Developing Elementary Mathematics Curricula Using Artificial Intelligence Applications from Experts' Perspective

Saeed Awad Alasmari[1,*], Sami M. Alshehri[1], Nedaa A. Alshehri[1], Rafi Zaher N. Alammari[1] & Mahdi Hamad S. Alajmi[1]

[1]College of Education, King Khalid University, Saudi Arabia

*Correspondence: College of Education, King Khalid University, Saudi Arabia

Abstract

The study aimed to explore the role of artificial intelligence (AI) in developing elementary mathematics curricula from the perspective of experts. A qualitative approach was adopted to gather comprehensive data from seven experts, utilizing interviews. The findings revealed that AI plays a significant role in personalizing education to meet students' needs, enhancing their understanding and academic performance, and fostering critical thinking and problem-solving skills. AI also leverages interactive media and virtual and augmented reality to enrich comprehension and increase student engagement with educational materials. However, the study highlighted challenges, such as the absence of clear policies regulating AI integration, high financial costs, and the need for robust technical infrastructure.

Keywords: curriculum development, mathematics curricula, mathematics education, AI applications

1. Introduction

The Ministry of Education in Saudi Arabia is deeply committed to transforming educational curricula to meet the demands of a rapidly changing world. By designing and modernizing these curricula, the ministry ensures they align with advancements across diverse fields and reflect the dynamic realities of the modern era. This initiative aligns with global trends shaped by the Fourth Industrial Revolution, emphasizing innovation and adaptation to scientific and technological breakthroughs. Furthermore, the ministry is focused on fostering 21st-century skills, demonstrating a steadfast dedication to realizing the ambitious goals of Vision 2030. Central to this vision is the development of forward-thinking curricula that prioritize essential skills, cultivate individual talents, and build character. These efforts aim to prepare a generation ready to tackle the challenges of tomorrow with confidence and competence.

Education is a cornerstone of national progress and a primary tool for societal development across all segments. The curricula adopted by educational institutions play a critical role in achieving educational objectives. As time waits for no one, the accelerating pace of global change calls for urgent action. It is imperative to equip future generations with the ability to think critically, articulate their ideas, and express their perspectives effectively (Mohi & Jabr, 2017).

Throughout history, the curriculum, the teacher, and the learner have been the three fundamental pillars of the educational process, whether in traditional or modern systems. The curriculum serves as the central element linking the teacher and learner within the educational context, and it is through the curriculum that the quality of educational outcomes is assessed. These outcomes, represented by the graduates of the educational system, form the foundation for building and developing society (Al-Omari, 2023).

In light of the digital revolution, education and curricula have become central topics of ongoing discussions in recent years. Education is now recognized as a critical investment in the future of nations. Given the significant role educational institutions play in this digital transformation, it has become essential for the education system to adapt to the developments brought about by this revolution at all levels. This adaptation requires updating curricula to include 21st-century skills, enhancing critical and creative thinking, and fostering the ability to adapt to new challenges. Moreover, educational institutions must adopt new technologies and innovative teaching methods to meet the evolving needs of students.

Educational institutions need to harness the technologies of the digital revolution to support the educational process.

The rapid advancement of artificial intelligence has recently become a decisive factor in shaping the nature of future jobs, which require new skills referred to as 21st-century skills. Therefore, it is essential for curricula to include content that promotes and develops these skills while introducing innovative ideas to enhance innovation and development in schools, colleges, and educational leadership. The goal is to prepare a generation capable of keeping pace with the fast-changing developments in various fields (Haddada, 2019).

The profound impact of technology on educational systems has led to fundamental changes in relationships, concepts, and lifestyles. The curriculum is a core component of the educational process and has interacted significantly with these changes. It serves as the backbone of the educational process and provides a framework for achieving desired objectives. With technological advancements, the approaches to addressing educational objectives and methods of achieving them have been redefined, making it imperative for the curriculum to play an effective role in facilitating these objectives in line with technological developments (Al-Sharman, 2013).

For this reason, both developed and developing countries strive to improve their educational curricula to align with modern transformations and enhance their citizens' abilities to become productive individuals capable of addressing global and local challenges. Since mathematics plays a pivotal role in both the present and the future, particularly in scientific and technological advancements, it is essential for mathematics curricula to adapt to these changes. Such adaptation will empower students to connect mathematical concepts to their real-world experiences and daily lives (Al-Shazly, 2018).

Updating and improving mathematics curricula is a major educational responsibility due to its significance in meeting societal needs and aspirations while linking mathematics to life and ongoing progress. This development addresses current shortcomings in mathematics curricula and aims to keep pace with global technological advancements. These advancements have become essential tools that students need to effectively handle future information and challenges. Such tools enable them to learn, search for information sources, and select the most appropriate information for educational contexts (Al-Qaisi, 2014; Salem, 2023).

For over a decade, the Saudi Ministry of Education has been working on developing mathematics curricula through the Mathematics and Natural Sciences Development Project. This initiative focuses on aligning with distinguished global series across all stages of public education. The project aims to transfer knowledge based on globally accredited standards in mathematics and natural sciences (Ministry of Education, 2016). One of the most notable outcomes of this project is the design of textbooks with high-quality educational and technical specifications, representing a significant leap in mathematics education and curriculum design (Al-Muathim, 2020).

The development of educational curricula is a pivotal step in achieving Saudi Arabia's Vision 2030, which aims to provide education that contributes to strengthening the national economy. This vision emphasizes the design of advanced curricula that focus on essential skills and seek to enhance the efficiency of the educational system and its pedagogical programs. All of this is undertaken within the framework of preserving religious constants and social values, in alignment with the latest global trends in education.

The relationship between artificial intelligence (AI) and education is complementary, as both contribute to enhancing each other. Education focuses on developing minds capable of expanding their horizons and utilizing knowledge, while AI provides tools that enable a deeper understanding of the mechanisms of human cognition. The digital nature of AI also opens doors to interactive educational opportunities not offered by traditional tools, such as textbooks. Consequently, AI applications in education drive innovation and explore new boundaries in learning, leading to ongoing technological and educational advancements (Khuwaildi, 2019).

Digitization and artificial intelligence are among the key pillars in developing educational curricula and academic evaluation methods. Data and analytics can be utilized to identify optimal educational strategies and develop innovative and effective educational content. AI also contributes to advancing assessment systems that enhance understanding of students' progress and help identify areas requiring additional support. As technology and digital tools advance, education is undergoing a significant transformation toward integrated and advanced digital learning environments, enhancing student interaction with content and deepening their comprehension of academic materials. AI and digitization have thus become major drivers of digital transformation in education, opening new horizons for improving the quality of education, fostering its development, and providing comprehensive and advanced learning experiences for students (Ballaj, 2018).

AI serves as a strategic tool for organizing educational systems by providing advanced digital learning platforms that integrate deep learning techniques. These platforms include interactive graphics, innovative game-based problem-solving models, virtual agents for teaching, and the provision of precise and context-sensitive feedback, as

well as the enhancement of curricula. AI-supported education is revolutionizing learning processes by employing simulation and incorporating human-inspired teaching strategies, heralding a new era in education (Malik et al., 2019).

In light of recommendations from educational bodies and organizations emphasizing education as the foundation of civilizations, UNESCO's General Directorate has highlighted that AI will bring about radical changes in education. These changes are expected to revolutionize teaching tools, learning methods, and access to knowledge. Furthermore, AI can accelerate the achievement of global educational objectives by reducing barriers to education (Sawalmeh, 2020). The Saudi Association for Mathematical Sciences (2020) has indicated that AI technologies will continue to evolve, potentially shaping a new reality for education. These technologies are expected to become widespread and widely applied in education and learning globally in the coming years. Despite concerns surrounding the use of AI technologies, both local and global experiences have demonstrated that this technology provides effective solutions to challenges in learning various academic subjects, particularly mathematics.

Mathematics is considered one of the fundamental pillars of primary education, playing a pivotal role in developing students' critical and logical thinking skills from their early stages. Despite the notable advancements in mathematics curricula over the past decades, teachers still face increasing challenges in delivering content that accommodates individual differences among students and meets their diverse educational needs. Amid rapid digital transformations and increasing reliance on technology in various aspects of life, AI applications have emerged as an innovative tool to improve curriculum quality and enhance teaching strategies. This highlights the need to explore ways to integrate these applications into the development of primary mathematics curricula.

Given the significance of AI and its applications, along with the ongoing transformations in knowledge, skills, and acquisition methods, the importance of these changes for mathematics cannot be overstated. Thus, there is a growing need to identify trends for developing primary mathematics curricula using AI applications.

2. Research Problem

Despite Saudi Arabia's significant efforts to develop the educational process in various aspects, particularly in digital transformation. As a result of the scarcity of studies that highlight the role of AI in curriculum development—specifically in mathematics curricula— this research is one of the earliest studies on both local and Arab levels. Given the importance of such development, reexamination of the curriculum development has therefore become essential to align with these advancements. Existing curricula require qualitative upgrading that align with technological developments, enhance critical thinking skills, and foster the scientific curiosity that underpins innovation and creativity. These curricula must also contribute to building individuals' knowledge and experiences in a manner that keeps pace with the rapid requirements of the era, meets individual needs, and aligns with national development plans and future labor market requirements.

Previous studies have emphasized the importance of leveraging AI applications in education. For instance, Al Saud (2017) predicted that AI would open new horizons for curriculum development, teaching strategies, and educational technologies across various fields of knowledge. This calls on educators to harness the unique advantages of AI applications, focusing on their careful design and implementation to ensure their effective use in the educational process and achieve optimal learning outcomes. Similarly, Al-Shibl (2021) highlighted the necessity of integrating AI-based technologies into teaching and learning mathematics, enhancing the educational environment with AI-driven tools, devices, and robots as educational resources, and adopting AI approaches in mathematics education. Al-Musaad (2023) also stressed the importance of incorporating AI concepts and applications into textbook content.

Through the researchers' experiences as a teachers and educational supervisor in mathematics, a significant decline in the performance of elementary school students has been observed. This is corroborated by the performance of Saudi students in international assessments such as TIMSS in 2003, 2007, 2011, 2015, and 2019, which revealed a clear weakness in mathematical achievement. Furthermore, the national assessments conducted by the Saudi Education and Training Evaluation Commission indicate a general decline in students' performance in mathematics.

Based on the importance of mathematics in elementary education, the importance of artificial intelligence, and the desire to keep pace with scientific and technological advancements, this study seeks to explore and review relevant literature to answer the following primary question: What is the role of AI applications in developing elementary mathematics curricula from the perspective of experts?

3. Methodology and Procedures

The current study relied on the qualitative method, due to its suitability for the study questions and achieving its objectives; it helps to extract the results related to the attitudes of mathematics teaching experts regarding the development of elementary mathematics curricula using AI applications from the study sample. The open-ended interview tool was used whereby the research tool was built by referring to the theoretical literature. The interview was conducted individually with the study sample, and thus the researcher relied on the opinions of the sample members. A total of 5 interview questions related to the development of elementary schoolmathematics curricula using AI applications were asked from the experts' point of view, and all responses of the study sample were written down as indicated by them, and data were collected from the interview transcripts.

3.1 Study Sample

The study tool was applied to seven professors of mathematics education, professors of educational technologies in Saudi universities, and mathematics supervisors in public education. The sample included four professors of mathematics education at universities, two professors of educational technologies, and an educational supervisor specialized in mathematics education technologies.

3.2 Study Instrument

Considering the study questions and objectives, based on previous studies and the theoretical framework of the study topic, as well as referring to international peer-reviewed scientific journals, and reading about methods of building qualitative research tools that are part of the data collection tools, the researcher designed the interview tool, which consists a set of questions. The interview was of an open-ended type to study the opinions of experts towards developing elementary mathematics curricula using AI applications. Each interview was recorded, and the duration of the interview ranged from 15 minutes as a minimum to an hour as a maximum with each respondent individually, as the interview was semi-structured according to the sequence of questioning according to their position within the interview questions.

4. Results and Discussions

Firstly, discussing and interpreting the results of the first question: How do experts perceive the role of artificial intelligence in developing mathematics curricula?

As follows: All experts confirmed that AI is a pivotal element in developing primary mathematics curricula. Meanwhile, experts 1, 4, and 6 indicated the prominent importance of applying AI in specializing education and analyzing students' performance. According to Expert 1, AI is capable of adjusting the level of difficulty of questions according to the student's level, ensuring the delivery of content that suits their learning needs. Moreover, Expert 4 emphasized that AI can design individualized, targeted exercises based on students' strengths and weaknesses, which enhances the effectiveness of the learning process. In addition, Expert 6 highlighted the role of AI in providing personalized learning paths based on the analysis of student performance data, which contributes to improving academic achievement. Such opinions are congruent with the study recommended by (Li, 2024) regarding the importance of analyzing performance using artificial intelligence to enhance specializing education Similarly, the study of Qiu (2022) shows that artificial intelligence through deep learning and data analysis techniques can contribute to improving students' academic performance. Both Experts 4 and 6 emphasized the pivotal role of AI in enhancing students' critical thinking and analysis by designing educational activities focusing on solving issues and applying mathematical concepts in innovative ways. As Expert 4 explained the importance of these activities to promote analytical thinking to support students in dealing with complex mathematical tasks more effectively. Expert 6 explained the ability of AI to provide innovative educational applications promoting the internalization of mathematical concepts in non-traditional ways. These views are aligned with Gao's study, which focused on the role of AI in developing innovation and independent thinking through innovative educational strategies. Al-Omari's (2023) also supported this view, as it recommended the necessity of including the characteristics of innovation in educational curricula to enhance students' critical thinking. Experts 3, 4, and 6 mentioned the significant role artificial intelligence could play in facilitating the assessment and feedback process. In particular, Expert 3 noted that AI provides immediate assessment of students, which helps them understand their strengths and weaknesses in real time. While Expert 4 emphasized that the technology provides quick and accurate feedback, which helps teachers to improve their performance and provide the necessary support for each student according to their learning situation. Meanwhile, Expert 6 emphasized that continuous assessment using AI has a significant and effective role in student outcomes via better monitoring of their progress. The aforementioned perspectives are aligned with Hwang's study

(2022), which proved the effectiveness of immediate assessment using AI in improving students' academic performance. Additionally, Qiu (2022) study also supported this perspective, indicating that smart assessment tools provide an accurate measurement of student progress, contributing to the improvement of the educational process.

Secondly, discussing and interpreting the results of the second question: What tools and applications can be used to integrate artificial intelligence into mathematics curricula?

It has been demonstrated through expert responses that numerous tools and applications can be utilized to integrate artificial intelligence into mathematics curricula, contributing to its development and enabling interactive and effective learning. Among these applications, as highlighted by Expert 1, is the GeoGebra application, which allows for the simulation of geometric shapes and the visualization of graphs. Additionally, the Mathway application was mentioned, covering a wide range of problems from basic arithmetic to calculus. In addition to the aforementioned applications, Photomath and MyScript provide detailed solutions with clear step-by-step explanations. These tools align with the study by Hwang (2022), which emphasized the effectiveness of intelligent assessment tools in enhancing student performance by offering targeted instruction and precise analysis. Expert 2, on the other hand, focused on the role of AI platforms such as ChatGPT as a primary tool for analyzing mathematical texts and equations, alongside tools like Microsoft Copilot and Gemini, developed by leading companies to keep pace with advancements in artificial intelligence. The expert also highlighted the advantage of customizing educational experiences through models like CustomGPT. These perspectives are consistent with the study by Egara and Mosimege (2024), which recommended the use of chatbots to improve student engagement and enhance learning efficiency. On the other hand, Expert 3 highlighted interactive tools such as CoSpaces, which support the creation of virtual environments to understand geometric shapes, and Mathletics, which offers educational games to encourage the learning of mathematics. Additionally, systems like DreamBox and Knewton were mentioned for their ability to analyze student performance and provide targeted feedback. This perspective aligns with the study by Li (2024), which emphasized the importance of specialized education using performance analysis tools to enhance academic achievement. Furthermore, Expert 4 discussed systems like Smart Sparrow and ALEKS, which deliver personalized instruction based on student data analysis. The expert also referred to virtual reality applications such as GeoGebra AR and VR Math, which enhance understanding through immersive educational experiences. Additionally, assessment tools like Gradescope and ASSISTments were mentioned for their capability to provide instant feedback. These insights are consistent with the results of Al-Sheidi (2022), which highlighted the role of virtual reality in improving student comprehension and increasing interaction. Expert 5 mentioned various applications such as ChatGPT, Claude, and Gemini, alongside interactive media tools like DALL-E and Fliki, which contribute to creating visual and interactive educational content. These applications align with the results of Gao (2020), which emphasized the role of interactive media in improving the quality of education and clarifying mathematical concepts. Expert 6 highlighted several applications and tools, including intelligent educational systems like Smart Sparrow and ALEKS, which provide personalized instructions based on student performance analysis. Machine learning applications such as Google TensorFlow and Microsoft Azure Machine Learning were also mentioned for their support in developing smart educational experiences and analyzing academic performance. Additionally, the expert underlined the importance of virtual and augmented reality applications like GeoGebra AR and VR Math, agreeing with Expert 4 on their ability to offer interactive experiences that foster a deeper understanding of mathematical concepts. Other supportive tools, such as Photomath and Wolfram Alpha, were mentioned for helping students solve mathematical problems with detailed step-by-step solutions. Educational robots like Dash & Dot and Root Robot were also highlighted for teaching logical thinking and programming in an engaging manner.

The expert further discussed the role of analytics platforms like Edmodo Insights and Knewton, which analyze student progress and assist teachers in tailoring effective teaching strategies. Finally, direct applications such as Photomath, Mathway, and Microsoft Math Solver were noted for their ability to provide detailed solutions and visually represent equations through graphs. Expert 6 perspective is consistent with the results of Hwang (2022) on the role of assessment systems in improving student performance through data analysis, Li (2024) on the importance of tools like GeoGebra AR and VR Math in supporting mathematical concept learning, and Gao (2020) on the significance of educational robots in fostering logical thinking and connecting mathematics to real-world applications.

Thirdly, discussing and interpreting the results of the third question: What opportunities can the use of artificial intelligence provide for improving mathematics education?

Expert responses revealed numerous opportunities provided by artificial intelligence to enhance mathematics education. As experts 1, 4, 5, and 7 particularly emphasized personalized learning and performance analysis as

significant opportunities for improvement. Expert 1 highlighted the capability of Artificial Intelligence to offer tailored instruction based on analyzing students' performance and addressing their specific needs. Moreover, experts 4 and 5 underscored the role of Artificial Intelligence in individualizing education and analyzing performance data to pinpoint each student's strengths and weaknesses. Furthermore, expert 7 focused on the philosophy of differentiated learning, advocating for the design of educational pathways that cater to individual differences among students. Accordingly, these perspectives align with the results of Li (2024), which emphasized the importance of leveraging Artificial Intelligence tools for specialized education to enhance the overall learning experience. Qiu (2022) study confirmed that performance analysis helps provide education that meets the individual needs of students. Experts 1, 6, and 7 discussed the role of artificial intelligence in improving assessment and providing feedback. Expert 1 emphasized that AI provides immediate feedback to help students correct mistakes and improve performance, Expert 6 highlighted the enhancement of ongoing assessment through systems that offer personalized and comprehensive feedback. Expert 7 explained the artificial intelligence role in analyzing performance data to create more precise learning plans. These propositions align with the findings' study of Hwang (2022), which affirmed the efficacy of intelligent assessment tools in enhancing academic performance. Al-Shaidi (2022) study supported the role of feedback in improving comprehension and fostering self-directed learning. Experts 2, 5, and 7 concurred that artificial intelligence can assist teachers by automating routine tasks, thereby reducing their workload. Expert 2 specifically pointed out that AI can save teachers time and effort by automating daily routine tasks. Expert 5 explained that artificial intelligence can assist teachers in creating activities, designing lessons, and generating ideas. Expert 7 focused on the role of artificial intelligence in improving teaching performance by building educational plans based on student data analysis. All these opinions align with the findings of Egara and Mosimege (2024) study, which indicated that artificial intelligence can help reduce teaching workloads and improve teachers' professional performance. Experts 3, 6, and 7 concurred on the potential of artificial intelligence to foster interaction and interactive learning, and Expert 3 specifically highlighting the diversity of ways information can be presented, such as through audio, video, and visuals. Expert 6 drew attention to virtual and augmented reality technologies, which can enhance student engagement with mathematical concepts. Expert 7 highlighted that artificial intelligence contributes to creating enjoyable learning environments that foster interaction and lead to significant knowledge advancements. This aligns with Gao (2020) study, which emphasized the importance of interactive media and virtual reality in enhancing understanding and increasing student engagement with educational materials. The fifth opportunity that experts 1, 6, and 7 agreed upon is to encourage critical thinking and problem-solving. Expert 1 pointed out that artificial intelligence can support the development of critical thinking by simulating complex mathematical models.

Expert 6 focused on the role of AI in providing learning environments that promote interaction and problem-solving, and Expert 7 clarified that intelligent tools can enhance critical thinking and systematic analysis of mathematical problems. The study of Li (2024) emphasizes the significance of enhancing critical thinking skills using AI applications designed to aid in problem-solving, and one of the opportunities that the experts highlighted is preparing students for the future job market. Both Experts 6 and 7 emphasized this point. Expert 6 highlighted that AI helps students acquire analytical and technical skills aligned with the demands of the job market. On the other hand, Expert 7 focused on building the intelligent skills that students will need in the future. This is supported by Gao (2020)s, which found that AI education prepares students for the job market by developing technical and analytical skills.

Fourthly, a discussion and interpretation of the results of the fourth question: What are the challenges of implementing artificial intelligence in developing mathematics curricula?

All experts agreed that artificial intelligence presents a significant opportunity to enhance mathematics curricula and improve the educational process. However, successful implementation requires overcoming numerous challenges through effective strategies that ensure the desired benefits are achieved without compromising the quality of education. Upon collecting the experts' responses, these challenges were categorized into seven main axes: policies, technical aspects, human skills, privacy, tool-related challenges, psychological, social, and educational aspects. Both experts 1 and 6 emphasized the absence of clear policies and plans to guide the use of artificial intelligence in education, and this opinion aligns with the recommendations of Al-Hakmi (2023) study, which called for establishing appropriate frameworks and standards for implementing AI programs in schools in the Kingdom. Li (2024) study emphasized on the importance of having clear policies to regulate the use of AI in a manner consistent with the local context. Experts 1 and 4 identified the transfer of experiences without adaptation to the local context as a prominent challenge. Al-Sheedi (2022) study recommended the necessity of adapting AI tools to align with the local context for greater effectiveness. Al-Ghamdi (2023) study recommended that policymakers and decision-makers in educational institutions strive to implement AI programs and raise awareness about their positive impact. Al-Sunni and

Al-Barami (2024) study recommended designing and adopting policies, programs, and making plans to integrate AI applications into mathematics teaching and learning. The second challenge that the experts highlighted was the technical aspect challenge, Experts 1, 3, 5, and 6 agreed on the high financial cost of equipment and maintenance. Experts 1 and 6, meanwhile, pointed out the weakness of the infrastructure in some educational institutions. Moreover, Expert 6 emphasized the need for continuous updates to tools and applications. Experts 1, 3, and 5 clarified the inadequacy of technological equipment in schools. These challenges align with the findings of Hwang (2022) study and Al-Dhahli (2024) study, both of which underscored the importance of developing technical infrastructure and internet networks to ensure the effective utilization of artificial intelligence. Qiu (2022) study emphasized that high costs pose a significant barrier, particularly in resource-constrained countries. Egara and Mosimege (2024) study pointed out the impact of rapid technological changes on educational institutions and the need for sustainable resources. Regarding the third challenge, which is related to human skills and training, experts 1, 4, 5, and 6 highlighted a lack of training and experience in dealing with AI tools. Additionally, experts 1, 5, and 6 emphasized the ongoing need for training programs that keep up with technological advancements. Experts 3 and 5 highlighted the need for specialized technicians to ensure the efficient operation of systems.

All of these viewpoints, in line with Qiu (2022) study, in emphasizing the urgent need for ongoing training programs to enhance teachers' proficiency in using artificial intelligence technologies. Other studies, such as (Al-Sani and Al-Baroumi, 2024; Al-Obaidaniah, 2024; Al-Dhahli, 2024; Al-Shabal, 2021; Al-Shaidi, 2022), support this view by recommending intensive training opportunities for teachers to enable them to utilize AI applications in education. Additionally, Gao (2022) study highlighted the importance of investing in human resource development to ensure maximum benefit from these technologies. As Hwang (2022) study emphasizes, there is an urgent need for specialized technicians to provide ongoing technical support and ensure the continuous operation of systems. Following this, the experts discussed the issue of privacy and security, Experts 1, 3, 5, 6, and 7 emphasized the paramount importance of protecting the privacy of student and teacher data when utilizing these technologies. As highlighted in Li (2024), it is imperative to enact stringent regulations and laws to protect data and ensure the ethical use of artificial intelligence. In addition, Hwang (2022) study underscores the necessity of enhancing trust in AI tools by providing comprehensive protection for student data. Regarding the fifth challenge, which addressed the issues related to tools and algorithms, both Experts 2 and 3 highlighted the challenge of hallucinations, referring to the generation of illogical responses. This aligns with the findings of Gao (2020) study, which identified the problem of AI tools providing misinformation and its impact on user trust. Experts 1 and 3 elaborated on the errors that occur within student performance evaluation algorithms. This corroborates (Qiu, 2022) study, which emphasized the need for developing precise algorithms to avoid unreliable student performance evaluations. Additionally, Experts 1 and 5 highlighted the scarcity of applications that support mathematics education for certain age groups and, in some cases, Arabic language learning. This aligns with (Li, 2024) study, which emphasized that the scarcity of specialized applications hinders the achievement of educational goals using artificial intelligence. The sixth challenge highlighted the psychological and social aspects, so Experts 1, 4, and 5 identifying the resistance of teachers and students to adopt these applications poses a significant challenge. This is in line with (Li, 2024) study, which emphasized the need to address resistance to change through appropriate training and guidance. Experts 6 and 7 discussed the impact of social isolation resulting from reduced human interaction during technology use, this finding aligns with (Gao, 2020) study on the detrimental effects of excessive technology reliance on human interaction, exacerbating social isolation. Additionally, Experts 3 and 5 highlighted a decline in students' motivation to learn, a finding supported by (Hwang, 2022) study, which emphasized the importance of enhancing student motivation through engaging interactive tools to enhance enjoyment in learning. Finally, the seventh and final challenge focused on educational and pedagogical aspects, as Experts 1, 3, and 5 expressing concerns that over reliance on artificial intelligence can diminish thinking and reasoning skills. This aligns with (Gao, 2020) study, which highlighted the detrimental impact of excessive reliance on artificial intelligence on diminishing students' critical thinking and creativity. Meanwhile, Experts 3, 4, and 5 emphasized the challenge of students' irresponsible use of AI. Experts 1, 6, and 7 discussed the negative impacts on human interaction between teachers and students. Additionally, Experts 1, 6, and 7 highlighted the diminishing role of the traditional teacher. These perspectives align with (Li, 2024) study, which emphasized the importance of guiding students and teachers in the responsible use of AI tools. Furthermore, (Al-Shaidi, 2022) study highlighted the need to enhance the role of teachers as mentors and facilitators in the educational process during the implementation of technology.

Fifthly, a discussion and interpretation of the results of the fifth question Answering the fifth question of the study questions: How can AI-based mathematics curricula impact students' academic achievement and skill development?

All experts agree that AI-based mathematics curricula are a powerful educational tool that contributes to improving

academic achievement, critical thinking, problem-solving, self-directed learning, 21st-century skills development, and boosting confidence in mathematics. In the realm of improving academic performance, experts 1, 3, 5, 6, and 7 highlighted that AI-based mathematics curricula contribute to improving academic achievement by the following: Experts 1, 5, and 6 confirmed that AI-based mathematics curricula provide personalized content tailored to students' individual needs and levels, whereas Expert 3 highlighted that AI-based mathematics curricula ease accessing information and provide diverse learning resources such as texts, images, and videos. Moreover, Experts 5 and 7 discussed that AI-based mathematics curricula provide personalized exercises and practices with immediate feedback to support the learning process and enhance academic achievement. These findings align with (Li, 2024) study, which recommended the importance of personalizing learning using AI to improve academic performance, (Hwang, 2022) study that demonstrated the role of intelligent tools in providing immediate feedback to enhance academic performance, and (Al-Hakmi, 2023) study that emphasized the importance of using AI tools to support students with personalized practice. Regarding the development of critical thinking and problem-solving skills, experts 1, 4, 5, 6, and 7 stated that AI-based mathematics curricula foster critical and creative thinking by designing challenging problem-solving activities. Experts 1, 4, and 6 further emphasized this point, while experts 5 and 7 highlighted the role of advanced technological tools in promoting analytical thinking. This is in line with (Gao, 2020) study, which confirmed the role of AI in developing critical thinking and problem-solving skills. Furthermore, (Al-Omari, 2023) study recommended incorporating innovative features to enhance students' critical thinking. and (Saad Allah and Shatouh, 2019) study highlighted the importance of AI-based creative activities. Experts 1, 5, 6, and 7 highlighted the impact of AI in fostering self-directed learning by providing personalized learning content that enables students to learn at their own pace and by offering accessible learning tools anytime and anywhere. (Li, 2024) study supported this finding by recommending the importance of AI-based tools in supporting self-directed learning. (Saad Allah and Shatouh, 2022) study further emphasized that AI enhances students' independence in learning. Experts 1, 5, 6, and 7 pointed out that AI empowers students to develop life skills and 21st-century skills such as analytical and creative thinking, as highlighted by experts 1 and 6, and effective technology use, according to experts 5 and 7. Expert 5 further added decision-making and responsibility to this list. This aligns with (Gao, 2020) study which indicated the importance of AI in developing critical thinking and creativity, and (Egara and Mosimege, 2021) study that confirmed AI role in enhancing analytical and technological skills. Experts 5 and 7 had a unique perspective on the impact of AI on boosting students' confidence in mathematics. According to Expert 7, this is achieved through the creation of personalized math exercises. Expert 5, on the other hand, emphasized the crucial role of immediate feedback in improving performance and, consequently, boosting students' self-confidence and confidence in the subject. This aligns with (Al-Hakmi, 2023) study, which addressed the impact of personalized practices on boosting students' confidence, and (Hwang, 2022) study that emphasized the significance of feedback in improving students' confidence in mathematics. Expert 1 added that if teachers and students who are interested in technology were given opportunities and support, such as organizing hackathon or tech gatherings for math teachers, especially those interested in building and developing AI-powered software and tools for math education, it would help us produce local content for these technologies. This is in line with (Egara and Mosimege, 2021) study, which highlighted the need for enhanced collaboration between teachers and developers to ensure the development of technological tools that meet educational needs.

5. Discussion

Based on the foregoing, the results of this study confirm that artificial intelligence is a promising and powerful tool for developing mathematics curricula, as it effectively contributes to improving academic achievement and fostering a wide range of skills among students. The results highlight the multifaceted dimensions of artificial intelligence applications, including the personalization of learning based on student needs, the enhancement of critical thinking, and the support of self-directed learning and the development of life skills aligned with the demands of the 21st century. However, the full potential of these technologies remains contingent on the ability to address the challenges associated with their integration. Thus, the significance of integrating artificial intelligence with the development of mathematics curricula is reflected in its pivotal role, as it supports personalized learning by analyzing student performance and delivering personalized content based on their needs. These capabilities align with the recommendations of studies by Li (2024) and Qiu (2022), which emphasized the importance of performance analysis in supporting individualized education and enhancing academic achievement. Furthermore, artificial intelligence has demonstrated substantial potential in fostering critical thinking, problem-solving, and creative thinking through the design of innovative and adaptive educational activities, as highlighted by studies such as Gao (2020), Al-Omari (2023), and Saad Allah and Shatouh (2019), which underscored the importance of AI-powered activities in nurturing

creative thinking. Regarding the conclusions related to artificial intelligence tools and their supportive applications, tools such as GeoGebra, Mathway, and Photomath demonstrate their ability to enhance conceptual and procedural understanding. Meanwhile, applications like ChatGPT and Smart Sparrow contribute to improving interaction and personalization of learning as supported by studies such as Hwang (2022) and Egara and Mosimege (2024), which confirmed the effectiveness of chatbots and interactive applications in enhancing educational outcomes. In addition to the exceptional opportunities provided by artificial intelligence to enhance the educational process—through personalized learning, improved assessment methods, and teacher support—it also promotes interactive and self-directed learning, cultivates critical and creative thinking, and improves teaching efficacy by enabling the creation of lesson plans aligned with students' proficiency levels. These results are corroborated by studies such as Li (2024) and Hwang (2022), which underscored the role of artificial intelligence in delivering real-time feedback and creating personalized learning paths. Additionally, Egara and Mosimege (2024) study demonstrated that artificial intelligence contributes to alleviating teaching workloads and improving teachers' professional performance. The conclusions also pointed to challenges related to the integration of artificial intelligence, including the lack of clear policies, insufficient infrastructure, resistance to change, high costs, inadequate training, and privacy concerns. These challenges were corroborated by studies such as Al-Sheidi (2022) and Al-Dhahli (2024), which emphasized the critical need to develop robust technical infrastructure to address issues related to high costs and technological deficiencies. Li (2024) study underscored the critical need for developing clear policies to govern the use of artificial intelligence, a perspective that aligns with Qiu (2022), which emphasized the significance of ongoing training programs to improve teachers' competence in leveraging artificial intelligence effectively. Al-Senny and Al-Barumi (2024), Al-Abidaniya (2024), Al-Dhahli (2024), Al-Shibl (2021), and Al-Sheidi (2022) studies underscored the necessity of offering teachers opportunities to engage in training workshops focused on using AI application in education, as well as adequately preparing and equipping them with relevant competencies, which aligns with the results of Gao (2020), which emphasized the critical importance of investing in professional development to ensure the effective and efficient use of these technologies. The study results also demonstrated a clear positive impact of artificial intelligence on improving academic performance and developing life skills, along with 21st-century competencies. This outcome is consistent with Gao (2020) and Li (2024) studies, which highlighted the role of AI applications in enhancing creative and analytical thinking skills.

6. Recommendations

Based on the significance and results of the current study, the following recommendations can be proposed:

1. Collaborating with technology-supporting entities, such as the Saudi Data & AI Authority (SDAIA) and the National E-Learning Center, to establish policies and regulatory frameworks governing the utilization of AI applications in educational curricula, ensuring complete privacy and secure processing of data.

2. Leveraging the technological advancements in artificial intelligence tools to enhance educational curricula by incorporating supportive tools and developing comprehensive instructional guides that promote their effective use and facilitate training for teachers. Additionally, adopting artificial intelligence technologies and tools to support the personalization of learning content.

3. Developing comprehensive training programs to empower teachers and students in leveraging artificial intelligence tools, coupled with crafting innovative educational strategies that seamlessly integrate these advanced technologies.

4. Fostering community partnerships with the private sector to invest in the technological infrastructure of schools, which includes equipping them with modern devices, networks, and applications, as well as providing specialized technicians for ongoing technical support to ensure the seamless and effective integration of artificial intelligence in education.

5. Embracing the integration of smart systems through artificial intelligence applications in mathematics curricula, recognizing their effectiveness in enhancing educational outcomes and aligning with technological advancements.

6. Promoting innovation among students, teachers, and curriculum developers to design artificial intelligence tools that meet local educational needs, aligned with age and academic levels,

7. through the development of creative solutions, specialized training, and collaboration with technology experts to enhance creativity in mathematics education.

7. Suggessions

Building on the conclusions and recommendations, a range of proposals and ideas for future research can be put forward, including:

1. Assessing the proficiency of mathematics teachers in utilizing AI applications.

2. Examining the impact of AI technologies on cultivating critical and creative thinking skills in mathematics.

3. Exploring the effects of integrating AI into mathematics curricula to strengthen mathematical expertise.

4. Creating interactive AI-powered learning platforms to evaluate student progress and deliver personalized learning content.

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