

Enhancing Numeracy: A Technological Approach to Improve Basic Math Skills

Raymund M. Igcasama

Faculty, Visayas State University, Baybay City, Leyte, Philippines
<https://orcid.org/0000-0002-3255-8784> | raymund.igcasama@vsu.edu.ph

Osias Kit T. Kilag

School Principal, PAU Excellencia Global Academy Foundation, Inc., Poblacion, Toledo City, Cebu, Philippines
and Vice-President for Academic Affairs and Research, ECT Excellencia Global Academy Foundation, Inc.,
Buanoy, Balamban, Cebu, Philippines
<https://orcid.org/0000-0003-0845-3373> | okkilag12@gmail.com

Lister M. Cabonilas

Assistant Director, Student Affairs and Services
Negros Oriental State University Mabinay, North Poblacion, Mabinay, Negros Oriental, Philippines
<https://orcid.org/0000-0002-4280-2015> | lestercabonilas16@gmail.com

Cora Marie E. Abarias

Elementary Teacher
Minglanilla Central Elementary School-Special Science Program
Poblacion Ward 1, Minglanilla, Cebu, Philippines
<https://orcid.org/0009-0007-3916-7130> | coramarie.abarias@deped.gov.ph

Cara Frances K. Abendan

Administrative Assistant,
ECT Excellencia Global Academy Foundation, Inc., Buanoy, Balamban, Cebu, Philippines
<https://orcid.org/0000-0002-6363-7792> | carafrances03@gmail.com

Ana Lorraine B. Bubuli

Teacher III, Department of Education,
Schools Division of Toledo City, Philippines
<https://orcid.org/0000-0002-7278-5439> | analorrainebubuli@gmail.com

Abstract

This systematic literature review examines the role of technology in enhancing basic math skills within the realm of mathematics education. Synthesizing findings from diverse studies, the review identifies key themes that elucidate the impact of technology on learning outcomes.

Interactive software, including virtual manipulatives and simulations, is recognized for its positive influence on fostering active learning and deepening conceptual understanding. The integration of online platforms, particularly through adaptive learning systems, emerges as a crucial strategy for personalized learning, contributing to improved student outcomes. Educational apps and gamification elements are explored as dynamic tools, providing flexibility and motivation in mathematics learning. While acknowledging the positive impact of technology, the review also underscores challenges such as access limitations, teacher training needs, and concerns about screen time. The findings highlight the importance of a balanced and thoughtful approach to technology integration, aligning interventions with educational objectives. In conclusion, this study contributes valuable insights to the ongoing discourse on technology in education, emphasizing its potential to revolutionize mathematics learning while addressing the nuanced challenges associated with its implementation. The synthesis of these findings provides a foundation for informed decision-making in educational practices and sets the stage for future research in the evolving landscape of educational technology.

Keywords: technology-enhanced learning, mathematics education, interactive software, virtual manipulatives, adaptive learning systems

Introduction

In an era characterized by rapid technological advancements, the integration of technology in education has become a focal point for enhancing learning outcomes across various disciplines (Lawless & Pellegrino, 2007). One critical domain that stands to benefit significantly from technological interventions is the acquisition of basic math skills. Basic math proficiency serves as a foundational element for academic success and future career opportunities, making it imperative to explore innovative approaches to improve its mastery (Cardino, et al., 2020).

Historically, traditional teaching methods in mathematics have predominantly relied on textbooks, lectures, and rote memorization. However, recent years have witnessed a paradigm shift in educational practices with the advent of technology. Educational technology, encompassing a wide array of digital tools and applications, has emerged as a promising avenue for transforming the learning experience, particularly in mathematics education. The potential of technology to engage students, personalize learning experiences, and provide real-time feedback aligns seamlessly with the dynamic and interactive nature of mathematical concepts (Diano, et al., 2023).

Previous research has indicated positive outcomes in various educational contexts where technology has been employed to teach mathematics, emphasizing its potential to bridge learning gaps and facilitate a more inclusive and interactive educational experience (González-Pérez & Ramírez-Montoya, 2022). The research focuses on evaluating the impact of specific technological tools, such as interactive software, online platforms, and educational apps, on students' mathematical proficiency. Additionally, the study explores the role of technology in promoting self-directed learning, critical thinking, and problem-solving skills – essential components for mastering mathematical concepts in the 21st century (Kim & Kim, 2017).

Literature Review

In recent years, the integration of technology into education has gained considerable attention, and this shift has been particularly pronounced in the domain of mathematics. As technology continues to evolve, educators and researchers are exploring innovative approaches to improve the teaching and learning of mathematics, recognizing its foundational importance for academic success and future career opportunities.

Traditionally, mathematics education has relied heavily on textbooks, lectures, and repetitive exercises. However, the effectiveness of these methods in promoting deep understanding and retention has been questioned. Research indicates that a significant number of students struggle with basic math skills, and traditional approaches may not sufficiently address the diverse learning needs of individuals (National Research Council, 2001). This has prompted a reevaluation of pedagogical methods, leading to an increased interest in leveraging technology to enhance math education.

Educational technology offers a diverse range of tools and platforms that can be tailored to address the specific challenges faced in teaching and learning mathematics. Interactive software, online platforms, and educational apps are among the technological interventions that have shown promise in engaging students and facilitating a more interactive learning experience (Rabi, et al., 2023).

Interactive software, such as virtual manipulatives and simulations, has been identified as an effective tool for enhancing conceptual understanding in mathematics (Moyer-Packenham & Westenskow, 2013). These tools provide students with opportunities to explore mathematical concepts in a dynamic and visual manner, promoting active engagement. Furthermore, the provision of real-time feedback in these environments allows for immediate correction and reinforcement, contributing to a more iterative and adaptive learning process.

Online Platforms for Personalized Learning:

Online platforms offer the advantage of personalized learning experiences, catering to individual learning styles and paces (Papastergiou, 2009). Adaptive learning systems, for instance, can adjust the difficulty of problems based on individual performance, ensuring that each student is appropriately challenged. Research suggests that such personalized approaches can lead to improved student outcomes in mathematics (Kilag, et al., 2023).

The integration of educational apps and gamification elements has also demonstrated positive outcomes in mathematics education. Mobile applications provide students with the flexibility to engage with mathematical concepts beyond the traditional classroom setting, promoting self-directed learning (Lee, 2015). Additionally, incorporating gamified elements, such as rewards and challenges, can enhance motivation and make the learning process more enjoyable (Hamari et al., 2014).

While the potential benefits of technology in improving basic math skills are evident, it is crucial to acknowledge and address associated challenges. Access to technology, teacher training, and concerns about screen time are factors that need careful consideration (Kersting et al., 2012).

Additionally, the effectiveness of technology integration depends on thoughtful design and alignment with educational objectives (Manire, et al., 2023).

Beyond basic skill acquisition, there is a growing interest in understanding how technology can contribute to the development of higher-order skills such as critical thinking and problem-solving. The dynamic and interactive nature of technology-enabled learning environments provides opportunities for students to apply mathematical concepts in real-world scenarios, fostering a deeper understanding of the subject (Gadanidis et al., 2017).

The literature reviewed here highlights the evolving landscape of technology in mathematics education. From interactive software to personalized online platforms and educational apps, a diverse array of tools holds promise for improving basic math skills. However, it is crucial to approach the integration of technology with a nuanced understanding of challenges and considerations (Valle, et al., 2023). As educators and researchers continue to explore innovative approaches, the potential impact on not only basic math skills but also on higher-order cognitive skills positions technology as a valuable ally in shaping the future of mathematics education.

Methodology

A comprehensive search strategy was developed to identify relevant studies. Multiple electronic databases, including PubMed, ERIC, IEEE Xplore, and Google Scholar, were systematically queried using a combination of keywords and controlled vocabulary related to technology, mathematics education, and basic math skills.

Inclusion and exclusion criteria were established to ensure the selection of studies aligned with the research questions. Peer-reviewed articles, conference papers, and book chapters published in English were included, while unpublished works and studies not directly addressing the impact of technology on basic math skills were excluded.

The screening process involved two stages: title and abstract screening followed by full-text assessment. Two independent reviewers conducted the screening, and any discrepancies were resolved through discussion. Studies meeting the inclusion criteria proceeded to the next stage.

A standardized data extraction form was developed to systematically collect relevant information from the selected studies. Data extraction included details such as the study design, sample characteristics, types of technology used, and key findings related to the impact on basic math skills.

The quality of selected studies was assessed to gauge the reliability and validity of the research findings. Commonly accepted quality assessment tools, such as the JBI Critical Appraisal Checklist for Quasi-Experimental Studies, were employed. Studies were not excluded based on quality but were considered in the synthesis with quality indicators taken into account.

A narrative synthesis approach was employed to analyze and integrate findings from the selected studies. Common themes and patterns related to the impact of technology on basic math skills

were identified. The synthesis process aimed to provide a coherent and comprehensive overview of the current state of knowledge in the field.

Findings and Discussion

Positive Impact of Interactive Software on Basic Math Skills:

Within the realm of technology-enhanced mathematics education, an overarching consensus in the literature reveals a positive impact of interactive software on the improvement of basic math skills. A pivotal finding emanates from the utilization of virtual manipulatives and simulations, recognized as powerful tools for fostering conceptual understanding and engagement among learners. This observation is substantiated by the work of Mills (2018), whose research underscores the effectiveness of dynamic and visually stimulating software in promoting active learning and cultivating a more profound comprehension of mathematical concepts.

The interactive nature of virtual manipulatives allows students to manipulate objects in a digital environment, providing a hands-on experience that transcends the limitations of traditional methods. Simulations, on the other hand, create dynamic scenarios that enable learners to interact with abstract mathematical concepts in a contextualized and visually immersive manner. Such engagement has been consistently associated with positive learning outcomes, as students not only acquire procedural knowledge but also develop a deeper conceptual understanding of fundamental mathematical principles (Ocariza, et al., 2023).

Moreover, the dynamic and visual attributes of interactive software contribute significantly to active learning. The literature suggests that when students actively engage with mathematical concepts through manipulation and exploration facilitated by these tools, they are more likely to retain information and develop problem-solving skills (Mills, 2018). This finding aligns with the broader educational literature emphasizing the efficacy of active learning in promoting a deeper understanding of subject matter.

The positive impact of interactive software on basic math skills is a recurrent theme in the literature, supported by empirical evidence. Virtual manipulatives and simulations emerge as effective tools that not only enhance conceptual understanding but also foster active learning. The dynamic and visual aspects of these technologies contribute to a more profound grasp of mathematical concepts, setting the stage for further exploration into the nuanced ways in which interactive software can be leveraged to improve mathematics education.

Personalized Learning through Online Platforms in Mathematics Education:

The literature consistently underscores the advantageous role of online platforms in supporting personalized learning experiences within the domain of mathematics education. Notably, the integration of adaptive learning systems emerges as a key factor in tailoring educational content to individual student needs, ensuring an optimal level of challenge. This finding is substantiated by the research of Papastergiou (2009) of whom contribute valuable insights into the impact of personalized learning approaches on basic math skill acquisition.

Adaptive learning systems, featured prominently in online platforms, possess the capability to dynamically adjust the difficulty of learning materials based on the individual learner's

performance. This adaptability ensures that each student receives content that aligns with their current proficiency level, providing an appropriate balance between challenge and comprehension. Papastergiou (2009) highlights the effectiveness of such adaptive systems in enhancing student engagement and performance in mathematics education, affirming the potential of personalized learning experiences to cater to diverse learning needs.

The consistent reporting of improved student outcomes in the reviewed studies further accentuates the positive impact of personalized approaches. These outcomes encompass not only quantitative measures such as test scores but also qualitative indicators, including increased confidence and a more positive attitude towards mathematics. Le, et al. (2014) research, in particular, delves into the benefits of online learning in terms of time flexibility and student-paced progression, emphasizing the capacity of personalized learning to contribute significantly to the acquisition of basic math skills.

The integration of online platforms, particularly through the implementation of adaptive learning systems, stands out as a facilitator of personalized learning experiences in mathematics education. The research by Papastergiou (2009) collectively supports the assertion that personalized approaches contribute substantially to enhanced basic math skill acquisition. The adaptability of online platforms to individual learning needs not only aligns with pedagogical best practices but also holds promise for addressing the diverse challenges students may encounter in their mathematical learning journey.

Effectiveness of Educational Apps and Gamification in Mathematics Learning:

An emerging and promising avenue in mathematics education is the incorporation of educational apps and gamification elements. The literature suggests that mobile applications play a pivotal role in providing students with unprecedented flexibility, enabling them to interact with mathematical concepts outside the confines of the traditional classroom setting. This observation is supported by the works of Lee (2014) and Hamari et al. (2014), both of whom contribute valuable insights into the effectiveness of educational apps and gamification in enhancing the learning experience.

Educational apps offer students the convenience of accessing math-related content anytime and anywhere through mobile devices. Lee (2014) emphasizes the flexibility afforded by educational apps, enabling students to engage with interactive and adaptive content at their own pace. This flexibility not only accommodates diverse learning styles but also extends the learning environment beyond the structured classroom, fostering continuous and personalized engagement with mathematical concepts.

The incorporation of gamification elements, including rewards and challenges, has been identified as a motivational driver in mathematics learning. Hamari et al. (2014) discuss the positive impact of gamified features in increasing student motivation and engagement. The gamification of mathematical tasks transforms learning into an enjoyable and interactive experience, encouraging students to persist in problem-solving and skill acquisition (Ondog, et al., 2023). This element of enjoyment, coupled with the sense of accomplishment derived from overcoming challenges, contributes significantly to a more positive attitude towards mathematics.

The literature consistently points to the effectiveness of educational apps and gamification in mathematics education. Lee (2014) and Hamari et al. (2014) collectively highlight the flexibility offered by educational apps and the motivational impact of gamification elements. This dual approach not only extends the reach of mathematics education but also enhances the overall learning experience, making it more enjoyable, engaging, and conducive to sustained skill development.

Challenges and Considerations in the Integration of Technology in Mathematics Education:

While the literature highlights positive outcomes from the integration of technology in mathematics education, it concurrently underscores several challenges and considerations that warrant careful attention. A recurring theme across studies is the issue of access to technology, as identified by Kersting et al. (2012). The digital divide, stemming from disparities in access to devices and the internet, poses a significant obstacle in ensuring equitable opportunities for all students to benefit from technology-enhanced learning experiences.

Teacher training emerges as another crucial consideration in the successful integration of technology. Kersting et al. (2012) emphasize the need for professional development programs that equip educators with the necessary skills to effectively integrate technology into their pedagogical practices. The literature suggests that teachers' familiarity and competence with technology influence the degree to which its potential benefits can be realized in the classroom, underlining the importance of ongoing training initiatives.

Concerns related to screen time, a prevalent issue in the digital age, are consistently echoed in the literature. Kersting et al. (2012) discuss the potential negative impact of excessive screen time on students' well-being and emphasize the need for a balanced approach to technology integration. Striking a balance between technology use and other forms of instruction is crucial to mitigate potential adverse effects on students' physical and mental health.

Moreover, the effectiveness of technology integration is contingent on careful design and alignment with educational objectives, as emphasized by Rabillas, et al. (2023). The literature underscores the necessity of aligning technological interventions with curriculum goals and pedagogical strategies to ensure a meaningful and coherent learning experience. Thoughtful design not only enhances the relevance of technology in supporting educational objectives but also helps address potential challenges associated with its implementation.

While the positive impact of technology in mathematics education is evident, it is imperative to address challenges and considerations for its equitable and effective integration. The works of Kersting et al. (2012) and Means et al. (2009) collectively underscore the significance of addressing issues related to access, teacher training, and thoughtful design to maximize the benefits of technology while minimizing potential drawbacks. This balanced approach is essential to create an inclusive and effective learning environment in which technology serves as a valuable tool in the hands of both educators and students.

Conclusion

The systematic literature review on "Improving Basic Math Skills Using Technology" provides valuable insights into the multifaceted relationship between technology and mathematics education. The synthesis of findings from diverse studies highlights several key themes that collectively contribute to the understanding of how technology can enhance the acquisition of basic math skills.

This emphasizes the dynamic and visual nature of tools like virtual manipulatives and simulations in fostering active learning. These technologies offer a hands-on, immersive experience, facilitating a deeper conceptual understanding of mathematical principles. Furthermore, the integration of online platforms, particularly through adaptive learning systems, emerges as a pivotal strategy for personalized learning. The flexibility afforded by mobile applications and the motivational impact of gamified elements collectively contribute to sustained student engagement and a positive attitude towards mathematical concepts.

However, the study also acknowledges the challenges and considerations inherent in the integration of technology into mathematics education. Issues of access to technology, teacher training, and concerns related to screen time, as highlighted by Kersting et al. (2012), underscore the importance of addressing these barriers to ensure equitable opportunities for all students and mitigate potential negative impacts.

The findings collectively emphasize the need for a balanced and thoughtful approach to technology integration. Aligning technological interventions with educational objectives, as emphasized by Means et al. (2009), ensures that technology serves as a meaningful tool in enhancing basic math skills without compromising pedagogical integrity.

As we navigate the evolving landscape of education, this study underscores the potential of technology to revolutionize mathematics learning. By leveraging the strengths of interactive software, personalized online platforms, and engaging educational apps, educators and policymakers can create an inclusive and effective learning environment that prepares students for success in mathematics and beyond. The synthesis of these findings contributes to the ongoing dialogue on the role of technology in education, providing a foundation for future research and informed decision-making in educational practices.

References

- Cardino Jr, J. M., & Cruz, R. A. O. D. (2020). Understanding of learning styles and teaching strategies towards improving the teaching and learning of mathematics. *LUMAT: International Journal on Math, Science and Technology Education*, 8(1), 19-43.
- Diano Jr, F., Kilag, O. K., Malbas, M., Catacutan, A., Tiongzon, B., & Abendan, C. F. (2023). Towards Global Competence: Innovations in the Philippine Curriculum for Addressing International Challenges. *Excellencia: International Multi-disciplinary Journal of Education* (2994-9521), 1(4), 295-307.

Gadanidis, G., Hughes, J. M., Minniti, L., & White, B. J. (2017). Computational thinking, grade 1 students and the binomial theorem. *Digital Experiences in Mathematics Education*, 3, 77-96.

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: systematic review. *Sustainability*, 14(3), 1493.

Hamari, J., Koivisto, J., & Sarsa, H. (2014, January). Does gamification work?--a literature review of empirical studies on gamification. In *2014 47th Hawaii international conference on system sciences* (pp. 3025-3034).

Kersting, N. B., Givvin, K. B., Thompson, B. J., Santagata, R., & Stigler, J. W. (2012). Measuring usable knowledge: Teachers' analyses of mathematics classroom videos predict teaching quality and student learning. *American Educational Research Journal*, 49(3), 568-589.

Kilag, O. K. T., Zarco, J. P., Zamora, M. B., Caballero, J. D., Yntig, C. A. L., Suba-an, J. D., & Sasan, J. M. V. (2023). How Does Philippines's Education System Compared to Finland's?. *EUROPEAN JOURNAL OF INNOVATION IN NONFORMAL EDUCATION*, 3(6), 11-20.

Kilag, O. K. T., Malbas, M. H., Miñoza, J. R., Ledesma, M. M. R., Vestal, A. B. E., & Sasan, J. M. V. (2023). The Views of the Faculty on the Effectiveness of Teacher Education Programs in Developing Lifelong Learning Competence. *European Journal of Higher Education and Academic Advancement*, 1(2), 92-102.

Kim, H. J., & Kim, H. (2017). Investigating teachers' pedagogical experiences with tablet integration in Korean rural schools. *The Asia-Pacific Education Researcher*, 26, 107-116.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of educational research*, 77(4), 575-614.

Le, C., Wolfe, R. E., & Steinberg, A. (2014). The Past and the Promise: Today's Competency Education Movement. Students at the Center: Competency Education Research Series. *Jobs For the Future*.

Lee, L. (2015). Digital media and young children's learning: A case study of using iPads in American preschools. *International Journal of Information and Education Technology*, 5(12), 947-950.

Manire, E., Kilag, O. K., Habig, M., Satin, R., Genovania, M. R., & Tan, S. J. (2023). A Technological Approach to Early Childhood Education: Unveiling the SEEDS Pedagogy. *Excellencia: International Multi-disciplinary Journal of Education* (2994-9521), 1(5), 333-344.

Mills, J. P. (2018). *Investigating the professional knowledge of New Zealand primary school teachers when teaching mathematics for numeracy* (Doctoral dissertation, The University of Waikato).

Moyer-Packenham, P. S., & Westenskow, A. (2013). Effects of virtual manipulatives on student achievement and mathematics learning. *International Journal of Virtual & Personal Learning Environments*, 4(3).

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2009). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies.

National Research Council. (2001). *Adding it up. Mathematics Learning Study Committee*, J. Kilpatrick & J. Swafford (Eds.), Center for Education, Division of Behavioral Sciences and Education. Washington, DC: National Academy Press.

Ocariza, E., Kilag, O. K., Olasiman, J., & Abendan, C. F. (2023). Breaking Barriers: An In-depth Exploration of Interventions for Enhancing Science Performance in Filipino Students. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(5), 268-278.

Ondog, J., & Kilag, O. K. (2023). A Constructivist Framework for Early Grade Numeracy: Drawing on Jean Piaget's Cognitive Development Theory. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(4), 308-320.

Ondog, J., Kilag, O. K., Padilla, J., & Abendan, C. F. (2023). Understanding Numerical Intuition: An Analysis of Junior High School Students' Innate Mathematical Abilities and Number Sense Competencies. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(5), 391-402.

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & education*, 52(1), 1-12.

Rabi, J. I. I., Kilag, O. K., Hinayon, K., Peras, C., Dumdum, J. N., & Ledesma, E. N. (2023). TED Talks: A Catalyst for Improving Oral Communication Skills in Educational Settings. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(4), 210-222.

Rabillas, A., Kilag, O. K., Cañete, N., Trazona, M., Calope, M. L., & Kilag, J. (2023). Elementary Math Learning Through Piaget's Cognitive Development Stages. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(4), 128-142.

Valle, J., Kilag, O. K., Villanueva, G., Escabas, F., Macapobre, H., & Poloyapoy, H. (2023). The Influence of Phonological Awareness and Rapid Automatized Naming on Early Numeracy. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, 1(5), 42-54.