

Integration of Mathematical and English Skills in Learning in the Era of Society 5.0: Challenges and Opportunities for Generation Alpha

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Abstract. This study explores the integration of mathematical and English language skills in the education of Generation Alpha, particularly in the context of Society 5.0. Using a Systematic Literature Review (SLR), the research analyzes existing literature to examine the role of these skills in shaping the future educational landscape. The findings suggest that both mathematical and English language skills are crucial for preparing students for the challenges of a technology-driven society. However, challenges such as gaps in educational resources and the digital divide persist. Opportunities arise from leveraging technology to enhance both subjects simultaneously, and project-based learning methods have shown promise. Furthermore, these skills are increasingly vital in the context of Society 5.0, where digital transformation, artificial intelligence, and technological advancement are central. This paper concludes by emphasizing the importance of integrating mathematical and English language skills to ensure that Generation Alpha is adequately prepared for future societal needs.

Keywords Generation Alpha, Mathematical Skills, English Language, Education, Society 5.0

1. INTRODUCTION

Education is a key factor in preparing individuals to adapt to the rapidly changing and complex world. Amidst the fast-paced technological advancements, the education sector faces significant challenges in preparing the next generation for success in the digital era. One of the major technological developments is the emergence of the Society 5.0 concept, which integrates artificial intelligence (AI), the internet of things (IoT), big data, and various other digital innovations into daily life. In Society 5.0, humans and machines work together to create a smarter and more sustainable society. However, this transformation also demands a change in how we learn and teach.

Generation Alpha, encompassing those born after 2010, is the first group to grow up in a fully digitally connected world. This generation is not only surrounded by technology but also influenced by new ways of interacting with the world, learning, and working. They are accustomed to smart devices from an early age and are often more familiar with technology than with books or traditional teaching methods. In this context, education in the Society 5.0 era must be capable of facilitating the skills necessary to face the challenges and opportunities posed by rapid technological developments.

One of the biggest challenges faced by education in this era is how to equip students, particularly Generation Alpha, with the skills needed to operate in the digital

world. Two skills that are increasingly considered fundamental in the Society 5.0 era are mathematical and English language skills. Mathematical skills are crucial given the world's growing reliance on data analysis and problem-solving based on technology. Meanwhile, English, as the dominant international language in various sectors such as science, technology, and the global economy, has become an indispensable skill. The ability to communicate in English opens up broader opportunities for Generation Alpha to collaborate, innovate, and compete in a global context.

Mathematical skills allow individuals to think analytically, solve complex problems, and make data-driven decisions, while English enables them to access global information, participate in international conversations, and leverage the various resources provided by the digital world. When combined, these two skills can provide a significant competitive advantage for Generation Alpha in the future.

However, despite numerous studies acknowledging the importance of these two skills, the integration of mathematical and English language abilities in the education of Generation Alpha in the Society 5.0 era remains an underexplored area. Therefore, it is essential to conduct a thorough literature review to examine how these two skills can be integrated into the curriculum in the digital era, as well as the challenges and opportunities that arise during this integration process.

This study aims to explore and analyze existing literature on the integration of mathematical and English language skills in education for Generation Alpha. Through a Systematic Literature Review (SLR), the research will identify and summarize findings from various related studies that examine how these skills can be taught simultaneously within the curriculum in the Society 5.0 era. Additionally, the study will highlight the challenges faced in implementing technology-based curricula that combine these two skills, as well as the opportunities that emerge from the digital transformation of education.

Several previous studies have demonstrated the importance of mathematical and English language skills in preparing students for a technology-driven world. For example, a study by Lee et al. (2020) found that strong numerical skills are closely linked to the ability to solve problems involving advanced technologies such as AI and big data. Likewise, English, as shown in the research by García & Torres (2021), has a significant correlation with success in higher education, particularly in STEM fields (Science, Technology, Engineering, and Mathematics). Moreover, some literature indicates that young generations, including Generation Alpha, are more likely to adapt

quickly to new technologies if they are equipped with adequate mathematical and language skills (Prensky, 2017).

By employing a Systematic Literature Review (SLR) approach, this study aims to provide a clearer picture of how these two skills can be integrated into educational curricula designed to meet the challenges of the Society 5.0 era. Through critical analysis of the existing literature, this research is expected to contribute to formulating strategic recommendations for educators and policymakers in creating learning environments that are aligned with technological developments and the needs of future generations..

2. LITERATURE REVIEW

Education in the era of Society 5.0 is undergoing rapid transformation, requiring the younger generation, especially Generation Alpha, to master various skills relevant to the digital world. Amid these changes, two key skills that have become a primary focus are mathematical skills and English language proficiency. In existing literature, these skills are often discussed separately, although there is significant potential to integrate them within a more holistic educational context. Therefore, this study aims to review the existing literature on the integration of mathematical skills and English language proficiency in education in the Society 5.0 era, highlighting the challenges, opportunities, and contributions to Generation Alpha's readiness.

In this context, it is important to note that education in the Society 5.0 era is not just about adopting new technologies but also focusing on developing skills that help individuals adapt and thrive in an increasingly connected and data-driven world. One skill that has been increasingly emphasized in education is mathematical ability, which plays a crucial role in developing critical and analytical thinking skills, as well as in understanding and managing data in various aspects of life. This skill is highly relevant, given the sophistication of technologies such as artificial intelligence (AI) and big data, which are increasingly dominating various sectors of industry and everyday life. Several studies have revealed that mathematical skills are an important predictor of academic and career success in the digital era (Lee, Kim, & Choi, 2020).

At the same time, English language proficiency has also become a critical skill. As the international language, English plays an irreplaceable role in academia and the professional world, particularly in technology-based sectors, science, and global communication. García and Torres (2021) in their research showed that English proficiency significantly influences academic success, especially in STEM (Science,

Technology, Engineering, and Mathematics) fields. English is not only the language of instruction in scientific literature but also a tool for collaboration and communication in the increasingly connected global community. Therefore, proficiency in English not only impacts students' academic abilities but also opens up greater opportunities in the global job market.

While literature has identified the importance of both skills, most of the existing studies examine mathematical and English skills separately. Some studies focus on enhancing mathematical skills through technology use, such as app-based learning and gamification (Keller, 2018). On the other hand, many studies emphasize the importance of teaching English as a global communication skill that should be taught early (García & Torres, 2021). However, there is little discussion on how these two skills can mutually support and be integrated into the learning process. Existing research is still limited in providing insight into how combining these two skills can enhance the readiness of future generations, especially Generation Alpha, to face the challenges of Society 5.0.

The challenges in integrating mathematical skills and English proficiency in education often stem from limitations in existing curricula. Many educational curricula in various countries still separate mathematics and English learning, without effectively integrating them in contexts relevant to the digital world. This leads to a lack of students' ability to link their mathematical knowledge to global and digital contexts, which heavily rely on English literacy. Research by Prensky (2017) shows that the current youth generation, including Generation Alpha, is quicker to adapt to technology and information based on English, but they often lack a strong foundation in mathematical skills to interpret and use this technology effectively.

In addition to the challenges, there are also various opportunities to integrate mathematical skills and English language proficiency in learning. One major opportunity is the use of digital technology, which can provide various platforms to combine these two skills. For example, the use of English-based mathematical software or project-based learning platforms that simultaneously involve both skills. In a study conducted by Lee et al. (2020), they identified that technology-based learning that combines mathematical content with English communication can enhance students' understanding of mathematical concepts while improving their language skills. Therefore, integrating technology into learning can be a solution to overcome existing challenges and create opportunities for the development of both skills.

Although these opportunities are promising, there is some controversy in the literature regarding how far technology can address the challenges in integrating these two skills. Some studies suggest that while technology can provide tools that support learning, factors such as teacher training and the digital divide remain significant barriers (García & Torres, 2021). Additionally, teaching English that focuses too much on technical aspects and neglects social and cultural contexts can reduce its effectiveness in preparing students to communicate effectively in the global community.

Existing research shows that despite various challenges, the opportunities to integrate mathematical skills and English proficiency in education for Generation Alpha are immense. However, this integration requires a more holistic approach that combines the use of technology, relevant curricula, and training for educators to create a learning environment that supports the development of both skills.

3. METHODS

This study employs a Systematic Literature Review (SLR) methodology, which aims to systematically review, analyze, and synthesize findings from relevant literature related to the integration of mathematical skills and English proficiency in education for Generation Alpha in the Society 5.0 era. This approach was chosen because SLR allows researchers to obtain a comprehensive and objective overview of the topic being studied by screening, organizing, and thoroughly evaluating existing literature. As explained by Grant and Booth (2009), SLR provides a clear structure in the process of searching, selecting, and analyzing literature, which helps generate evidence-based conclusions.

The Inclusion and Exclusion Criteria for this study are based on several important factors. First, the articles included must have been published within the last 10 years to ensure the relevance and currency of the information discussed (2013-2023). Additionally, only articles relevant to the main topic, the integration of mathematical skills and English proficiency in education for Generation Alpha in the Society 5.0 era will be considered. Articles published in English will be selected to ensure higher-quality sources. Accepted types of sources include peer-reviewed journal articles, academic books, and research reports that contribute substantially to the topic being studied.

The Literature Search and Selection process was conducted using several leading academic databases, such as Google Scholar, Scopus, and ERIC. The search keywords used include a combination of terms such as “Mathematical Skills,” “English Proficiency,” “Society 5.0,” “Generation Alpha,” “Digital Education,” and “STEM

education.” These search steps were taken to ensure that the selected literature truly covers relevant topics related to the research objectives.

Data Analysis was carried out by filtering the findings from the literature based on emerging themes or categories. This process involves grouping articles by similarities in topic and methodology, as well as evaluating findings related to the integration of mathematical skills and English proficiency in education in the digital era. Based on this analysis, the researcher can identify key trends, gaps in research, and directions for future research development.

4. RESULTS AND DISCUSSION

Integration of Mathematical and English Skills

The integration of mathematical and English skills in the educational curriculum for Generation Alpha is crucial because both are interconnected in helping students develop the skills needed in a world that increasingly relies on technology. Research by Lee and Kim (2020) reveals that this integration provides students with the opportunity not only to better understand mathematical concepts but also to sharpen their communication skills in English. This integration allows students to master technical terms frequently used in English-language mathematical literature, which is essential for delving into science and technology at a global level (Prensky, 2017).

An important example of this integration is the use of technology-based applications that support mathematics instruction in English, such as Khan Academy and Coursera. Research by García and Torres (2021) shows that digital technology allows students to access math lessons while practicing English, providing them the opportunity to learn both simultaneously, thereby deepening their understanding. Furthermore, project-based learning that involves the use of both skills has shown positive results in enhancing students' understanding of mathematical concepts while improving their speaking and writing skills in English (Gómez et al., 2020).

According to Keller (2018), gamification-based learning methods can also be used to integrate these two skills, making learning more enjoyable and effective. Apps like DragonBox for mathematics and Duolingo for English offer interactive and enjoyable learning experiences, increasing student engagement. In this context, technology allows students to learn in a more directed and fun way, which is essential for Generation Alpha, who are accustomed to technology from an early age.

Additionally, in technology-based learning, communication skills in English are essential because it is the international language used to convey knowledge in mathematics and other scientific fields. According to research by García and Torres (2021), proficiency in English allows students to access more learning materials and research available in the language, which is vital for their academic development.

Research by de Lange et al. (2018) indicates that technology-based learning provides significant benefits in developing numerical and English communication skills simultaneously, as technology supports more interaction-based and collaborative approaches, which facilitate the learning of both skills.

Challenges Faced

Despite the many opportunities, there are significant challenges in integrating mathematical and English skills in education. One of the main challenges is the skill gap among students in both of these areas. Many students, especially in developing countries, struggle to understand technical terms in English used in mathematics instruction (García & Torres, 2021). This is exacerbated by limited teaching practices in schools, where mathematics and English are still taught as separate subjects without adequate integration (Bakker et al., 2019).

Moreover, technological barriers are a major issue in implementing a curriculum that integrates these two skills. Although technology has great potential to support learning, many schools lack the infrastructure to make full use of technology in education (UNESCO, 2019). This is especially evident in more remote areas where limited access to hardware and software makes technology-based education difficult to implement. As Prensky (2017) stated, "If we cannot provide technology for all students, we will leave most of them behind."

Additionally, the development of a curriculum that can integrate these two skills is hindered by the limited time available for teachers in crowded classrooms. Many teachers face challenges in effectively dividing their time between teaching mathematics and English simultaneously. Bakker et al. (2019) suggest that it is crucial to provide sufficient training for teachers to master the integration of these subjects.

Available Opportunities

Despite these challenges, there are numerous opportunities that can be leveraged to improve the integration of mathematical and English skills in education. One of the biggest opportunities is the use of digital technology, which enables students to learn both skills simultaneously in a more engaging and interactive context. Technology-based learning apps can combine mathematics education with instructions in English, allowing students to learn both on the same platform (Prensky, 2017; García & Torres, 2021).

Gamification is also a highly effective approach for enhancing this integration. Research by Keller (2018) shows that game elements can increase student motivation to learn mathematics and English, making learning more engaging and enjoyable. Apps like Duolingo (for English) and DragonBox (for mathematics) use gamification to teach both skills in a more enjoyable and interactive way.

Project-based learning methods have also proven effective in integrating both skills. In data-based projects, for example, students can use mathematics to analyze data and then present their findings in English. This encourages students to develop both communication skills and a deeper understanding of mathematical concepts simultaneously, in line with the approach advocated by Lerman (2017), which emphasizes the importance of project-based learning in enhancing student skills.

Research by Gómez et al. (2020) shows that project-based learning allows students to solve real-world problems using both their mathematics and English skills simultaneously. This gives them the opportunity to develop skills relevant to the technology-driven workforce.

Relevance to Society 5.0

Mathematical and English skills are crucial in the context of Society 5.0, which combines advanced technology with daily life to create smarter, more efficient, and more humane societies. Society 5.0, promoted by the Japanese government, focuses not only on high technology, such as artificial intelligence (AI), robotics, and the Internet of Things (IoT), but also on the application of technology to enhance the overall quality of life (Hino, 2019). In a society driven by data and technology, these two fundamental skills (mathematics and English) become essential.

Mathematical ability in the era of Society 5.0 plays a vital role. With the increasing volume of big data generated daily, the ability to analyze and process data quickly and accurately becomes an essential skill. In this context, applied mathematics is

not just about the formulas taught in classrooms, but about the ability to model real-world problems using data and create innovative solutions. This aligns with the development of the business and industrial world, which increasingly relies on algorithms and data analysis for decision-making (Pahl et al., 2019). Therefore, a generation that can master mathematics in the context of technology, such as computer programming, statistics, and data analysis, will have an advantage in the increasingly interconnected global job market.

Moreover, English proficiency is becoming increasingly important because it is the international language used in science, technology, and the global economy. In Society 5.0, where collaboration among countries and individuals from diverse cultural backgrounds becomes more common, English proficiency enables individuals to communicate effectively in an increasingly global world. English is also the primary language in international research and technology development. As García and Torres (2021) point out, mastering English allows individuals to access more international learning resources and opens up opportunities for global collaboration in various innovative projects. For example, almost all technical literature and scientific journals in fields like science and technology, including mathematics and engineering, are published in English.

In Society 5.0, mastering cross-disciplinary skills like mathematics and English not only enables individuals to access global knowledge but also to create more effective solutions to societal problems. The use of digital technology and big data in education allows students to learn both skills simultaneously in real-world contexts, bridging the gap between theory and practice. Through project-based learning that integrates mathematics with English communication, students can develop the skills needed to solve real-world problems faced by society in this digital age.

On the other hand, the ability to work with AI and advanced technologies used in Society 5.0 also requires a deep understanding of mathematics. For example, AI technologies used in many modern applications, such as natural language processing, rely on complex mathematical concepts. As reliance on technology in the workplace grows, the ability to speak and write in English will become increasingly important for communicating with AI systems, accessing technological tools, and interacting with international colleagues.

Society 5.0 is not just about technological progress, but also about how technology can be used to advance society in a more inclusive and sustainable way. The

development of mathematics and English skills in Generation Alpha is key to ensuring they can contribute effectively to a society increasingly driven by artificial intelligence, data, and globalization. Education that integrates these two skills will provide them with a strong foundation to adapt to the rapid changes that will occur in the future, both in their professional careers and in their social lives. Given the increasing reliance on technology in various industrial sectors, mathematical and English competencies are no longer optional, but essential needs.

Therefore, the relevance of these two skills in the era of Society 5.0 is clear. Mathematics provides the ability to understand and use the technologies that drive this digital society, while English ensures access to global knowledge needed to innovate and collaborate on the international stage. Thus, education that integrates these two skills is critical to equipping Generation Alpha with the abilities they need to become successful and productive members of society in this digital age.

5. CONCLUSION

In this study, the integration of mathematical skills and English language proficiency in the education curriculum for Generation Alpha has been thoroughly discussed, along with the challenges, opportunities, and its relevance to Society 5.0. The results of the study indicate that both skills are crucial in equipping the next generation with competencies that are relevant in an increasingly digital and globalized world. The integration of mathematics and English in education not only enhances students' understanding of fundamental concepts but also prepares them to face a workforce that focuses on technology and artificial intelligence.

The importance of integrating mathematical and English skills has become more apparent, especially with the role of mathematics in data analysis and the application of technology, and English as the international language in science and technology. Although various challenges were found, such as gaps in students' abilities and limitations in teaching methods, the opportunities to leverage technology to enhance both skills are significant. The use of technology in learning, along with the application of project-based learning methods, can provide effective solutions to address these challenges.

There are some limitations in this study that need to be noted. First, this research only relies on existing literature without experiments or field studies that could provide more concrete and applicable data. Therefore, these limitations may affect the validity of

the findings, as the analysis is based solely on theory and literature reviews that may not necessarily cover all the educational conditions in the field. Second, while several opportunities have been identified, not all existing studies are consistent in their results, which raises questions about the accuracy and application of these concepts in a broader context.

As a suggestion for further research, it is essential to conduct field studies involving various schools and real-world teaching to obtain more representative data on how these skills can be effectively integrated. Additionally, further research should also investigate the specific challenges faced by educators, including how they can address students' ability gaps in the context of an increasingly technology-focused curriculum. The relevance of this research is particularly significant in the face of rapid global changes, providing guidance for the development of educational policies and teaching methodologies in the future.

Thus, this study successfully provides a comprehensive picture of the importance of integrating mathematics and English in preparing Generation Alpha to face Society 5.0, despite some limitations that should be considered by future researchers.

LIMITATION

Although focused on literature analysis, this study has several limitations that need to be addressed. First, the Systematic Literature Review (SLR) methodology limits the research to existing literature sources, without incorporating empirical data or firsthand experiences. This reduces the ability to answer the research questions with primary evidence, making the findings secondary in nature.

Second, the scope of the literature used in this study is limited to sources found through keyword searches in academic databases. While diverse, there is a possibility that some relevant literature was overlooked. This selection process also impacts the depth of the analysis.

Third, the application of concepts found in the literature to real-world educational contexts is limited. This study cannot explore external factors such as local educational policies, technology, and the preparedness of educators, all of which may influence the implementation of mathematical and English language skills. Therefore, there is a potential gap between the theories found in the literature and practical applications in the field.

Finally, the limited time available posed a constraint on expanding the literature search and delving into the most recent relevant methods. This time limitation also reduced the completeness and depth of the analysis that could be conducted.

Overall, the limitations in methodology, literature scope, concept application, and time constraints affect the validity and completeness of the findings in this study. Therefore, further empirical, field-based research is needed to enrich the existing findings.

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