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Literature Review

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Transforming Classrooms with Technology: A Review of AI Adaptive Learning

Models in K-12 Education from 2019-2024

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INTRODUCTION

Artificial Intelligence (AI) has profoundly transformed K-12 educational environments, emerging as a modern tool in enhancing student engagement. This literature review examines the application of AI adaptive learning models within K-12 education, analyzing 20 research papers published from 2019 to 2024. Employing thematic analysis, this study aims to extend existing theories concerning adaptive educational technologies. The focal question investigates the implementation strategies of AI models and their efficacy in engaging students, thereby uncovering emergent patterns and theoretical inconsistencies. The qualitative methodology underscores an in-depth exploration of contextual implementations and theoretical expansions in AI-driven education.

REVIEW OF THE RELATED LITERATURE

From 2019 to 2024, numerous studies have explored the application of AI models in educational settings. This body of research has done data collection on encompassing surveys, reviews, experiments, questionnaires, tests, and scholarly articles, that has primarily aimed to assess students' perspectives on the integration of advanced AI technologies in schools.

Similar to the study conducted by Ankush and Manishi on the assessment of AI and computer language in the medical field, research conducted at India's Government Medical College indicates that nearly 89.1% of students expressed optimism regarding the integration of AI into medical studies. This sentiment was gauged through the administration of 10 web-based questionnaires. (Jindal & Bansal, 2020). Ke Zhand and Ayse Aslan conducted a comprehensive review across a diverse array of educational settings, including K-12 schools and higher education institutions. The analysis included over 17 studies, examining the impact of Artificial Intelligence in Education (AIEd) on learning outcomes for K-12 subjects. The technologies analyzed include Intelligent Tutoring Systems (ITS), chatbots, expert systems, and machine learning algorithms. Ther findings highlight both the advantages and challenges of AI, demonstrating an overall enhancement in learning concepts (Zhang & Aslan, 2021) While in Japan by 2020, an experiment approach on delivering AI bingo assisted game to K-12 students was done to assess the results of the concept which still being developed to avoid ethical problems, but it showed shows positive learning outcome (Eguchi et al., 2021). While studies by Yu-Sheng Su in Taiwan, has made a comparative analysis on using AI to assist teachers produce learning materials and models like a companion and resulted

that it has increased engagement compared to traditional learning (Su et al., n.d.).

The concept of adaptive AI has demonstrated potential in customizing educational content based on student interactions and exam performance, as noted in Joshi's 2024 study on AI machine learning technology. It identified challenging lessons, allowing educators to modify materials and monitor progress effectively with the use of adaptive models where the AI automatically tailor the examinations until the student progresses (Joshi, 2024) where in this review it explores the approaches and insights of the concepts.

OBJECTIVES

To define all AI technology terminologies gathered by researchers and state how it is used in education specifically by subject which are limited to K-12 study courses. In this review, subjects that has been included are the following:

- English

- Math

- Science

- Medical

- Physical Education

- Music

The approach on sorting the data would allow to visualize the various AI Education (AIEd) technologies used and present data visually to explore the outcomes, effects, challenges and limitations using a thematic analysis. To further clear the objectives, the terminologies used in this review are stated and as defined by the researcher. In addition, each technology has been qualitatively sorted to a general term which are AI Assistive Technology, AI Intelligent Agents and AI technology-enhanced learning platforms.

AI Assistive technology - AI has the potential to alleviate the workload for both teachers and academic administrators, as it has the ability to take on a variety of tasks, including the ability "to record academic
achievements, develop personalized learning materials, provide reviews and analyse

data". This could potentially give teachers more time to focus on teaching and create a more optimal learning environment for the students. (Tapalova & Zhiyenbayeva, 2022)

The term "AI-based multi-sensory technology," as defined in this review, refers to a platform that utilizes artificial intelligence to assist teachers in creating materials. This technology enhances learning by integrating multiple sensory modalities, including visual, auditory, and tactile elements, to support students' educational experiences (Srinivasan & Murthy, 2021). This study further classifies AI-powered tools for students as AI assistive technology. For instance, textually assigning a task to an AI that generates a result that aids the student or teacher is an example of this. (Sol et al., 2024) Any customized large language model AI such as ChatGPT and customized to cater specific tasks for students also counts as assistive technology in this review.

AI Intelligent Agents – autonomous systems that demonstrate human-style social intelligence, including the ability to recognize emotions, exhibit socially and emotionally appropriate behavior, and provide social artifacts such as emotions and aspects of personality (Mårell-Olsson et al., 2021) usually in-forms of Chatbots or automated robotic responses approaches. An intelligent agent refers to bots that are specifically trained to deliver content to users in a targeted manner. For instance, an entity is defined as the valuable information extracted from user input. The user's message inquiries about the definition of a "Sprite." The term "Sprite" refers to an entity. Consequently, the bot is anticipated to provide a pre-defined response based on its

programmed instructions. (Mathew et al., 2021) . Also included are systems such as AI Speaker System which is used to deliver instant responses to students when prompted questions in class allowing clarifications in limitless forms to students (Tan & Cheah, 2021).

AI technology-enhanced learning platform - taking into consideration various tools driven by artificial intelligence (AI), such as intelligent tutoring systems, adaptive assessments, and virtual learning environments. These tools are intended to meet the specific requirements of individual students, to offer individualized feedback, and to modify the content of instructional presentations. (Salido, 2023). AI Gamified approach is classified as enhance learning platform in this study, as defined from researchers, the platform is provided to student to interact with gaming activities related to a subject and automatically adjust contents depending on students' performance (Tan & Cheah, 2021). In addition to the reviewed researches, a computer Aided Teaching System is mentioned where AI utilizes video image technology to enhance training and instruction to students. A digital whiteboard for tactical diagrams and player annotations lets players interact with this system's tactics visually. It optimizes training outcomes by supporting self-directed practice and feedback through video playback, which is personalized and adaptive to individual learning styles and speeds. ("Polito et al., 2023).

The hypothesis then arises from the observations:

Q1: How are the evolving AI adaptive learning models effectively facilitating K-12 subjects for students?

Q2: What underlying mechanisms have AI models addressed from 2020 to 2025 across K-12 subjects for students?

METHODOLOGY - THEMATIC ANALYSIS

A six-step thematic analysis is used on 20 research papers gathered in existing research between year 2021 up to 2024 on students undertaking K-12 related subjects. The approach involves a qualitative research method commonly used to analyze and interpret patterns within qualitative data (Kampira et al, 2019). The steps outlined for thematic analysis are designed to guide in conducting qualitative analysis and generating insights from qualitative data (Byrne, 2022)

1. DATA FAMILIARIZATION

A comprehensive search was conducted using keywords such as "AI Adaptive Learning Models". "K-12 education" and "student engagement" in academic databases including PubMed, Google Scholar, ResearchGate and IEEE Xplore.

2. GENERATING CODES

Involves identifying and labeling relevant pieces of the research papers related to AI education and feedbacks on teachers or students of data with short, descriptive code.

3. CATEGORIZING CODES TO THEMES

After gathering the descriptive code on the research papers, it is then distributed into themes such as "Subject", "Effects on Teachers/Student Engagement" and "AI technology used".

4. DEFINING AND NAMING THEMES

Each theme was reviewed to accurately represent data. This required a thorough review as well as theme adjustments to match the coded data's scope. Themes were named and defined to provide clear, descriptive titles related to their content.

5. REVIEW THEMES

To ensure theme coherence, themes were reviewed and refined in this key stage. This included reevaluating the coded data and proposed thematic map to assess if themes captured the research data's key concepts.

6. WRITING THE REPORT

A detailed analysis of the thematic framework. This includes weaving the themes together to create a coherent narrative that addresses the research question(s) and is supported by the dataset.

FINDINGS

The below are the gathered codes sorted into themes to easily visualize AI in K—12 related subjects.

MUSIC

Authors: (Wu, 2023)

AI Technology: AI Enhanced Platform by providing tailored-specific materials to students

Sample Size: 375 data collected from students via questionnaires and survey

Effects on Teachers/Student Engagement:

- "Actively participated in guided learning"

- "AI technology has a better effect. undergraduate are becoming more and more active in learning music, and the effect is getting better and better."

- "It can be rationally designed and forecasted according to the actual situation of each university student, combined with the previous learning situation, and developed a targeted Sexual education plan, thereby effectively improving the learning effect of students."

- "Most students among the interviewees do not recognize the traditional university music education model"

Authors: (Yu et al., 2023)

AI Technology: AI Enhanced Platform for teachers providing study course, while students deliver training to AI independently via Music Information Retrieval (MIR).

Sample Size: N/A

Effects on Teachers/Student Engagement:

- "Actively participated in guided learning"

- "AI technology has a better effect. undergraduate is becoming more and more active in learning music, and the effect is getting better and better."

- "Assist the performer to complete the music performance and reduce the difficulty of performance."

- "One person can play multiple instruments"

- "Traditional teaching method through dictation is boring, while AI has independent preview, learning expectation, situational experience, cooperative learning, onstage explanation, consolidation of quiz, and breakthrough points, and the interaction between teachers and students is more vivid and rich"

Authors: (Polito et al., 2023)

AI Technology: AI Assistive Technology using Computer Aided Teaching System (CATS) for football Teaching and training based on video image

Sample Size: 55 teachers, 102 students

Effects on Teachers/Student Engagement:

- "The use of clear animations to replace blackboard practices has led to student satisfaction.

- Students reported that courseware is outdated and teachers need to prioritise network information. Lack of public physical education teaching materials is the cause."

- 'CATS' effectiveness in encouraging student interest in learning is not as anticipated. Many students suggested that "the courseware made by the teacher is a simple scan of the book", "the PPt is full of words, no animation and flash links", and "Can increase the video playback of teaching competitions".

- In computer-aided physical education classes, students perceive increased interaction with teachers, 5.8% perceive decreased interaction, and 69.8% are unsure.

Authors: (Yu et al., 2023)

AI Technology: AI Intelligent Agents - using AI chatbot on post-pandemic medical education and clinical assistance

Sample Size: ChatGPT, Bings AI and Google Bard as participants

Effects on Teachers/Student Engagement:

• All AI participants provided general medical problem test answers.

• Google's Bard was less thorough. It advised reexamining the patient and considering other diagnoses.

• BingAI's concise, generic response to cellulitis was unhelpful for junior doctors in clinical settings.

In its initial management approach, ChatGPT neglects crucial assessments for patient care.

• Bard summarizes key management points but lacks a clear system for junior doctors to follow in clinical settings.

Authors: (Wardat et al., 2024)

AI Technology: AI Enhanced Platform – for mathematics

- **Sample Size:** Gender: Male: 282 teachers (48.6%) Female: 298 teachers (51.4%) in Abu Dhabi

Effects on Teachers/Student Engagement:

- AI adoption in classrooms hindered by teachers' reluctance to embrace technology

- Automation of administrative tasks by AI can significantly reduce instructors' workload

- Older teachers may struggle to adapt to modern teaching methods, increasing their workload

- Despite expectations, many teachers remain hesitant to fully utilize AI for enhancing teaching and learning processes

CONCLUSIONS & RECOMMENDATIONS

The examination considered both the opportunities and challenges of integrating AI into education when assessing its effects on students across subjects. Teachers may struggle to apply complex knowledge to teach students with AI, requiring comprehensive training and support. Students' experiences with various AI technologies in subjects do have pros and cons. Based on exploratory analysis studies, assistive AI with teacher collaboration may enhance student engagement rather than fully adopting an independent platform for teaching, as it has been repetitively found as codes in the analysis representing good outcomes, but it may affect uncontrolled, inappropriate, or excessive mobile phone use. (Choliz, 2010). The unconscious integration of AI into human life and phones may deepen this, as participants noted that mobile devices already stripped people of their social interactions and wonder about the next step with AI development in the mobile world.(Gocen & Aydemir, 2020).

Developers have tried to adapt AI for complex subjects, but this review shows that K-12 AI education can be improved based on researchers' efforts and results. This field is growing rapidly and offers many education system improvements. It teaches traditional knowledge using competitive and motivational methods to engage students. AI can help K-12 students learn complex subjects interactively and engagingly, according to this review. However, more development is needed to make the education system more precise, informative, and enhanced, rather than just an enhanced traditional delivery when not maximised.

APPENDIX 1

Limitations of the document

Sources of the study is limited to a date of 2019 to 2025 and the technological terms used in each AI used in the analysis may consume plenty of words and vocabulary that may shift the focus of the document into a more technical detail analysis of each. Therefore, this study has analyzed documents related and compiled it into an audience that may understand in a higher—level hierarchy rather than a breaker down into programming algorithms. The in-depth explanation or challenges may be directed to the references listed in this review, as the written review only provides a themed based analysis. It does have the potential to expand themes however to define and breakdown into a more detailed view would not meet the word count.

The amount of research papers concluded here are limited due to the word count which limited to only 20 research papers of multiple subjects that are implementing AI. The required university format has limited the data representation quality therefore a bullet approach was used.

Further enhancement of this document is to use tools for larger resource gathering and automated codes, themes for qualitative thematic analysis such as NVivo(*About NVivo*, n.d.) or MAXDA (*MAXQDA | Official Site | All-In-One Tool for Qualitative Data Analysis*, n.d.)which may aid to conduct larger scale analysis.

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