engagement and learning outcomes. The way students learn and teachers instruct has undergone a radical transformation due to integration of technology and artificial intelligence into higher education. HEIs can better deliver individualized and exciting learning experiences by utilizing improved learning structures, virtual reality classrooms, and AI-enabled systems. The potential of these breakthroughs will continue to be fully unlocked as time passes, thanks to ongoing research and technological developments, which catapult higher education into a vibrant and learner-centered future.

Methodology

The systematic mapping approach advocated by Petersen et al. (2015) is used in this investigation. A systematic mapping survey technique classifies and quantifies the contributions made to a studied issue to give a thorough overview. It works well for studying a significant research topic since it enables a detailed investigation of research articles about a particular issue. Systematic mapping creates a thorough map of a more significant research topic than content-based analytical methods like bibliometric analysis, which quantitatively evaluates academic outlets within a specific research field (Farshchian & Dahl, 2015; Chen et al., 2020). On the other hand, bibliometric analysis focuses on assessing academic venues within a particular study topic. Three research questions (RQs) have been developed in the context of this study to investigate the potential implications of AI-enabled learning systems:

RQ1: What are the primary goals and driving forces behind research on gaining knowledge of environments using AI?
RQ2: What are the key troubles and issues, in addition to the recommended interventions and solutions, inside the region of AI-enabled mastering systems?
RQ3: Which conventional AI and information analytics strategies have been applied to the interventions?

A methodical mapping strategy was used throughout the research process to offer broad recommendations. Extensive searches that included formal and informal sources were done to accomplish the research objectives. Only studies published within the last five years were chosen to guarantee the usage of current research. A thorough mapping of the pertinent literature was done in the second step. To ensure impartiality, the systematic mapping process started with creating a search strategy based on a mapping technique. The research questions (RQs) were initially used to develop this technique, which was further honed for accuracy. Different search terms and strings, including alternative spellings and synonyms, were created to streamline the search results. Given that these phrases were frequently used interchangeably, the significant search terms "adaptive learning system" and "artificial intelligence" were employed, and database searches were carried out simultaneously. Alternate terms for adaptive learning systems include "adaptive learning environment," "adaptive learning platform," "adaptive learning technology," and "adaptive learning setting."

The terms "machine learning" and "artificial intelligence," which have broader meanings, were used interchangeably since discussions concerning adaptive learning systems that use AI frequently involve them. They cover more specialized methods like text mining and data mining. Boolean operations (AND and OR) combined these terms into a single search string, making it possible to include synonyms and other spellings. This strategy made sure that the literature on the subject was thoroughly examined.

Research Overview

51% of the papers covered have been published in scholarly publications, with the closing forty-nine% being convention papers gathered in conference lawsuits. Consistent with Wieringa et al. (2006), the articles were split into agencies based totally on the type of take-a-look-at technique used. The two most normally used research tactics were literature opinions (32 papers) and assessment research (forty-three courses).

Different AI-Powered Educational Initiatives

The research articles were divided into five categories based on the actual interventions and solutions used in AI-learning scenarios: systems, frameworks, models, methodologies, and combinations of interventions. Frameworks were discovered to be structured, hierarchical systems that explained presumptions, methods,

customs, concepts and instructions for implementing these definitions. Many of the frameworks suggested in the studies included vital elements and skills that might be used in educational settings. These frameworks suggested using user (learner) models, AI procedures, and other flexible methods as potential fixes.

These frameworks produced more adaptable learning environments by identifying and describing the links between diverse components. Various important tactics and procedures were found using the coding frameworks. Additionally, models were used in 22 research described by Stoica et al. (2015) as "a pattern of something to be made, an outline, or an analogy used to visualize and reason about the system to be developed and its likely outcomes."

These models fulfilled various functions, such as illustrating an experiment, a strategy for solving an issue, or a condensed version of a system or component that needed improvement. Some of these models needed to be rebuilt entirely to achieve their intended goals. Twenty study articles also looked into adaptable methods for treating diverse illnesses. An adaptive approach is a group of presumptions or viewpoints applied to recognize, define, and address issues resulting from certain phenomena. These adaptive methods show flexibility in addressing a range of learning-related problems. The categories of systems, frameworks, models, approaches, and combinations of interventions that have been discovered show the breadth and depth of interventions used in AI-learning scenarios, offering insightful information for developing the field of AI in education.

Instances of AI Learning Systems

The published papers focused on creating learning environments that used AI in various disciplines, including biology, computer literacy, psychology, nursing, and arithmetic. The identified languages taught in these applications are English, German, and Greek. These AI-integrated systems were also created to support language teaching and acquisition. These AI-enabled learning environments had two primary goals in mind. They first sought to improve teaching strategies, making them more efficient for various topic areas. Second, these settings were created to benefit English, German, and Greek students by assisting with language education and learning. These AI-integrated systems' overarching objectives included enhancing students' performance in all subject areas and tailoring learning opportunities to suit unique requirements and preferences. Researchers aimed to develop adaptable and responsive learning environments using AI technology, improving students' overall educational experiences. Those improvements had been developed as structures for handing over level-suitable, custom content material. Moreover, environments with AI integration are used to educate and study programming languages like Java and Square. The remaining themes are proven in desk 2.

Strategies for AI and Information Evaluation

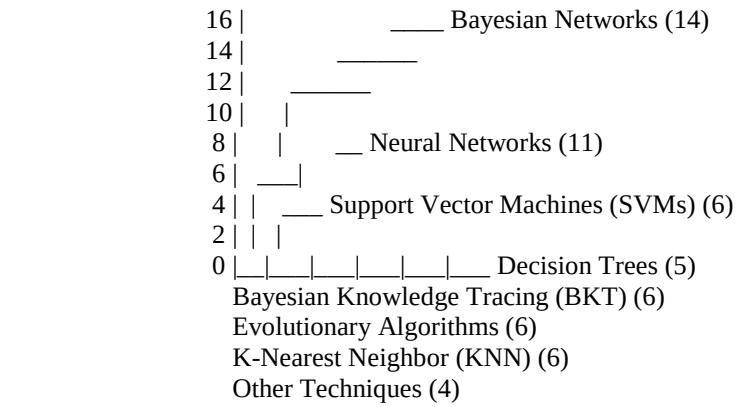

Figure 1. Frequency of AI and Records Analytics Techniques in Research Mapping

The frequency of each strategy identified in the research mapping is shown in the graph. With 14 papers relating to learning contexts facilitated by AI, Bayesian Networks were the most frequently cited technique. With 11 research articles mentioning it, neural networks came in second. The study mapping made six references to Support Vector Machines (SVMs), Bayesian Knowledge Tracing (BKT), Decision Trees, Evolutionary Algorithms, and K-Nearest Neighbor (KNN) approaches. Four study articles mentioned additional methods. Overall, Bayesian Networks and Neural Networks are the most widely used methods in the research, and the

graph gives an overview of the most frequently used AI and records analytics techniques in the context of AI-enabled learning settings.

Discussion

The study's objective was to assess the writings of diverse writers in light of these preset objectives. The research mapping highlighted numerous critical areas of relevance in AI-enabled learning systems. CorTexT network analysis was used to examine the connections between these topics. A co-occurrence matrix was used to cluster the papers, portraying each one as a tiny node and creating clusters based on the degree of author link. These groups were automatically identified and coloured using a clustering algorithm, which also assigned the labels "System," "Literature," "Algorithms," "Evaluation," and "Framework" to the diagram's central portions.

Most AI-enabled learning interventions concentrate on algorithmic, systematized, and framework-based methods. The majority of these commonly used frameworks and structures were still in the testing stage and had yet to be applied in actual classrooms. It was difficult for educational institutions to adopt these modalities of instruction because of the lack of practical application since it was only possible to thoroughly understand their advantages and disadvantages by assessing their efficacy in actual use.

There need to be more modern ways of learning that are AI-enabled and that deal with complex problems. Despite its potential, research on adaptive learning systems, particularly those leveraging modern AI approaches, could have been more impressive. Although there have been significant reviews of the literature, relatively few research have looked at the more complex issues that students face when using modern AI-enabled learning methodologies.

The bulk of systems for adaptive learning concentrated on teaching languages, programming languages, and other subjects, indicating that while they have potential, they have yet to be commonly employed. However, this field can have a research gap because these technologies might not always help users deal with difficult situations or require the requisite skills to use such systems correctly. Users may find it challenging to use these technologies to their full potential if unfamiliar. AI-enabled learning systems' handled issues were separated from those not thoroughly investigated using predetermined themes. This is a valuable tool for improving research in this field of study because it identifies gaps and potential research areas of interest.

The Implications of the Theory

The research work identifies knowledge gaps in the field of AI adaptive learning systems, particularly through literature reviews and observation analysis. This is a significant advancement over the previous studies that have been conducted. It was determined that there were significant holes in research in the following three areas:

Coincidences between the Authors and Their Research Subjects: This study provided a graphical representation of the links between the basic aims of the selected research and their authors. It also highlighted the primary ideas in the field of AI-enabled learning systems and how they are related to one another.

AI-enabled Learning Interventions and obstacles: The research found that instructors and students both confront a variety of obstacles in the environments in which they are engaged in learning. Problems with students' learning strategies, backgrounds, and profiles, as well as concerns regarding engagement and motivation, were included among these problems. (Dunn & Kennedy, 2019; Papamitsiou et al., 2018) The purpose of the study was to gain an understanding of the challenges that AI-enabled learning interventions have successfully overcome as well as the challenges that remain unsolved.

Applications of Analytics Methods in Learning Systems Using AI: The work primarily centered on analytics methodology and how various types of learning systems make use of various types of AI. It was discovered that the two types of analytics that were employed the most frequently were descriptive and predictive. The research highlighted various applications of these methodologies, such as improving students' academic performance and motivation, enabling personalized learning, assessing students' learning challenges, and detecting anomalies in student and lecturer behavior (Almohammadi et al., 2017; Wang et al., 2020; Aldowah et al., 2019; Manjarres et al., 2018; Wakelam et al., 2015). These applications were highlighted in the study. The research gives useful insights into the current status of AI-enabled learning systems, the obstacles they confront, and the possibility for improvement as well as ongoing research in this field by tackling these three essential areas.

Conclusion

The research findings emphasize the prevalence of adaptive learning systems, intelligent mechanisms, and AI-powered learning systems as the most frequently presented and utilized solutions for addressing challenges students and teachers face. Particularly during the pandemic, the significance of these systems has increased due to their contribution to maintaining solid educational standards and improving learning design in information technology and information systems education (Pappas & Giannakos, 2021). However, it is essential to note that despite their potential, most of the suggested systems and frameworks are still in the testing phase and have yet to be applied in real-world classroom settings or undergo rigorous evaluation. Many of these systems have yet to be fully developed.

The study highlights the potential widespread impact of AI-enabled learning systems and encourages higher education institutions (HEIs) to adopt these systems wherever possible. By synthesizing the latest discoveries in AI-enabled educational systems, the study significantly contributes to the existing body of knowledge and provides valuable insights into various related subjects. This mapping is crucial given the increasing research on AI-powered learning systems and their diverse applications for educational institutions, including universities.

The mapping can aid in selecting the most suitable AI-enabled learning intervention for specific challenges, facilitating more efficient management of educational systems. Future research should address unresolved issues and barriers preventing the broader adoption of AI-enabled learning systems in academic institutions. Bridging the knowledge gap between education and artificial intelligence (AI) is essential, and researchers should work on integrating course material, student expectations, and instructor requirements with various technological platforms. Investigating and implementing novel frameworks, models, and structures will be crucial in evaluating their effectiveness in helping students overcome learning obstacles. The research acknowledges its limitations, such as the impact of selected keywords, phrases, and databases on the extent of the mapping. Future research can explore more specific applications of AI, such as data mining or text mining, and delve deeper into the objectives and methodological approaches used in AI-driven learning systems.

In conclusion, the research underscores the significance of AI-enabled learning systems and advocates for continuous development and application of advanced frameworks to enhance the educational experiences of both students and teachers. By focusing on innovation and addressing research gaps, AI has the potential to revolutionize and optimize learning environments, paving the way for more effective and personalized education in the future.

Recommendations

The study offers helpful insights for practitioners looking to use AI-enabled learning systems in educational settings. The results show that systems and frameworks are the main topics of most AI-enabled learning interventions. Nevertheless, many suggested frameworks and systems are still experimental and must be ready for widespread usage. The ability to quickly distinguish between vital and particular information is one of the difficulties encountered in this domain. For instance, Padron Rivera et al. (2018) studied Tamaxtil. This AI-powered learning tool monitors students' affective states as they work through math problems in order to assist them in controlling their negative emotions. This example shows how AI-enabled learning systems might help students with trouble regulating their emotions during the learning process. It also emphasizes the necessity for future development and evaluation to ensure these technologies are efficient and valuable in educational settings. Practitioners interested in implementing AI-enabled learning systems should be informed about the latest developments and current research. They should carefully weigh the possible advantages and difficulties of implementing such systems and try to work with researchers to successfully address particular educational requirements. The study's findings emphasize the significance of rigorous testing and assessment to ensure the successful integration of AI-enabled learning interventions, providing helpful advice for practitioners wishing to leverage the power of AI in educational environments.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the author.

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