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Exploring the Potential of AI Integration in Mathematics Education for Generation Alpha — Approaches, Challenges, and Readiness of Philippine Tertiary Classrooms: A Literature Review

Peter John M. Melchor*, Laila S. Lomibao, Jennifer O. Parcutilo

University of Science and Technology of Southern Philippines, Cagayan de Oro City, Philippines
*Corresponding author: peterjohn.melchor@ustp.edu.ph

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Abstract This literature review aims to explore the integration of Artificial Intelligence (AI) in mathematics education for Generation Alpha students. It examines approaches, challenges, considerations, and assesses the readiness of Philippine tertiary mathematics classrooms for AI integration within the context of Generation Alpha students. The review follows a six-step process outlined by Templier and Paré (2015): formulating research questions and objectives, searching the literature, screening for inclusion, assessing the quality of primary studies, extracting data, and analyzing data. It includes academic articles published between 2018 and 2023, written in English. The integration of AI in mathematics education offers personalized instruction, fosters critical thinking skills, and prepares Generation Alpha students for the demands of the digital age. Approaches such as robotics, gamification, AI-assisted teaching, and virtual reality enhance learning experiences. While the integration of AI in mathematics education for Generation Alpha students holds immense potential, it also encounters challenges such as infrastructure limitations, quality assurance, social interaction, and data privacy. The Philippines is making strides in embracing AI integration, with initiatives promoting AI in education, the adoption of smart campus technologies, and collaboration between government and universities. To successfully integrate AI in math education for Generation Alpha students, higher institutions, including those in the Philippines, should conduct further studies to address concerns and challenges of integrating AI tools in education. Additionally, understanding Generation Alpha's perspective on exemplary teachers would help prepare tertiary institutions for these upcoming college students.

Keywords: *Generation Alpha, Artificial Intelligence (AI), AI integration, Mathematics Education*

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1. Introduction

In the realm of education, it is crucial to acknowledge the growing influence of Generation Alpha. This distinctive generation has been immersed in technology since a young age, shaping their perspectives and worldview [1]. With easy access to a vast amount of information and exposure to diverse cultures, they perceive technology as a means of connecting with the world. As future college students, they expect educational institutions to have a strong online presence and offer interactive experiences that align with their digital upbringing [2]. Philippine tertiary schools must be prepared to address the unique opportunities and challenges presented by Generation Alpha, who have grown up with ubiquitous access to smart devices, resulting in unparalleled tech-savviness and diversity [3].

Meanwhile, recent advancements in Artificial Intelligence (AI) have ushered in a new era in education, transforming teaching and learning [4]. AI tools equip students with future job skills, while AI algorithms analyze data to provide personalized feedback and automate administrative tasks. Real-time adaptive AI-powered assessments offer more accurate evaluations of students' knowledge and skills, enhancing the learning experience and improving outcomes [5]. By embracing these advancements and overcoming challenges, educational institutions can adapt to meet the evolving needs of Generation Alpha, offering dynamic and engaging learning experiences [3].

The integration of AI tools undeniably influences the future of education [6,7]. As AI becomes increasingly prevalent in various industries, colleges and universities must keep pace with these advancements. Graduates are now expected to possess a solid understanding of AI tools and their applications. Encouraging student participation in AI-related research projects facilitates skill development

and practical experience. Equipping Generation Alpha students with the necessary AI proficiency ensures they are well-prepared for the job market and can contribute effectively to society [3].

Despite the potential benefits, the implementation of AI technologies in education encounters several hurdles, including ethical considerations, infrastructure and resource limitations, and pedagogical considerations [7]. However, the importance of AI integration in mathematics education, particularly for Generation Alpha students, is increasingly evident. Understanding the potential of AI in education is essential for adapting teaching methods to the digital age and preparing students for the future workforce [3].

The primary objective of this literature review is to explore the integration of Artificial Intelligence (AI) in mathematics education for Generation Alpha students, examining approaches, challenges, considerations, and assessing the readiness of Philippine tertiary mathematics classrooms for AI integration within the context of Generation Alpha students. Overall, this literature review provides a comprehensive understanding of AI integration in mathematics education for Generation Alpha, advancing educational practices, improving student outcomes, and preparing students for the AI-driven world.

2. Method

This literature review follows the process outlined by Templier and Paré, which includes six generic steps in conducting a review article [37]. These steps include formulating the research questions and objective, searching the extant literature, screening for inclusion, assessing the quality of primary studies, extracting data, and analyzing data.

The objective is to explore the integration of Artificial Intelligence (AI) in mathematics education for Generation Alpha students, covering approaches, challenges, considerations, and the readiness of Philippine tertiary mathematics classrooms for AI integration within the Generation Alpha context. The research questions addressed are: (1) How can AI revolutionize mathematics classrooms for Generation Alpha students? (2) What are the different approaches and methods of using AI in mathematics education? (3) What challenges and considerations arise when integrating AI tools in educational institutions? (4) What is the readiness of Philippine tertiary mathematics classrooms for AI integration and Generation Alpha students?

An exhaustive coverage strategy was employed, ensuring the inclusion of all relevant studies, published and unpublished, to establish conclusions based on a comprehensive knowledge base. A Google search was conducted using specific terms such as "Generation Alpha," "AI in Mathematics Education," "Future of Mathematics Education," and "AI in Philippine Education Context" to search the extant literature. The screening process focused on academic articles written in English between 2018 and 2023, with at least one reference to mathematics education. Initially, over 350 articles were obtained, which were reduced to 49 articles after applying the review's criteria and removing duplicates.

The quality of the primary studies was assessed, resulting in the selection of 36 academic articles aligned with the review's objectives. Data were then extracted from each primary study, focusing on relevance to the research problem. Finally, the extracted evidence was analyzed by collating, summarizing, aggregating, organizing, and comparing the data. Themes aligned with the research questions were used to present the findings.

3. Findings and Discussion

This literature review delves into the integration of Artificial Intelligence (AI) in mathematics education for Generation Alpha students, exploring approaches, challenges, considerations, and the readiness of Philippine tertiary mathematics classrooms. AI's influence is pervasive, revolutionizing various aspects of our lives, and its application in education is increasingly crucial. By harnessing AI's power, mathematics education can be transformed, providing personalized instruction, fostering critical thinking skills, and preparing students for the demands of the digital age. However, implementing AI tools in education encounters hurdles such as infrastructure limitations, quality assurance, social interaction, and data privacy. Despite challenges, the Philippines shows progress in embracing AI integration, aiming to equip Generation Alpha students with the skills to thrive in the AI-driven future. This review provides comprehensive insights into the potential and challenges of AI integration in mathematics education, paving the way for innovative and inclusive learning experiences for Generation Alpha.

3.1. AI Integration: The Future of Mathematics Classrooms for Generation Alpha

Artificial Intelligence (AI) pervades our daily lives in various ways. From the GPS mapping tool on our smartphones that intelligently reroutes us to avoid traffic or roadblocks, to the emergence of driverless cars that rely on AI algorithms to navigate without human drivers, the impact of AI is profound. It extends to our communication as well, with tools like Google's Smart Reply that analyze our emails and offer suggested responses, making our replies quicker and more convenient. AI's presence is undeniable, enhancing efficiency and convenience across multiple aspects of our technological interactions [8].

Indeed, the influence of AI technology has permeated every aspect of people's daily lives, profoundly shaping society's development [9]. Mathematics education has also embraced AI, with both teachers and students implementing it for several years. The utilization of AI in mathematics learning offers numerous advantages [10], including the development of critical thinking skills and a sense of responsibility when approaching everyday problem-solving. It also fosters a deeper understanding of fundamental geometry, mathematics, and statistics problems. Moreover, AI integration enhances interpersonal abilities, promotes better social interaction, and creates an effective learning environment that facilitates the acquisition of mathematical concepts [7].

AI is a sophisticated system that has demonstrated numerous positive effects, particularly in mathematics education [10]. One study revealed that AI-based teaching can lead to math scores approximately 30% higher than those achieved through traditional teaching methods. Moreover, it fosters improved collaboration among students [9]. As nations formulate national AI strategies, the importance of mathematics education becomes increasingly evident [7].

Adaptive AI-driven learning platforms have the remarkable potential to revolutionize math education for students of all ages and skill levels [11]. For instance, when students struggle with complex numbers, an adaptive AI platform can provide tailored explanations, visual aids, and practice problems based on their individual learning style. As students improve, the platform adjusts by offering more challenging problems and introducing new topics. This personalized AI approach supports students, boosts their confidence, and helps them excel in math [12]. Research suggests that integrating AI, such as adaptive AI platforms, into math education enhances interactivity and deepens students' understanding of the subject [7]. By fostering creativity and innovation, AI integration in classrooms prepares students for the demands of our technologically advanced society.

In today's digitally-driven and interconnected world, it is more crucial than ever for students to acquire skills that effectively prepare them for the future [13]. AI-integrated math education goes beyond improving students' comprehension of mathematical concepts; it also cultivates essential 21st-century skills highly sought after in the modern workforce. Research has shown that the use of AI in math education, such as animating figures and mathematical representations, enhances students' imagination and problem-solving abilities [10]. Furthermore, incorporating AI in mathematics education fosters creative and critical thinking skills among both students and educators. The positive effects of incorporating robotics in math classes have also been observed, promoting student understanding and skill development [7].

In summary, it is evident that the integration of Artificial Intelligence (AI) in mathematics education has significant potential to transform the learning experience for students. As we witness the growing impact of AI in diverse fields, its incorporation in mathematics education becomes increasingly crucial in preparing students for the challenges and opportunities of an increasingly technologically advanced world. By harnessing the power of AI, we can unlock new possibilities for enhancing mathematical learning and equipping the upcoming Generation Alpha college students with the necessary skills to thrive in the digital age.

Approaches of AI in Mathematics Education

In the field of mathematics education, there are various approaches that harness the power of artificial intelligence (AI) to enhance learning experiences and improve student outcomes. Among these approaches, robotics has emerged as a popular and promising method [7,14]. Research conducted by Zhong and Sia highlights the potential for future investigations and evidence-based research on using robotics to teach and learn mathematical content knowledge [15]. Additionally, Seckel et al. found that teachers have positive perceptions regarding the integration of robots for teaching mathematics [16].

Another effective approach in math education is gamification, which incorporates game-like elements into non-game environments. The advent of AI technology has facilitated the development of innovative and captivating learning experiences that keep students engaged [17]. By integrating AI into math games, educators can create a fun and immersive learning atmosphere that captures students' attention while fostering essential mathematical skills [12].

AI-assisted teaching offers a unique approach to addressing individual learning gaps and providing targeted support to help students overcome challenges [12]. Through personalized instruction and real-time feedback, students struggling with math can develop a strong foundation in the subject, enabling them to comprehend complex concepts more effectively. Intelligent tutoring systems and integrated systems, such as micro-intelligence support, have been implemented in mathematics education to enhance teaching practices and provide individualized assistance [9,18,19].

Virtual Reality (VR) is yet another approach that combines AI with educational practices. By utilizing VR technology, educators can create immersive learning environments that facilitate active participation and practice [20]. Integrating AI-powered visualizations and interactive simulations using VR in math education allows students to engage in hands-on experimentation with mathematical principles, demystify complex topics, and cultivate a passion for learning.

Overall, the integration of robotics, gamification, AI-assisted teaching, and virtual reality offers innovative and engaging approaches to enhance students' learning experiences. These AI-powered methods provide opportunities for hands-on exploration, personalized instruction, and immersive learning environments that foster critical thinking, problem-solving skills, and a deeper understanding of mathematics. Embracing AI in mathematics education enables the creation of dynamic and inclusive classrooms that prepare students for the challenges and opportunities of the future, while simultaneously making mathematics more enjoyable and accessible to all learners.

Challenges and Considerations in Integrating AI Tools in Higher Institutions

In the realm of modern education, higher institutions may face several challenges and considerations when it comes to integrating AI tools. One of the primary challenges is infrastructure. To effectively utilize AI in education, higher institutions need to have a strong technical backbone that can support the implementation of AI algorithms and technologies [21,22,23]. This includes robust computing resources, reliable internet connectivity, and the capacity to handle and analyze large amounts of data. Without the necessary infrastructure, higher institutions may struggle to leverage the full potential of AI in enhancing the learning experience [3].

Another important consideration is quality assurance. As AI tools become increasingly integrated into educational processes, higher institutions must ensure that these tools deliver accurate and reliable results. This requires rigorous testing and evaluation to verify the effectiveness and efficiency of AI algorithms in enhancing

teaching and learning outcomes. Additionally, higher institutions need to address concerns related to bias and ethical considerations in the development and use of AI tools in education [3,24].

Furthermore, fostering social interaction and collaboration among students is crucial when incorporating AI in education [3,12,25]. While AI can provide personalized and individualized learning experiences, it is essential to balance it with opportunities for peer-to-peer interaction and collaborative activities. This promotes a sense of community and enhances the overall learning experience for students [3].

Data privacy and security are also critical considerations [3,26,27,28]. As AI relies on collecting and analyzing vast amounts of data, higher institutions must prioritize the protection of student data and ensure compliance with privacy regulations. They need to implement robust data security measures and establish ethical guidelines for the collection, storage, and use of student data in AI-driven educational systems.

Higher institutions have the opportunity to revolutionize education and shape the future for Generation Alpha students by effectively addressing these challenges and considerations associated with integrating AI tools. The potential benefits are vast and captivating. AI-powered tools can provide personalized learning experiences tailored to each student's needs, allowing for individualized instruction and targeted support. AI algorithms can analyze vast amounts of data to identify patterns and trends, providing valuable insights for educators to optimize their teaching methods and curriculum design. The integration of AI tools also opens up exciting possibilities for immersive and interactive learning experiences, such as virtual reality simulations and gamified educational platforms, which can make learning more enjoyable and foster a deeper understanding of complex concepts. By preparing Generation Alpha students to navigate the opportunities and challenges of the AI-driven future, higher institutions play a vital role in equipping them with the necessary skills and competencies to thrive in a rapidly evolving world.

3.2. Readiness of Philippine Tertiary Mathematics Classrooms for AI Integration and Generation Alpha Students

In the Philippines, social networking has emerged as one of the most popular online activities, with Filipinos recognized as highly active users on various social networking platforms. Notably, the extensive use of social networking websites in the country has earned it the distinction of being dubbed "The Social Networking Capital of the World" [29]. This widespread engagement in social networking is particularly appealing to Generation Alpha, a generation known for their tech-savviness and digital fluency. However, a report published by the World Economic Forum (WEF) in 2020 stated that the Philippines ranked 56th out of 100 countries in terms of digital skills readiness. The report highlighted the need to improve digital literacy and skills in order to fully harness the benefits of the digital economy, despite the country having a large pool of young and digitally connected population [30].

AI undoubtedly offers significant benefits for the future of Generation Alpha's education, especially when combined with high-quality learning materials [31]. The Philippine government's initiatives, such as the National AI Roadmap and the establishment of the National Centre for AI Research (N-CAIR), demonstrate the country's commitment to incorporating AI into education and adapting curricula accordingly [30]. De La Salle University and other learning institutions in the Philippines already offer courses related to AI, while the Department of Science and Technology collaborates with local universities to promote AI development in the country [32].

Universities and colleges in the Philippines are embracing the smart campus concept, utilizing advanced digital infrastructure technologies like cloud access control, machine learning, artificial intelligence, big data, and the Internet of Things (IoT) [30]. This adoption aims to enhance operational efficiency, create convenient experiences for students and faculty, and improve campus safety. Several universities, including Mariano Marcos State University and the University of Northern Philippines, have already implemented smart campus approaches with support from grants and initiatives by the Commission on Higher Education [33,34]. These smart campus technologies, infused with AI, offer personalized learning environments and improved user experiences for students.

Despite some progress in integrating AI into the Philippine education system, the COVID-19 pandemic has highlighted the need for further improvement. A qualitative study titled "Difficulties in Remote Learning: Voices of Philippine University Students in the Wake of COVID-19 Crisis" by Rotas and Cahapay surveyed students from a tertiary institution using purposive and convenient sampling methods [35]. The study revealed various challenges encountered in remote learning, including unstable internet connectivity, inadequate learning resources, power interruptions, unclear learning materials, excessive workload, limited teacher support, difficulties in peer communication, conflicts with home responsibilities, unfavorable learning environments, financial issues, compromised physical health, and mental health struggles.

Furthermore, the Philippines faces challenges in terms of budget allocation for education, lagging behind other ASEAN countries in this regard. The lack of classrooms, teachers, and essential learning tools further exacerbates the problem [36]. To successfully integrate AI into the Philippine education system, it is crucial for the government to examine the factors that led to the crisis experienced by many tertiary schools during the transition from face-to-face to online learning amid the pandemic.

Despite these obstacles, the Philippines is gradually making strides towards integrating AI into its education system, signaling a promising future for Generation Alpha college students. The potential benefits of AI in education, such as personalized learning, improved outcomes, and enhanced critical thinking skills, are driving the country's efforts to overcome challenges and pave the way for innovative educational experiences. By harnessing the power

of AI, the Philippines can unlock new possibilities for its students, empowering them to thrive in the digital age and become future-ready individuals capable of navigating the ever-changing landscape of the AI-driven world.

4. Conclusion and Recommendation

The integration of Artificial Intelligence (AI) in mathematics education holds immense potential to revolutionize the learning experience for Generation Alpha students despite challenges related to infrastructure, quality assurance, social interaction, and data privacy. AI offers personalized instruction, fosters critical thinking skills, and prepares students for the challenges of the digital age. Approaches such as robotics, gamification, AI-assisted teaching, and virtual reality provide innovative and engaging methods to enhance mathematics education. Meanwhile, the readiness of Philippine tertiary mathematics classrooms for AI integration shows progress, with initiatives promoting AI in education, the adoption of smart campus technologies, and collaboration between government and universities. However, improvements in digital literacy, infrastructure, and budget allocation are needed. By effectively addressing these challenges, the Philippines can unlock the benefits of AI integration, empowering Generation Alpha students for a future driven by AI.

To ensure the successful integration of AI in mathematics education for Generation Alpha students, it is recommended that higher institutions, such as those in the Philippines, undertake further studies to address the concerns and challenges of integrating AI tools in an educational setting. Additionally, conducting studies to understand the dimensions of an exemplary teacher according to Generation Alpha's perspective would serve as a good starting point in preparing tertiary institutions for the upcoming college students of Generation Alpha.

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