Jurnal Inovasi Pendidikan IPA

Volume 10 | Number 2 Article 15

2024

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Recommended Citation
Azari, A. M., Rochintaniawati, D., & Agustin, R. R. (2024). Can Web-Based AI Be Implemented in the Middle School Science Classroom? A Critical Review. *Jurnal Inovasi Pendidikan IPA, 10*(2), 175-184. https://doi.org/10.21831/jipi.v10i2.75364

Available online at: http://journal.uny.ac.id/index.php/jipi

Jurnal Inovasi Pendidikan IPA, 10 (2), 2024, 175-184

Can Web-Based AI Be Implemented in the Middle School Science Classroom? A Critical Review

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Received: 25 June 2024; Revised: 16 August 2024; Accepted: 9 September 2024

Abstract: This literature review examines the effect of artificial intelligence (AI) on science education, particularly in middle schools, and addresses both its limitations and future directions. This review critically assesses the potential implications of AI on science learning in middle school. It does so by examining 17 Scopus-indexed studies. The review reveals significant positive outcomes regarding how web-based AI-powered education affects students' learning outcomes, technological skills, and better decision-making. Despite these promising results, this article recognizes the possible dangers and difficulties associated with implementing AI in the classroom, such as limited access to technology in the region, reliance on AI, and ethical considerations when using AI-generated content. Solutions such as expanding technological knowledge and encouraging critical thinking are proposed to address these issues, anticipating the danger of bias and ethics toward AI. The conclusion of this review indicates that AI implementation in science learning has significant potential benefits despite limitations and challenges. In addition, this review also guides students, educators, and AI developers on optimizing AI's educational benefits.

Keywords: AI, science, web-based

How to Cite: Azari, A., Rochintaniawati, D., & Agustin, R. (2024). Can Web-Based AI Be Implemented in the Middle School Science Classroom? A Critical Review. *Jurnal Inovasi Pendidikan IPA, 10*(2), 175-184. doi:https://doi.org/10.21831/jipi.v10i2.75364

INTRODUCTION

Artificial intelligence (AI) has been used widely in many fields, becoming a typical contemporary feature in the twenty-first century (Al Darayseh, 2023, Chiu et al., 2022, Cooper, 2023, Hornberger et al., 2023, Koć-Januchta et al., 2020 & Nja et al., 2023). Interest in AI increased after the coronavirus (COVID-19) pandemic, particularly in education (Al Darayseh, 2023). Many regions developed AI curricula to be implemented in schools (Chiu et al., 2022, Hornberger et al., 2023, Sanusi et al., 2023 & Chiang et al., 2022), as one of the efforts to improve the habit of using technology, in conjunction with many studies in the world of education done to find out how technology affects humans to carry out certain activities (Castellano et al., 2023; Chiu et al.; 2022; Cooper, 2023; Dindler et al., 2023; Fernández-Martínez et al., 2021; Park & Kwon, 2023; Sanusi et al., 2023 & Chiang et al., 2022)

AI is a machine that can imitate human intelligence functions (Al Darayseh, 2023), like teaching and learning, to solve problems (Nja et al., 2023). Websites are widely used to facilitate learning (Iyamuremye et al., 2022 & Sylvia Dewi et al., 2023), where AI is commonly accessed. They affect various aspects of education, such as content, teaching methods, schedules, and communication (Al Darayseh, 2023). People are expected to be educated on the goals of this technological system by decision-making and taking action (Castellano et al., 2023; Sanusi et al., 2023; Wang et al., 2024; & Zhang et al., 2022). Building educators' and students' skills to utilize this technology is crucial (Al Darayseh, 2023; Nja et al., 2023; Sanusi et al., 2023 & Wang et al., 2024) because learning to run successfully requires many parties.

On the other hand, the development of digital media for learning by AI is more often used in higher education or outside the classroom context Chiu et al.; 2022; Fernández-Martínez et al; 2021; Koć-Januchta et al., 2020; Park & Kwon, 2023; & Zhang et al., 2022), especially in science courses. A thorough curriculum for artificial intelligence (AI) in pre-college education must exist. This is because curriculum creation involves essential aspects such as pedagogy and evaluation. Teacher training and active involvement in curriculum design are crucial to AI program success (Chiu et al., 2022). This situation is far from the ideal picture of science learning using AI on the web in Indonesia. Korea introduced AI education in 2019 and in 2021 AI-related subjects were launched in high schools. Due to the increasing demand for informatics and AI education in public schools, they have been implemented for more than seven years. However, no AI curricula and subjects are included in the Korean national curriculum for elementary and middle schools. Therefore, there is a need to develop a new curriculum suitable for these school levels in the future (Lee et al., 2022).

While existing studies have shown an essential start to supporting students in learning AI via the web, this paper introduces a novel perspective by extending AI knowledge for middle schoolers in the science education context. This study aims to bridge the gap in current literature by reviewing the relevant literature by analyzing the latest development of the AI-web in the education field, the challenges of web-based AI, and the effects, potential, and findings of the application of AI in science education. The main contribution of this research is its focus on the feasibility of applying AI in the formal middle school system in Indonesia, highlighting how web-based AI learning facilitates students' inquiry and discussion skills that are linear with one of the objectives of science education.

METHOD

The articles reviewed are gathered from Scopus, a database containing high-quality journal papers, and selected Q1 to Q3 indexed papers. Since AI is still an emerging field, limited literature is available on the topic. Our study explicitly examines how web-based AI-powered tools are integrated into middle school science education, aiming to explore both the benefits and challenges of this technological shift. The primary goal is to assess the impact of AI on students' learning outcomes, their development of technological skills, decision-making processes, and ethical awareness regarding AI. Our literature collection was conducted from September to October 2023, and we used specific keywords such as "artificial intelligence education," "AI classroom," "web learning," "web-based learning," and "science education" or "science classroom" that appeared in the title, abstract, main text, or keywords. After downloading the articles, we thoroughly reviewed them to determine their relevance to the specific objectives of our study, ensuring they aligned with our focus on the application of AI in middle school science classrooms. During the examination, we used inclusion and exclusion criteria to ensure the findings were generalized and to avoid biases in selecting the articles. Our search resulted in 17 articles that were examined further in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion	Exclusion
The papers should be related to the implementation of teaching and learning using AI on websites in the classroom that can be implemented in science education	Related to the making of AI rather than the implementation.
Papers should be peer-reviewed journal papers	Purely theoretical or opinion-based
Publication year: 2019 – 2023	Involved for elementary students
The research methodology is quantitative, qualitative, and mixed methods, along with theoretical or descriptive articles.	Not related to classroom or education context
Indexed by Scopus	Not written in English

This literature review is centered around investigating the application of AI in teaching and learning across various educational fields, including Machine Learning (ML). The selected study period ensures that the most recent developments in the field are considered. The review analyzed various studies according to these criteria by comparing them across crucial aspects, including theme/purpose, methods and instruments, data analysis techniques, implications, novelty/specialty, limitations, and future directions. This comparison was made to provide a clear overview of how these studies approached the

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

investigation of AI, such as through methodological or pedagogical approaches, evaluations of curriculum or instructional unit design, measurement of AI learners' performance, and discussions around applications that introduce AI to young people through mediums such as web-based interactive platforms or AI games. The data were analyzed by dividing them into several essential points, which were then elaborated on to propose a solution to the gaps in the available literature. However, this research did not include programming or numerical computation studies because they were beyond its scope.

RESULTS AND DISCUSSION

The study's results section focuses on three main topics to answer the research questions. These topics are: (1) the latest development of AI technology on the web in education, (2) the challenges faced by AI on the web, and (3) the potential effects and benefits of using AI in science education.

1) The Latest Development of AI Websites in the Education Fields

a. AI Used as a Part of Curricula

The development of AI education for schools is still in its initial phase. Providing pre-tertiary AI education demands thoughtful consideration, especially of the needs of schoolteachers who might not have prior knowledge of AI and students who are acquiring knowledge of this intricate subject at a relatively young age (Chiu et al., 2022). As an effort, many nations have tried to include AI as one of the curriculum activities to support learners in engaging with AI, especially in middle school (Sanusi et al., 2023). One example is the DAILy curriculum by Zhang et al (2022) conducted by an online workshop during the COVID-19 pandemic. The DAIly curriculum provided five modules that focus on one critical technical concept. The module titles are (1) *Introduction to AI* (including algorithmic bias), (2) *Logic Systems* (including logic systems like decision trees), (3) *Machine Learning* (comprises modules 4 and 5), (4) *Supervised Learning* (for example neural network), and (5) *Unsupervised Learning* (including Generative Adversarial Networks). Students favored activities related to ethics that were implanted into the DAIly curriculum, allowing them to apply their learning and understand the moral consequences of technology design, thereby fostering beneficial self-concepts concerning AI.

AI4Future, an initiative at The Chinese University of Hong Kong (CUHK), introduced the first AI curriculum for junior high schools in Hong Kong. The project involves collaboration with local junior high schools (referred to as "pioneering schools") (Chiu et al., 2022). The curriculum complements other subjects and reflects the broad range of use cases and impacts of AI rather than being a standalone subject. The framework focuses on creativity, critical thinking, and ethics rather than requiring teachers to learn robotics and coding. This approach aims to respect differences in learning styles and allow teachers to tailor content to their student's needs and abilities, giving teachers autonomy in designing classroom activities and school-based curricula. The curriculum successfully brings AI subject matter, traditionally taught at the tertiary level, into secondary classrooms. This overview can be seen in Figure 1.

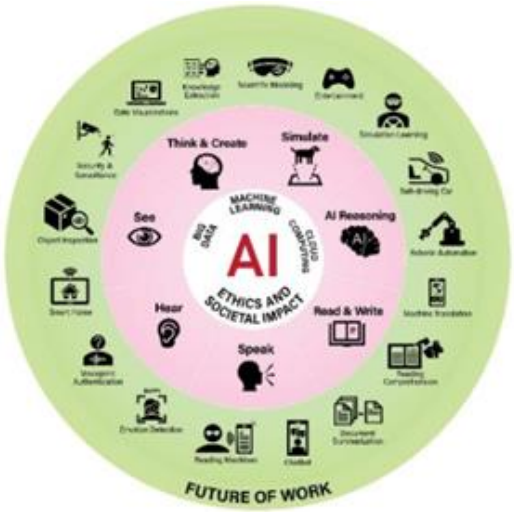

Figure 1. Overview of the New AI Curriculum
Source: (Chiu et al., 2022)

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

b. AI Technology Supports Learning

The emergence of advanced AI tools demonstrates the impact of AI on various aspects of our lives, such as ChatGPT (Hornberger et al., 2023). High-end computers integrated with AI can facilitate teaching through simulation and interactive experiences using a range of sensory channels (Nja et al., 2023). In the research carried out by Castellano et al. (2023) ,satisfaction and usability were achieved using gamified components and AIEd techniques like challenges, ranking, tournaments, and a digital assistant. The students who utilized the application achieved scores that were higher but less varied than those in the control group.

The development of generative AI already has significant implications for science educators (Cooper, 2023). Efficient technical infrastructures, including digital devices, LMS systems, and various educational platforms, were developed in Korea to distribute and operate online classes. These platforms benefit informatics and AI education practice (Lee et al., 2022).

c. Utilize Decision Making

It is crucial to consider the intended goals of technological systems and differentiate between corporations' promoted and actual aims in making informed choices regarding their active participation. (Zhang et al., 2022). Therefore, there is a Technology Acceptance Model (TAM) as a solid theoretical foundation. It is a questionnaire that explains behavior toward technology use and its acceptance based on conscious decision-making and behavioral intentions (Al Darayseh, 2023). Another example is the AIEd techniques, which use recommendation engines based on digital assistants and simple neural networks to communicate with students. These techniques are designed specifically for human anatomy learning applications and are expected to improve students' decision-making in learning anatomy significantly (Castellano et al., 2023).

In recent research conducted by Sanusi et al., (2023), students were introduced to create a PowerPoint presentation material that explains the concept of decision trees. They were asked to create a decision tree to classify various types of pasta and then use it to classify an unknown type of pasta. During the discussion, the students were asked whether the decision tree they built had any bias. This approach to data categorization helped the students understand that decision trees represent the division of a source group into subgroups based on their characteristics. The students' responses revealed their comprehension of how biases can arise from the decisions related to data collection and selection for training algorithms. It can be concluded that decision-making is such an essential skill to classify things based on features that only humans can make accurately, while machines are susceptible to bias and errors. It is also related to scientific literacy, which is crucial in science learning, where individuals can be considered scientifically literate when they are familiar with and engage in inquiry, problem-solving, and decision-making processes (Judson, 2015).

The importance of AI in teaching and learning through the Internet and its accessibility for teachers and students to acquire relevant information should be emphasized (Nja et al., 2023). According to Iyamuremye et al. (2022), online discussions are built on the community of inquiry model. Additionally, Sylvia et al. (2022) found that the web inquiry environment can be divided into two parts: the teacher's room is where the subject teacher can set up materials and virtual labs and provide feedback on student work; the student's class is where students can access particular types of virtual experiments and submit their answers. As we continue to witness significant advancements in computer technology and information processing, it has become crucial to integrate AI into science education. To achieve this, science teachers must proficiently utilize AI as a teaching tool (Nja et al., 2023).

To incorporate biology knowledge into digital resources, one practical approach is to use inquiry learning (Linn et al., 2014) and allow students to ask questions that AI reasoning systems can answer. Dindler's (2023) study illustrates how the DORIT model can assist in creating teaching through the digital technologies children encounter in daily activities that focus on critical inquiry. DORIT stands for “Do your Own Research in Technology” and is rooted in Human-Computer Interaction (research-based) and research-oriented, inviting students to critically examine digital technology in K-9 education through three main components: research area, research questions, and inquiry methods that promote responsible use of intelligent technologies like AI. As a result, the impact of AI applications on communication, schedule, teaching methods, and content significantly contributes to the educational process, and some of the most important areas where AI applications are used are highlighted (Al Darayseh, 2023).

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

2) The Challenges of the Web-Based AI

There are certainly many issues that require attention when implementing AI in education (Wang et al., 2023). It has been discovered that only a few students have had the opportunity to attend a lecture specifically on AI. This poses a significant challenge for educators teaching diverse students, particularly in AI education. Course developers should consider many factors when designing practical AI courses for various student groups (Hornberger et al., 2023). Teaching methods should be differentiated based on student's learning styles (Demir, 2021) and has been a matter of concern since the Merdeka Curriculum was enacted in Indonesia.

Artificial intelligence is taught differently in various countries, due to the resistance to modifying curriculums, and the many other topics likely to be included in school syllabuses (such as environment, gender, or financial education) make it challenging to teach AI to a broader audience beyond those who are already knowledgeable. This challenges AI researchers who want to explain AI to a broader audience beyond university courses (Fernández-Martínez et al., 2021). On the other hand, the development of digital resources for science education is improving faster than research into their effectiveness (Koć-Januchta et al., 2020). As much as AI offers a massive prospect in education, teachers cannot be guaranteed to apply AI during teaching; hence, relevant factors must be considered when sourcing alternatives for the efficient use of AI in science education. AI adoption in science education must catch up, as evidenced by the scanty literature review (Nja et al., 2023).

Based on research by Koć-Januchta et al., (2020); Chiu et al., (2022); Fernández-Martínez et al., (2021); Park & Kwon, (2023); Zhang et al., (2022), AI is more often used in higher education, not for teachers and preservice teachers or secondary school students who are directly involved in the classroom. Even though AI is necessary, more education or support is needed for field or preservice teachers. This creates a gap between the field atmosphere and the policy. Although the Ministry of Education of Korea and related ministries actively promote free semesters with AI education projects, implementing them in schools still presents many challenges (Park & Kwon, 2023). Furthermore, teacher involvement and training in curriculum design are crucial for the AI curriculum's success. However, more thorough research is needed to evaluate curriculum effectiveness robustly and is essential for continually refining the curriculum (Chiu et al., 2022). While educational programs and opportunities in AI are increasingly available, introducing AI education within K-12 schooling poses a challenge. The curricula must be relevant, engaging, and suitable for novice students. Every K-12 student needs to gain skills and knowledge of AI (Zhang et al., 2022). Due to inconsistencies between elementary, middle, and high schools, educational goals and content systems need to be aligned (Lee et al., 2022).

The use of AI in education is rapidly advancing, and it is important to ensure that science teachers are well-informed about AI technology and how to effectively integrate it into their teaching. A study by Al Kanaan in 2022 found that pre-service science teachers require more awareness of AI. Therefore, it is essential for those responsible for science education to focus on training science teachers about the use of AI in education and keeping them updated with the newest AI information. The readiness of teachers to use AI can be measured by four parts: vision, cognition, ethics, and ability. Teachers with different readiness levels tend to have varying attitudes toward AI, innovation, and job satisfaction. Having a critical view of AI (vision), enough knowledge of AI (cognition), and developing teachers' ethical awareness toward the responsible use of AI is as vital as skills and competence in using AI (ability). This is an important issue that has been receiving significant attention from various sectors that have adopted AI (Ng et al., 2021). AI is a rapidly evolving field with frequent developments in new algorithms. It is impractical and unnecessary for human teachers to be programmers. Instead, teachers should be informed consumers capable of selecting suitable AI applications and algorithms to enhance their work and job satisfaction. Therefore, teachers need to possess the necessary vision, knowledge, ethics, and skills such as AI readiness, to make well-informed decisions about the effective use of AI (Wang et al., 2023).

However, there is a need to increase the number of electronic devices with guaranteed labs and performance for AI education and informatics (Lee et al., 2022). This situation is happening in Indonesia, highlighting the urgent need to promote digital skills and access (SMERU, 2022). Besides that, most AI on learning websites for children are in English, for example Cognimates, Survival of the Best Fit, Machine Learning for Kids (Fernández-Martínez et al., 2021), AI4kids, Code.org's AI for Oceans, MIT AI Education Initiative's collection of AI curricula and tools including the Media Lab's

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

AI + Ethics curriculum for middle school, ReadyAI's AI-in-a-box (Zhang et al., 2022), and Google Teachable Machine (Fernández-Martínez et al., 2021; Sanusi et al., 2023). There is a concern that English language learning and teaching may not be as effective in parts of Indonesia with low levels of English proficiency. This is because English is not the native language of Indonesians. According to Alrajafi (2021), the correct and proper use of English in Indonesia is still relatively low, at less than eight percent.

Framing AI as closely intertwined with society (Zhang et al., 2022) effectively engaged students from typically underrepresented groups in computing and STEM. The minority female students were discovered specifically actively examining bias and discussing the issue of under-representation of women of color in market datasets used for visual identification. One student highlighted that AI systems tended to exhibit inherent biases against individuals like her and found this concerning as a woman belonging to a group that should be depicted.

3) AI's Impact and Potential in Science Education.

a. AI Supports Education

AI-powered learning environments can simplify the building of mental models of complex biological phenomena. These environments can connect biological processes with a flexible and responsive ability to answer questions, as Koć-Januchta et al. proposed in 2020. Many studies investigate the reasons behind educators' decision to integrate AI in science education. However, a study by Nja et al. (2023) reported divergent reasons for teachers adopting AI. It explores the aspects affecting the implementation of AI technology in education: anxiety and stress, self-esteem, user-friendliness, action plans, how people feel about using AI, and expected advantages. These aspects were confirmed by a study by Al Darayseh in 2023, which reported that they significantly impacted teachers' intent to use AI. He found that teachers teaching science subjects were more inclined towards using AI in their teaching and learning process.

The gamified recommender system needs to be utilized more effectively to enhance its usefulness. This requires ongoing efforts to personalize the types of advice and the feedback provided. By doing so, the application is proposed to significantly impact students' decision-making process when it comes to learning anatomy with the help of a technological tool that uses game-like elements (Castellano et al., 2023). This confirms Novia' s opinion (2020) that her literature review shows a relationship between the variables studied in general regarding an increase in creativity based on the use of educational games, although its use is most dominant in elementary schools (30%), then subjects or participants aged 19 and 32 as many as 10%, and other levels of education as much as 5%, namely from kindergarten to master's level. Koć-Januchta et al. (2020) writes that, according to the feedback provided by students, the AI feature that suggested questions based on the highlighted text was beneficial for their learning. They also exchanged ideas for further book development, highlighting the necessity for more personalized education and real-time assessment.

In a study by Chiu et al. (2022), it was suggested that a new curriculum framework, an alternative evaluation approach, and a new measure - Perceived AI knowledge (AIKG) could be introduced to the AI education community. This could enhance the learning experience of students concerning AI. The curriculum framework consists of 12 chapters and five levels of depth, as shown in Table 2, to address the introduced pedagogy.

Table 2. Table of Curriculum Framework.

Modules \ Teaching Units (✓)	Awareness	Ethics and Impact	Knowledge	Interactions	Empowerment
1. Introduction to AI	✓	✓	✓	-	-
2. Fundamentals of AI	✓	✓	✓	✓	-
3. "See the World"	✓	✓	✓	✓	✓
4. "Hear"	✓	✓	✓	✓	✓
5. "Speak"	✓	✓	✓	✓	✓
6. "Read"	✓	✓	✓	✓	✓
7. "AI Reasoning"	✓	✓	✓	✓	✓
8. "Simulate"	✓	✓	✓	✓	✓
9. "Think and Create"	✓	✓	✓	✓	✓
10. Societal Good, Societal Impact and Challenges of AI	✓	✓	✓	✓	✓

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Modules \ Teaching Units (✓)	Awareness	Ethics and Impact	Knowledge	Interactions	Empowerment
11. AI and Ethics	✓	✓	✓	-	✓
12. AI and the Future of Work	✓	✓	✓	-	✓

✓ Beginner Unit (BU) ✓ Intermediate Unit (IU) ✓ Advanced Unit (AU)

Source: Chiu et al. (2022)

b. Prior Knowledge Supports AI Readiness

The multiple data collection shows that a middle school can learn and grasp the concepts of machine learning, even with no interest in science-related careers or prior knowledge (Sanusi et al., 2023). Nevertheless, it may be more appropriate to introduce the topic of artificial intelligence to students at a higher level of adulthood. A study by Al Darayseh (2023) concluded that no significant differences were found among education expertise, gender, and qualification regarding their intent to use AI applications in science teaching. Teachers often have comparable situations and skills, resulting in a need for more differentiation. Moreover, the UAE Ministry of Education's vision emphasizes the need for all teachers, regardless of qualification, experience, or gender, to possess essential digital competencies and skills. This mutual understanding between science teachers and the ministry further confirms the importance of such skills.

To succeed, it is essential to have prior university courses on AI, engage in informal learning about AI, possess knowledge of computer science, and demonstrate discipline (Hornberger et al., 2023). Owing to the claim that Machine Learning algorithms mainly carry out the current development in AI, understanding how machine learning algorithms work is essential for AI literacy. It is crucial to build human capabilities to utilize this technology effectively. To achieve this, a proactive approach involves preparing young people from an early age to learn the fundamentals of machine learning operations (Sanusi et al., 2023). Hornberger et al. (2023) state that students with prior experience in AI or a technical study background have higher AI literacy. Future directions suggest that when designing AI courses, educators should take into account the variance of students' prior knowledge. Concerning Fernández-Martínez et al. (2021) research participants' background, all of the students who participated in the study had taken Programming for at least one semester, with a preference for learning Scratch. Children could understand the fundamental concepts of AI by constructing and experimenting with models.

Teachers' guidance is required to effectively use a web inquiry environment that students may need to become more familiar with (Sylvia et al., 2022). Therefore, it is essential to prepare teachers before starting the investigation class by providing workshops and seminars to train them to utilize AI tools. This training will enable them to master AI in their classes, increasing confidence and self-esteem. Incorporating AI training into teachers' education programs would ensure that they are familiar with AI from the early career stages, which could significantly improve their attitudes and self-efficacy toward AI tools. Distributing a manual about effective AI use and its tools for in-service teachers would also enable them to learn about implementing AI easily. Furthermore, the curriculum for science subjects should undergo revision to incorporate AI tools since some teachers might resist using anything not included in the prescribed curriculum. Providing science teachers with easy-to-use tools for integrating AI into their teaching processes improves attitudes towards using AI and self-efficacy (Al Darayseh, 2023; Nja et al., 2023).

c. AI Education Should Include Practical Experience

According to Fernández-Martínez et al. (2021), practical learning experience in Artificial Intelligence (AI) should provide students with hands-on experience in training and testing AI models for speech and image recognition. They suggested conducting an AI workshop as part of their programming, technology, and robotics curriculum for middle school students. According to the result, students included in practical and interactive activities tend to achieve higher scores in motivational evaluations and end-of-term tests. Therefore, the workshop should focus on practical applications of AI rather than theoretical concepts by offering intuitive learning experiences to enhance students' comprehension of AI. The interaction between students and teachers is also crucial for knowledge construction. This allows students to exchange ideas, knowledge, and experiences with one another (Iyamuremye et al., 2022).

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

c. Learning AI Can Be Seen from Various Approaches

AI has become essential to education, especially in science, technology, engineering, and mathematics (STEM). Research in AI education focuses on two approaches -"learning about AI" and "learning with AI." Combining both approaches has proven to be effective in science and mathematics education. Park & Kwon (2023) argue that while AI can serve as a tool in computer science or educational methods, the effect of STEM education on technology education can be profound. They emphasize that educators should introduce AI as cutting-edge technology and address its societal implications. Since AI can play a crucial role in assisting teachers in facilitating and assessing learning (Al Darayseh, 2023), effective teachers must harness technology's potential to enhance students' understanding, arouse their interest in learning, and improve their skills (Abdullah, 2023).

In research by Zhang et al. (2022), 25 secondary school students actively participated in a rigorous summer STEM program, devoting a minimum of 25 hours to DAIly workshops. The students were divided into small groups of 7 or 8 for activities and discussions. This increased motivation and interest in AI, leading to independent work at home. Fernández-Martínez et al. (2021) found that gender differences were insignificant in the results. Girls showed interest in STEM, but further effort is required to cultivate and maintain this interest in STEM among students. There is also ai4stem.org to support research applying AI to STEM education funded by the National Science Foundation and NAEd/Spencer (AI4STEM, n.d.).

d. Career Directions

The concept of cognitive computational thinking is in line with the conventional interpretation of computational thinking in the realm of education. It supports critical computational perspectives, concepts, and practices that benefit students in college and their future careers. In this context, computational empowerment concerns how to empower future generations to make informed technological decisions and act responsibly in a digitized society (Dindler et al., 2023).

Based on the work of Park & Kwon (2023), students can gain insight into future societal changes, particularly those related to AI, and explore opportunities in emerging fields. They can familiarize themselves with different technologies and potential career paths within the fourth industrial revolution, including roles such as app developer, data scientist, and data engineer. By assuming the roles of technology developers, students can engage in collaborative development projects and gain valuable hands-on experience. This exploration of technology education can help students broaden their perspectives on technology-related careers and consider new possibilities within the field. Educators should have a clear vision of AI for education. Educators must possess a definitive understanding of AI's role in education. Despite concerns about AI impacting the job market for educators, it is imperative to recognize that their role cannot be substituted entirely (Wang et al., 2023).

e. The Need to Change Rules in Many Facets to Implement AI

The importance of AI education has led many countries to change their education policies, with policies being established to develop AI talent in schools, research institutes, and collaborating industries (Lee et al., 2022). In the UAE, most schools have access to digital platforms, tools, and applications, which makes it easier for science teachers to incorporate them into their teaching. However, practical ways must be found to reduce teachers' reluctance and raise their confidence in using AI applications when planning science teaching activities (Al Darayseh, 2023). In Nigeria, stakeholders are calling for the inclusion of AI in the science education curriculum. However, it is essential to remember that regardless of the curriculum's quality, the teachers must implement it, and if they do not, it will not be effective (Nja et al., 2023). To implement various learning methods in labs, financial support is needed to establish and manage devices, and research on deploying devices in labs is necessary (Lee et al., 2022).

f. AI literacy

AI systems have the potential to exhibit bias, which can impact their predictions. Therefore, the designers of AI systems need to implement necessary measures to minimize the potential negative impacts caused by biased datasets, models, and predictions. It is also vital for the public to be aware of the possibility of bias in technological systems that might go against them. Such awareness can help people evaluate the impact of these systems and seek justice for themselves and others. To prepare all students for success in the age of artificial intelligence, it is crucial to take specific actions (Zhang et al., 2022). Study participants have been able to consider ethical dilemmas and issues concerning using ML applications, which can help raise ethically aware citizens (Sanusi et al., 2023).

ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Students must have internal attitudes towards learning and digital skills to acquire knowledge effectively. Providing students with advanced technology cannot change learning patterns for optimal knowledge acquisition. Future research should investigate how precise guidance can help regulate students' learning and ensure that AI-enhanced educational resources are used to their fullest potential (Koć-Januchta et al., 2020). Furthermore, the interconnectedness of vision, cognition, ethics, and the utilization of AI can motivate the creation of methodologies to enhance ethical decision-making (Wang et al., 2023). Evaluating the current state of AI literacy is crucial to crafting effective AI curricula accessible to all students (Hornberger et al., 2023).

CONCLUSION

Over the years, numerous investigations have been conducted into utilizing AI in various fields. The research is ongoing to achieve better results and to transition to a digital era. Several papers were published between 2019 and 2023, showcasing the growth of evidence-based research on AI in classrooms. However, the use of AI also has its limitations, such as a lack of funding and a need for more qualified teachers. Despite this, previous literature shows that AI has benefited students and teachers, outweighing the limitations and promising a better education. While there have been instances of AI being effectively utilized in middle school science classrooms, the topic still needs refinement. This review has certain limitations that indicate potential areas for future research. Despite searching prominent scholarly databases using relevant AI-related keywords, there is a chance of biases and missing data during the search and screening process. Given that AI is a technology-driven field, certain studies may concentrate solely on the technology rather than the educational context and may not exclusively focus on web-based applications. Therefore, future studies could refine the search criteria for these potential issues.

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ISSN 2406-9205 (print), ISSN 2477-4820 (online)