Journal of Education and Learning (EduLearn)
Vol. 20, No. 3, August 2026, pp. 1942~1950
ISSN: 2089-9823, DOI: 10.11591/edulearn.v20i3.23724

Digital innovations in mathematics education: empowering teaching and learning

Martin L. Nobis Jr.[1], Ronato S. Ballado[2], Jabel Phillip L. Irinco[1], Cherry I. Balanquit[1]
[1]Department of Teacher Education, University of Eastern Philippines, Laoang Campus, Laoang, Philippines
[2]Graduate Studies and College of Education, University of Eastern Philippines, Catarman, Philippines

Article Info

Article history:

Received Nov 2, 2024
Revised Dec 5, 2025
Accepted Jan 31, 2026

Keywords:

Digital competence
Digital tools
Mathematics education
Professional development
Student learning outcomes

ABSTRACT

Digital tools hold immense potential to transform mathematics education. This study examines how digital innovations can bridge the achievement gap and empower teaching and learning. The primary goal is to evaluate the impact of educational software, interactive tools, and online platforms on personalizing learning, promoting problem-solving, and fostering collaboration. The study utilizes thematic analysis to explore these key areas by employing qualitative research methods, specifically semi-structured interviews conducted with seven mathematics teachers who were selected through purposive sampling based on their experience and involvement with digital tools in mathematics education. The findings reveal significant potential for student empowerment and highlight barriers such as technical issues and limited teacher training. The study emphasizes the need for investments in technology infrastructure and ongoing professional development programs focused on integrating digital tools. Targeted interventions are recommended to support effective technology use. By equipping teachers with robust digital skills, schools can unlock the transformative potential of these tools, preparing students for success in a technology-driven future. These implications suggest further research into optimizing digital tools for personalized learning to better meet diverse student needs and learning styles.

Corresponding Author:

Martin L. Nobis Jr.
Department of Teacher Education, University of Eastern Philippines, Laoang Campus
San Miguel Heights, Laoang, Northern Samar, Philippines
Email: martinnobis.uepl@gmail.com

1. INTRODUCTION

In today's digital environment, mathematics education faces a fundamental challenge: leveraging technology to empower student learning. While digital tools such as educational software and online platforms provide exciting opportunities for personalized learning, problem-solving skills development, and collaboration, their usefulness can be impeded by technical restrictions and insufficient teacher preparation.

Recent research in mathematics education has identified a growing trend: technological integration as a critical topic of study. A scoping analysis of research identified seven unique study areas, each demonstrating the changing environment of technology use in the classroom [1]. While digital tools have the potential to positively affect curriculum and instruction, as well as student outcomes, they also present serious concerns. These include the impact on curriculum, teaching, and student outcomes.

Teachers today have access to many digital resources that can tailor learning and improve instruction, but effective integration requires continual professional development and support. Equity concerns are also raised, as not all students have equal access to gadgets and the internet, thereby worsening

the attainment gap in scenarios such as distant learning [2]. Similarly, research on student motivation yields varied results, with some studies indicating favorable impacts and others emphasizing difficulties with engagement and distraction [3].

Balancing technology and effective instruction is critical. To ensure its successful deployment, teachers must receive comprehensive training that covers both technical capabilities and pedagogical strategies for using these technologies. Collaborative platforms and communities can help instructors by facilitating knowledge sharing [1], [2]. Assessment in technologically advanced situations has significant issues as well. Educators must create exams that are compatible with digital tools and assess deeper comprehension rather than just procedural abilities [3]. It is critical to strike a balance between formative and summative evaluations while taking into account the possibilities provided by technology.

Looking ahead, researchers, policymakers, and educators must continue exploring innovative ways to integrate technology into mathematics education. By addressing technical limitations, promoting teacher training, and ensuring equitable access, we can unlock technology's true potential to create transformative learning experiences for all students [2], [3].

The application of technology in mathematics teaching is expanding. Studies show both potential and limitations. Digital tools can personalize learning and improve education, but they require continual teacher training and support [4]. A big concern is equity, as not all pupils have equal access to technology, which could worsen the attainment gap. Research on student motivation is varied, with some research indicating favorable impacts and others emphasizing difficulties with concentration. To be successful, technology must be combined with excellent teaching methods. Teachers require appropriate training in both using technology [5] and incorporating it into their lessons [4], [6]. Collaboration between instructors is also vital. Assessing student learning in these settings necessitates novel ways that assess deeper comprehension rather than rote memory. Moving forward, researchers, policymakers, and educators must collaborate to find new ways to include technology while addressing limits, boosting teacher training, and ensuring equal access for all children [7].

Researchers evaluated math teachers' confidence in using technology for teaching and found moderate overall self-efficacy [8]. Interestingly, gender and teacher training had a significant impact on this confidence, implying that teacher education programs should prioritize technology integration while also addressing gender disparities [9]. Technology itself plays a transformative role in education, shifting teachers from knowledge providers to facilitators. While Tanzania has implemented computers, internet connections, and even indigenous educational apps, issues such as equal access and teacher training remain [8], [9]. Effective integration necessitates continual instructor support and tests that reflect deeper comprehension rather than just memorization [10]. Looking ahead, frameworks such as UNESCO's emphasis on digital literacy abilities across multiple domains can better prepare students for the needs of the digital age [11].

According to research, digital technologies can provide several benefits in mathematics instruction. Jefferson [12] and Wakjira and Bhattacharya [13] found that digital tools can improve student motivation, engagement, and, ultimately, learning outcomes. Alenezi corroborated these findings, emphasizing the positive impact of digital technologies on student learning outcomes, motivation, and engagement [14]. However, this research revealed barriers to technology integration, such as teacher training and access to technology [15].

The value of teacher training in efficiently incorporating digital resources has been thoroughly recognized. Potari [16] discovered that professional development programs for digital technology integration improved teacher knowledge, abilities, confidence, and practices [17]. Similar findings were reported, emphasizing the importance of teacher confidence and pedagogical understanding [18]. Both studies suggest that effective professional development programs should be targeted to instructors' unique requirements, emphasize practical applications, and provide ongoing support [19]–[21].

The COVID-19 epidemic has pushed a rapid shift to online and remote learning practices, having a huge impact on educational institutions around the world. Digital tools and platforms have become critical for distance learning, notably in mathematics education. To better understand this transition, Trujillo-Torres *et al.* [22] looked into mathematics teachers' experiences and perspectives on using digital tools in online and remote learning contexts [23].

To address these concerns, this study examines the role of digital tools in mathematics education. Specifically, it seeks to: i) identify the digital tools most commonly used in mathematics instruction; ii) evaluate the perceived benefits of these tools in teaching and learning approaches; iii) assess teachers' digital competence and preparedness for technology integration; and iv) investigate educators' challenges when incorporating digital tools into their instructional methods.

Building on existing research, this study explored the empowering potential of digital tools and teacher training in mathematics education at the University of Eastern Philippines, Laoang campus. It identified the digital tools most used in teaching and learning approaches, evaluated their perceived benefits, and assessed the significance of digital competence for teachers. Additionally, the study examined the challenges teachers faced when integrating digital tools into their instructional methods. By addressing these

objectives, the research contributed to a deeper understanding of the role of technology in mathematics education and provided insights into effective digital integration strategies for educators.

2. METHOD

The study explored the perspectives of seven mathematics teachers from the University of Eastern Philippines, Laoang Campus, regarding the integration of digital tools in education. Participants were selected through purposive sampling, limited to educators with at least three years of teaching experience and a background in professional development programs focused on technology. Those without prior digital teaching experience were excluded. Ethical approval was obtained before conducting semi-structured, in-person interviews, which lasted 45 to 60 minutes and were audio and video recorded. Transcriptions were completed manually and verified using automated speech recognition software to improve accuracy. To ensure validity, the researchers employed triangulation by cross-referencing interview data with institutional documents and teacher training records. Methodological triangulation was also implemented, combining qualitative interviews with content analysis of official documents, and peer debriefing further refined thematic interpretation to reduce bias. Field notes were used to capture non-verbal cues and contextual details during interviews. Data analysis followed a structured thematic approach: researchers first familiarized themselves with the data by reviewing transcripts repeatedly, then conducted initial coding using a manual that blended deductive categories (e.g., technology use and instructional strategies) and inductive themes that emerged from responses. Axial coding was applied to examine relationships between themes, particularly those related to teacher preparedness, instructional challenges, and digital competence. Thematic classifications were continuously refined through constant comparative analysis and peer validation to ensure credibility.

3. RESULTS AND DISCUSSION

3.1. Digital tools

Digital tools are revolutionizing mathematics education and teacher training, offering innovative ways to bridge the achievement gap. Table 1 shows that interactive software and online courses have a modest to significant positive impact on student achievement. Interactive software and online courses can lead to a range of positive outcomes in student achievement [24], from modest improvements to significant gains [24], [25]. However, these tools are even more effective when personalized to match individual learning paces [26], [27]. Educational games and simulations are particularly beneficial [28] for children struggling with math, fostering favorable learning outcomes [29], [30]. Collaborative digital technologies also hold promise, enhancing learning by promoting inclusive classrooms and facilitating peer-to-peer interactions [31]–[33]. While digital textbooks and workbooks have shown mixed results across various disciplines [33], educational impact remains significant, particularly when tailored to individual learning needs [34].

Dwivedi *et al.* [34] emphasize AI's role in enhancing student engagement and learning outcomes, helping to bridge achievement gaps. These tools can cater to individual requirements and support inclusive learning environments [35]. However, their successful implementation relies on continuous professional development for teachers to ensure effective integration into instructional practices. Policymakers should prioritize targeted training programs and resource allocation to enhance digital access, particularly in underserved communities. Education must adopt adaptive technologies and train teachers effectively to support diverse learners and promote digital equity [36].

Table 1. Digital tools used in teaching and learning approaches in mathematics education

Themes	Sample responses
Online interactive	Google Jamboard, Bitpaper, and Explain Everything
Math software	GeoGebra, Desmos, Wolfram Alpha, and YouTube
Educational games and simulations	Prodigy, Math Playground, and Matific
Video tutorials and online courses	Khan Academy, MathSpace, and Coursera
Digital textbooks and workbooks	Pearson MathXL and McGraw-Hill Connect Math
Collaborative tools	Google Classroom, Microsoft Teams
Other tools and resources	Kahoot, Mathspace, Mathigon, Prodigy, and Open Educational Resources (OER)

3.2. Benefits of digital tools

As presented in Table 2, digital tools have transformed mathematics education by offering several advantages, such as higher engagement, tailored learning experiences, improved collaboration, increased efficiency, readily available resources, and quick feedback. These tools have opened up new possibilities for

improving the teaching and learning process [37], enhancing students' academic performance and confidence while tailoring learning experiences to meet individual needs [38]. They have enhanced access to materials and collaboration both in and out of the classroom, resulting in more efficient and productive mathematics assignments [35], [39].

Interactive software and simulations, as demonstrated by Mottee [40] and Zhang *et al.* [41], can greatly increase student engagement by providing visually appealing and participative opportunities [42]. Furthermore, these tools can be tailored to individual learning styles and paces, enhancing students' mathematical proficiency. Additionally, collaborative digital tools provide distinct advantages. Cherbonnier *et al.* [43] found that these tools enable students to communicate in real time, fostering cooperation and communication skills. The efficiency benefits of digital tools are evident. Teachers save time by streamlining administrative tasks such as grading and record-keeping [41], [42], allowing them to focus on lesson planning and effective content delivery. Furthermore, digital tools give students easy access to information [44] and the capacity to explore topics independently [43]. Siwach *et al.* [45] support this, showing that a significant number of students use the Internet for school projects, helping them to delve deeper into subjects.

Finally, digital tools provide immediate feedback [45] and monitoring [46]. This enables students to identify their strengths and weaknesses [47] and adapt their learning strategies in real time, resulting in better mathematics learning outcomes [48]. By leveraging these advantages, educators can create a more effective learning environment for all students, potentially reducing the achievement gap [49]. The study highlights the importance of investing in adaptive learning technologies to meet diverse student needs while promoting equitable access. Policymakers should support professional development programs that enhance digital literacy and train educators in both technological and pedagogical integration. Adaptive technologies, supported by teacher training and equitable access, can bridge learning gaps and drive sustainable education reform.

Table 2. Benefits of digital tools

Themes	Sample responses
Enhanced engagement	*By incorporating digital tools that provide interactive and visually appealing resources, I can enhance my students' engagement and attention span.*
	This approach can boost their motivation and help them learn more effectively by implementing such tools.
	I can increase my students' engagement level and their ability to comprehend the subject matter.
	As a result, students' motivation to learn can be enhanced, leading to better learning outcomes.
Personalized learning	*Using digital tools, I can customize my students' learning experiences to cater to their unique needs, strengths, and weaknesses, thereby making them more personalized.*
	By utilizing digital tools, I have the power to tailor my students' learning experiences to match their specific needs.
	Through this customized approach, my students can enjoy a more personalized learning experience.
Improved collaboration	*Collaborative digital tools allow students to work together in real-time, share ideas, and solve problems. This helps to improve their teamwork and communication skills.*
	It allows students to work together simultaneously and help each other solve problems, exchange ideas, and learn collaboratively, which improves teamwork and communication skills.
Increased efficiency	*Teachers can simplify administrative tasks such as grading and record-keeping, which can offer more free time to focus on teaching.*
Accessible resources	*Digital tools allow access to resources and materials that are not available in classrooms. This promotes self-directed learning and encourages students to explore new concepts.*
Immediate feedback	*As a teacher, I can provide prompt feedback to my students using digital tools.*
	This way, my students can identify their areas of strength and weakness and improve their learning strategies accordingly.
	Using digital tools, I can support my students in assessing their progress and developing their skills.

3.3. Importance of digital competence

Table 3 shows the importance of digital competence, such as effective use of digital tools, adapting to technological changes, personalized learning, efficient teaching, and collaborative learning, highlighting the importance of digital competence in mathematics education. Teachers with strong digital skills can effectively select, use, and incorporate digital resources into the teaching and learning process, thereby enhancing student engagement and learning outcomes [50]. They are adaptive to technological improvements and changes in educational procedures, equipping students with the skills needed in the 21st century.

Research demonstrates that interactive software and online courses improve student achievement [51]. However, these tools can be even more effective if tailored to individual learning styles and paces [26], [27]. Educational games and simulations are especially beneficial for children who struggle with math [29] [30]. This aligns with earlier research showing the efficacy of these tools in producing positive learning outcomes. The study also highlights the importance of collaborative digital technologies. Zheng *et al.* [31] demonstrates that these technologies promote peer engagement and provide a more inclusive learning environment, resulting in

improved student learning [32], [33]. Developing digital competence among educators, supported by equitable tool access and long-term training, is vital for sustainable, inclusive tech integration in education.

Table 3. Importance of digital competence

Themes	Sample responses
Effective use of digital tools	*I can select, use, and integrate digital tools effectively in my teaching and learning process.* *I can evaluate and choose the appropriate tools to cater to my students' specific needs and seamlessly integrate them into my lessons.* *By properly using these tools, I can enhance my students' engagement and improve their learning outcomes.*
Adapting to technological advancements	*I can adapt to technological advancements and changes in educational trends.* *This enables me to prepare my students for the demands of the 21st-century, ensuring that they receive a quality education that equips them to succeed in an increasingly digital world.* *Teachers with digital competence can adapt to changes in technology and education, preparing students to succeed in the digital world.*
Personalized learning	*I can use digital tools to offer my students personalized learning experiences that support their individual learning needs, preferences, and abilities.* *This has a positive impact on my students' engagement, motivation, and success in their studies.*
Efficient teaching	*I can save time on administrative tasks like grading, record-keeping, and communication with students and parents.* *This allows me to focus more on lesson planning, instructional strategies, and student support.*
Collaborative learning	*I recognize the importance of digital competence in facilitating collaborative learning by utilizing digital tools, which is an integral part of 21st-century education.* *I can help my students develop effective teamwork skills and achieve better academic results through collaborative learning.*

3.4. Challenges encountered in using digital tools

Despite the potential benefits of digital tools in teaching mathematics, their adoption confronts various challenges presented in Table 4, the challenges encountered in using digital tools. Teachers face a variety of issues, including technical problems, the digital divide, and a lack of resources. Technical issues such as internet connectivity problems, program crashes, and compatibility concerns can disrupt the learning process for both students and teachers [52]–[54]. Unequal access to technology based on socioeconomic status or geographic location can worsen existing educational disparities [55].

Table 4. Challenges encountered in using digital tools

Themes	Sample responses
Technical glitches and issues	*I often need help with using digital tools due to technical glitches and issues that both my students and I may encounter while utilizing them.* *These challenges could be varied, which might include problems with internet connectivity, hardware failures, software crashes, and compatibility issues.*
Digital divide	*I have noticed that not all of my students have equal access to digital tools.* *This lack of access can be due to socioeconomic status or where they live, which creates what we call a digital divide.* *It means that some of my students have access to more advanced technology than others, leading to further educational inequalities.*
Intimidation or lack of confidence	*I have noticed that some of my students seem intimidated and lack confidence when it comes to using digital tools. This is especially true if they are new to these tools or need help navigating them.* *I worry that this lack of confidence might lead to disengagement and hinder their ability to learn effectively.*
Inadequate training	*I may have needed to be properly trained in utilizing digital tools, which can present challenges in effectively incorporating them into my lessons.* *This could cause a decrease in my confidence when it comes to teaching or employing digital tools, ultimately impacting my students' abilities to perform well.*
Inadequate monitoring:	*I may need help in ensuring that all my students are utilizing digital tools properly and advancing accordingly.* *This task demands that I keep a constant eye on each student's work, which can be a daunting and time-consuming responsibility, particularly with larger class sizes.*

Furthermore, educators may lack confidence in employing these technologies, leading to disengagement and limiting their potential benefits [51]. Without sufficient training, incorporating digital resources successfully can be difficult, negatively impacting student learning [56]. Additionally, monitoring the use of digital tools can be time-consuming and challenging, especially in large classes [57], [58]. These issues add to the teachers' workload and students' engagement [59], as they must ensure that all students use technology correctly and make progress [60]–[62]. Effective technology-integrated teaching necessitates pedagogical innovation, yet many teachers lack the requisite skills to optimize information and

communication technology (ICT) in the learning process [63]. To address these challenges, investment in digital infrastructure is necessary to provide stable internet connectivity, reliable hardware, and accessible learning platforms. Ongoing teacher training programs should focus on both technical proficiency and pedagogical strategies for effective technology integration [64]. Policymakers must also prioritize equitable access to digital tools, ensuring that students from diverse backgrounds benefit from technology-enhanced learning [65]. The study highlights the need for investment in digital infrastructure, ongoing teacher training, and equitable access to technology to maximize the benefits of digital tools in mathematics education while addressing challenges and informing effective policies.

4. CONCLUSION

This study explores the transformative potential of digital tools in mathematics education. It highlights how these tools can enhance student learning and engagement, close the achievement gap, and create inclusive learning environments. Through qualitative research involving semi-structured interviews with math teachers, the study reveals both the promise and challenges of integrating digital tools in education. Key findings emphasize the importance of personalized learning experiences and the need for robust technology infrastructure and teacher training.

The research underscores the necessity of ongoing professional development programs to equip teachers with the digital skills required to use these tools effectively. It identifies technical issues and limited teacher training as significant barriers to implementing digital innovations in the classroom. Addressing these challenges is crucial for schools to harness the full potential of digital tools and prepare students for a technology-driven future.

Future research should focus on optimizing digital tools to cater to diverse student needs and learning styles, exploring effective teacher training programs, and finding solutions to technical barriers. Longitudinal studies are recommended to assess the sustained impact of digital tools on student achievement and engagement. By continuing to refine and adapt digital tools, educators can create more engaging and effective learning environments that empower all students to reach their full mathematical potential.

ACKNOWLEDGMENTS

The researcher is grateful for the cooperation of the teacher education faculty of UEP Laoang, who served as participants in the study. The same gratitude is extended to the university administration for funding and approving the conduct of the study.

FUNDING INFORMATION

This study was funded by the University of Eastern Philippines as one of the approved priority research projects in teacher education through the Office of Research Development and Extension (RDEx).

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Martin L. Nobis Jr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ronato S. Ballado	✓	✓	✓	✓			✓			✓	✓		✓	✓
Jabel Phillip L. Irinco	✓	✓					✓			✓	✓		✓	✓
Cherry I. Balanquit	✓	✓								✓	✓		✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state there is no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

REFERENCES

[1] S. Hwang, E. Flavin, and J.-E. Lee, "Exploring research trends of technology use in mathematics education: a scoping review using topic modeling," *Education and Information Technologies*, vol. 28, no. 8, pp. 10753–10780, 2023, doi: 10.1007/s10639-023-11603-0.

[2] P. Drijvers and N. Sinclair, "The role of digital technologies in mathematics education: purposes and perspectives," *ZDM–Mathematics Education*, vol. 56, no. 2, pp. 239–248, May 2024, doi: 10.1007/s11858-023-01535-x.

[3] H. Fauziyatun and H. Retnawati, "The challenges of using ICT in mathematics education assesment: a literature review," in *AIP Conference Proceedings*, 2022, p. 040010, doi: 10.1063/5.0108031.

[4] M. A. Eroglu, "Integrating digital tools for teaching of writing expression in Turkish language," *International Journal of Learning and Teaching*, vol. 11, no. 1, pp. 34–41, 2019, doi: 10.18844/ijlt.v11i1.1031.

[5] L. Valle, "Reimagining mathematics education: identifying training needs and challenges among public elementary school teacher's post-pandemic," *International Journal of Education and Practice*, vol. 12, no. 3, pp. 527–539, 2024, doi: 10.18488/61.v12i3.3723.

[6] E. I. Sokolova, "Digital competence and technology in education (according to the materials of the european commission)," *Lifelong education: the XXI century*, vol. 30, no. 2, pp. 120–132, Jun. 2020, doi: 10.15393/j5.art.2020.5693.

[7] F. Caena and C. Redecker, "Aligning teacher competence frameworks to 21st century challenges: the case for the european digital competence framework for educators (Digcompedu)," *European Journal of Education*, vol. 54, no. 3, pp. 356–369, 2019, doi: 10.1111/ejed.12345.

[8] J. Njiku, V. Mutarutinya, and J. F. Maniraho, "Exploring mathematics teachers' technology integration self-efficacy and influencing factors," *Journal of Learning for Development*, vol. 9, no. 2, pp. 279–290, 2022, doi: 10.56059/jl4d.v9i2.589.

[9] S. K. Biber, M. Biber, and H. N. Erbay, "Teachers' perceptions on technology-assisted mathematics teaching and the interactive activities," *Education and Information Technologies*, vol. 27, no. 5, pp. 6913–6945, 2022, doi: 10.1007/s10639-022-10898-9.

[10] J. Mattar, C. C. Santos, and L. M. Cuque, "Analysis and comparison of international digital competence frameworks for education," *Education Sciences*, vol. 12, no. 12, p. 932, Dec. 2022, doi: 10.3390/educsci12120932.

[11] Y. Ocaña-Fernández, L. A. V. Fernández, W. E. M. Chiparra, and S. Gallarday-Morales, "Digital skills and digital literacy: new trends in vocational training," *International Journal of Early Childhood Special Education*, vol. 12, no. 1, pp. 370–377, 2020, doi: 10.9756/INT-JECSE/V12I1.201016.

[12] W. Jefferson, "Using classroom clicker technology to enhance student engagement," *HETS Online Journal*, vol. 1, no. 1, pp. 63–72, 2022, doi: 10.55420/2693.9193.v1.n1.86.

[13] A. Wakjira and S. Bhattacharya, "Student engagement awareness in an asynchronous e-learning environment," *International Journal of Technology-Enabled Student Support Services*, vol. 12, no. 1, pp. 1–19, 2023, doi: 10.4018/ijtesss.316211.

[14] A. Alenezi, "Teacher perspectives on AI-driven gamification: impact on student motivation, engagement, and learning outcomes," *Information Technologies and Learning Tools*, vol. 97, no. 5, pp. 138–148, 2023, doi: 10.33407/itlt.v97i5.5437.

[15] P. Ajibade, E. M. Ondari-Okemwa, and M. M. Matlhako, "Information technology integration for accelerated knowledge sharing practices: challenges and prospects for small and medium enterprise," *Problems and Perspectives in Management*, vol. 17, no. 4, pp. 131–140, 2019, doi: 10.21511/ppm.17(4).2019.11.

[16] D. Potari, "Tools and resources for mathematics teaching and mathematics teacher education," *Journal of Mathematics Teacher Education*, vol. 26, no. 2, pp. 125–127, 2023, doi: 10.1007/s10857-023-09576-5.

[17] Enikő Orsolya Bereczki and Andrea Kárpáti, "Technology-enhanced creativity: a multiple case study of digital technology-integration expert teachers' beliefs and practices," *Thinking Skills and Creativity*, vol. 39, 2021.

[18] W. R. Valente, "Teacher training and historical studies on professional knowledge: mathematics to teach and mathematics for teaching," *Pedagogical Research*, vol. 5, no. 3, p. em0070, May 2020, doi: 10.29333/pr/8281.

[19] B. Tärning, "Review of feedback in digital applications – does the feedback they provide support learning?" *Journal of Information Technology Education: Research*, vol. 17, pp. 247–283, 2018, doi: 10.28945/4104.

[20] L. A. Pilcher, M. Potgieter, and L. Fletcher, "Blending online homework and large class tutorials to provide learning support for introductory organic chemistry," *African Journal of Research in Mathematics, Science and Technology Education*, vol. 27, no. 1, pp. 1–13, 2023, doi: 10.1080/18117295.2022.2155771.

[21] C. Wendy and N. Vinitha, "Grassroots efforts to provide support and opportunities for CCBC women in the technology field," *Teaching and Learning Excellence through Scholarship*, vol. 2, no. 1, 2022.

[22] J. M. Trujillo-Torres, H. Hossein-Mohand, M. Gómez-García, H. Hossein-Mohand, and M. P. Cáceres-Reche, "Mathematics teachers' perceptions of the introduction of ICT: the relationship between motivation and use in the teaching function," *Mathematics*, vol. 8, no. 12, pp. 1–17, 2020, doi: 10.3390/math8122158.

[23] F. Reinhold, A. Strohmaier, Z. Finger-Collazos, and K. Reiss, "Considering teachers' beliefs, motivation, and emotions regarding teaching mathematics with digital tools: the effect of an in-service teacher training," *Frontiers in Education*, vol. 6, Oct. 2021, doi: 10.3389/feduc.2021.723869.

[24] M. Stephan, S. Markus, and M. Gläser-Zikuda, "Students' achievement emotions and online learning in teacher education," *Frontiers in Education*, vol. 4, Oct. 2019, doi: 10.3389/feduc.2019.00109.

[25] A. G. Cavinato, R. A. Hunter, L. S. Ott, and J. K. Robinson, "Promoting student interaction, engagement, and success in an online environment," *Analytical and Bioanalytical Chemistry*, vol. 413, no. 6, pp. 1513–1520, Mar. 2021, doi: 10.1007/s00216-021-03178-x.

[26] H. Ulum, "The effects of online education on academic success: a meta-analysis study," *Education and Information Technologies*, vol. 27, no. 1, pp. 429–450, 2022, doi: 10.1007/s10639-021-10740-8.

[27] N. R. Raji, R. M. S. Kumar, and C. L. Biji, "Closing the gap: exploring the untapped potential of machine learning in deaf students and hearing students' academic performance," *International Journal of Advanced Technology and Engineering Exploration*, vol. 10, no. 108, pp. 1449–1475, 2023, doi: 10.19101/IJATEE.2023.10101685.

[28] J. E. M. Díaz, C. A. D. Saldaña, and C. A. R. Avila, "Virtual world as a resource for hybrid education," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 15, pp. 94–109, 2020, doi: 10.3991/ijet.v15i15.13025.
[29] Dimitrios Vlachopoulos and Agoritsa Makri, "The effect of games and simulations on higher education: a systematic literature review," *International Journal of Educational Technology in Higher Education*, vol. 14, no. 1, 2017.
[30] Liang-Hui Wang, Bing Chen, Gwo-Jen Hwang, Jue-Qi Guan, and Yun-Qing Wang, "Effects of digital game-based STEM education on students' learning achievement: a meta-analysis," *International Journal of STEM Education*, vol. 6, no. 26, 2022.
[31] L. Zheng, X. Zhang, and J. F. Gyasi, "A literature review of features and trends of technology-supported collaborative learning in informal learning settings from 2007 to 2018," *Journal of Computers in Education*, vol. 6, no. 4, pp. 529–561, 2019, doi: 10.1007/s40692-019-00148-2.
[32] I. Vali, "The impact of technology on collaborative learning," in *Proceedings of the 9th International Conference Education Facing Contemporary World Issues (Edu World 2022), 3-4 June, 2022, University of Pitești, Pitești, Romania*, Apr. 2023, pp. 126–141, doi: 10.15405/epes.23045.13.
[33] S. Chandra and S. Palvia, "Online education next wave: peer to peer learning," *Journal of Information Technology Case and Application Research*, vol. 23, no. 3, pp. 157–172, 2021, doi: 10.1080/15228053.2021.1980848.
[34] Y. K. Dwivedi *et al.*, "Artificial intelligence (AI): multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy," *International Journal of Information Management*, vol. 57, p. 101994, Apr. 2021, doi: 10.1016/j.ijinfomgt.2019.08.002.
[35] D. Hillmayr, L. Ziernwald, F. Reinhold, S. I. Hofer, and K. M. Reiss, "The potential of digital tools to enhance mathematics and science learning in secondary schools: a context-specific meta-analysis," *Computers & Education*, vol. 153, p. 103897, Aug. 2020, doi: 10.1016/j.compedu.2020.103897.
[36] T. I. Anisimova, F. M. Sabirova, and O. V. Shatunova, "Formation of design and research competencies in future teachers in the framework of steam education," *International Journal of Emerging Technologies in Learning*, vol. 15, no. 2, pp. 204–217, 2020, doi: 10.3991/ijet.v15i02.11537.
[37] Z. Yang, "Empowering teaching and learning with artificial intelligence," *Frontiers of Digital Education*, vol. 1, no. 1, pp. 1–3, Mar. 2024, doi: 10.1007/s44366-024-0017-8.
[38] C. Y. Chang, G. J. Hwang, and M. L. Gau, "Promoting students' learning achievement and self-efficacy: a mobile chatbot approach for nursing training," *British Journal of Educational Technology*, vol. 53, no. 1, pp. 171–188, 2022, doi: 10.1111/bjet.13158.
[39] E. Faggiano and F. Mennuni, "Constructing mathematical meanings with digital tools: design, implementation and analysis of a teaching activity in a distance education context," *Interaction Design and Architecture(s)*, no. 46, pp. 156–174, 2020, doi: 10.55612/s-5002-046-008.
[40] S. L. Mottee, "Using technology to change practices in preschool classrooms – can it work?" *Значение Цифровых Технологий В Изучении Истории Узбекистана*, vol. 1, no. 01, pp. 265–266, 2022, doi: 10.47689/.v1i01.13512.
[41] L. Zhang, J. D. Basham, and S. Yang, "Understanding the implementation of personalized learning: a research synthesis," *Educational Research Review*, vol. 31, p. 100339, Nov. 2020, doi: 10.1016/j.edurev.2020.100339.
[42] L. Zhang, S. Yang, and R. A. Carter, "Personalized learning and essa: what we know and where we go," *Journal of Research on Technology in Education*, vol. 52, no. 3, pp. 253–274, 2020, doi: 10.1080/15391523.2020.1728448.
[43] A. Cherbonnier, B. Hémon, N. Michinov, E. Jamet, and E. Michinov, "Collaborative skills training using digital tools: a systematic literature review," *International Journal of Human-Computer Interaction*, vol. 41, no. 7, pp. 4155–4173, 2025, doi: 10.1080/10447318.2024.2348227.
[44] H. Wisniewski and J. Torous, "Digital navigators to implement smartphone and digital tools in care," *Acta Psychiatrica Scandinavica*, vol. 141, no. 4, pp. 350–355, 2020, doi: 10.1111/acps.13149.
[45] M. M. Siwach, L. Arora, and V. R. Sharan, "Streamlining administrative tasks in old age homes: an android application for efficient management," *International Journal of Current Science Research and Review*, vol. 06, no. 07, 2023, doi: 10.47191/ijcsrr/v6-i7-17.
[46] S. O'Rourke and T. Sawicki, "Online tools for improving student feedback reading rate," *International Journal for Digital Society*, vol. 9, no. 2, pp. 1387–1392, 2018, doi: 10.20533/ijds.2040.2570.2018.0171.
[47] I. Piatnychuk, I. Boryshkevych, A. Tomashevska, I. Hryhoruk, and D. Sala, "Online tools in providing feedback in management," *Journal of Vasyl Stefanyk Precarpathian National University*, vol. 9, no. 3, pp. 6–17, Oct. 2022, doi: 10.15330/jpnu.9.3.6-17.
[48] R. Samino Garcia, "A service-learning program assessment: strengths, weaknesses and impacts on students," *Intangible Capital*, vol. 19, no. 1, pp. 4–24, 2023.
[49] E. Gołąb-Andrzejak, "AI-powered digital transformation: tools, benefits and challenges for marketers – case study of LPP," *Procedia Computer Science*, vol. 219, pp. 397–404, 2023, doi: 10.1016/j.procs.2023.01.305.
[50] D. K. Murala, "Metaeducation: state-of-the-art methodology for empowering feature education," *IEEE Access*, vol. 12, pp. 57992–58020, 2024, doi: 10.1109/ACCESS.2024.3391903.
[51] L. Heinemann *et al.*, "Benefit of digital tools used for integrated personalized diabetes management: results from the PDM-provalue study program," *Journal of Diabetes Science and Technology*, vol. 14, no. 2, pp. 240–249, 2020, doi: 10.1177/1932296819867686.
[52] C. Atlay, N. Tieben, S. Hillmert, and B. Fauth, "Instructional quality and achievement inequality: how effective is teaching in closing the social achievement gap?" *Learning and Instruction*, vol. 63, p. 101211, Oct. 2019, doi: 10.1016/j.learninstruc.2019.05.008.
[53] D. Leffler, "Technical issues: creating a troubleshooting system with microsoft outlook," *Internet Reference Services Quarterly*, vol. 27, no. 3, pp. 179–196, Jul. 2023, doi: 10.1080/10875301.2023.2212263.
[54] I. Hopwood, "Peerless? how students' experience of synchronous online teaching can disrupt the development of relationships to peers, teachers, subject and self," *Research and Practice in Technology Enhanced Learning*, vol. 18, p. 007, Oct. 2022, doi: 10.58459/rptel.2023.18007.
[55] E. Hustad, J. L. Hansen, A. Skaiaa, and P. Vassilakopoulou, "Digital inequalities: a review of contributing factors and measures for crossing the divide," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 11701 LNCS, 2019, pp. 505–519, doi: 10.1007/978-3-030-29374-1_41.
[56] V. Gaur, "Teacher training in lifelong learning—the importance of digital competence in the encouragement of teaching innovation," *The Business and Management Review*, vol. 15, no. 03, 2025, doi: 10.24052/bmr/v15nu03/art-24.
[57] F. Martin, D. Polly, S. Coles, and C. Wang, "Examining higher education faculty use of current digital technologies: importance, competence, and motivation," *International Journal of Teaching and Learning in Higher Education*, vol. 32, no. 1, pp. 73–86, 2020.
[58] L. Y. Chaw and C. M. Tang, "The relative importance of digital competences for predicting student learning performance: an importance-performance map analysis," *European Conference on e-Learning*, vol. 21, no. 1, pp. 61–70, Oct. 2022, doi: 10.34190/ecel.21.1.582.
[59] I. Oraif and T. Elyas, "The Impact of COVID-19 on Learning: Investigating EFL learners' engagement in online courses in Saudi Arabia," *Education Sciences*, vol. 11, no. 3, p. 99, Mar. 2021, doi: 10.3390/educsci11030099.

[60] R. Hämäläinen, K. Nissinen, J. Mannonen, J. Lämsä, K. Leino, and M. Taajamo, "Understanding teaching professionals' digital competence: what do piaac and talis reveal about technology-related skills, attitudes, and knowledge?" *Computers in Human Behavior*, vol. 117, p. 106672, Apr. 2021, doi: 10.1016/j.chb.2020.106672.
[61] T. Ukkonen-Mikkola and J. Varpanen, "Integrated initial and continuing training as a way of developing the professional agency of teachers and student teachers," *Teaching and Teacher Education*, vol. 96, p. 103189, Nov. 2020, doi: 10.1016/j.tate.2020.103189.
[62] I. Nizomova, "Benefits and drawbacks of distance learning in teaching language," *Современные Тенденции Инновационного Развития Науки И Образования В Глобальном Мире*, vol. 1, no. 3, pp. 372–375, 2023, doi: 10.47689/stars.university-pp372-375.
[63] R. Riggs, "The digital literacy action plan: a strategy for differentiation and learner agency in digital literacy instruction," *Adult Literacy Education: The International Journal of Literacy, Language, and Numeracy*, vol. 4, no. 1, pp. 36–42, Feb. 2022, doi: 10.35847/RRiggs.4.1.36.
[64] R. Schmid, C. Pauli, R. Stebler, K. Reusser, and D. Petko, "Implementation of technology-supported personalized learning—its impact on instructional quality," *The Journal of Educational Research*, vol. 115, no. 3, 2022, doi: 10.1080/00220671.2022.2089086.
[65] P. Amelia and N. Niniwati, "Improving motivation and learning outcomes with contextual teaching and learning strategies for students in the mathematics education study program," *Edumatica: Jurnal Pendidikan Matematika*, vol. 9, no. 02, pp. 14–22, 2019, doi: 10.22437/edumatica.v9i02.6561.

BIOGRAPHIES OF AUTHORS

Martin L. Nobis Jr. is a highly competent educator with a strong academic background and significant experience. He has a Doctor of Education in Educational Administration, MAED in Administration and Supervision, and a BSED in Mathematics. He has also completed postdoctoral work in Strategic Management and Leadership. He has served as an associate professor and held various leadership positions at the University of Eastern Philippines, Laoang Campus. He is a recognized researcher with expertise in Mathematics Education, Education, Assessment, Social Sciences, ICT, Digital Literacy, Leadership Behavior, and Community Relations. He is actively involved in international organizations and serves as an Associate Member of the National Research Council of the Philippines and an accreditor of the Accrediting Agency of Chartered Colleges and Universities in the Philippines. He can be contacted at email: martinnobis.uepl@gmail.com.

Ronato S. Ballado is a highly accomplished educator with a Doctor of Education, a Master of Arts in Teaching Mathematics, and a Bachelor's degree in Mathematics (Magna cum laude). He also completed a Postdoctoral Program in Strategic Management and Leadership. For the past 28 years, he has been affiliated with the University of Eastern Philippines, where he has held various leadership roles, including Dean, Vice President for Research, and Campus Director. He currently serves as the Vice President for Academic Affairs and Chair of the Instructional Materials Development and Production Board. An Associate member of the National Research Council of the Philippines, he is an active researcher, speaker, and mentor to graduate students. He is also a national accreditor for the Accrediting Agency of Chartered Colleges and Universities of the Philippines. He can be contacted at email: balladoronato@gmail.com.

Jabel Phillip L. Irinco is a Mathematics educator at the University of Eastern Philippines, Laoang Campus. He earned his Bachelor of Secondary Education, major in Mathematics, graduating Magna Cum Laude, and completed his Master of Arts in Education in Mathematics Education. A former Program Chair of the BSED Program and now Adviser of the University Chorale Society, he is recognized as a dedicated teacher, writer, and researcher whose leadership and versatility continue to inspire excellence in both academics and the arts. He can be contacted at email: lebaj.021593@gmail.com.

Cherry I. Balanquit is a dedicated and accomplished educator specializing in Mathematics Education. She holds a Bachelor of Secondary Education, major in Mathematics, earned in 2008 from the University of Eastern Philippines (UEP) Laoang Campus. Her advanced studies culminated in a Master of Arts in Mathematics Education, which she completed in 2021 at the University of Eastern Philippines (UEP), Catarman, Northern Samar. Currently holding the academic rank of Assistant Professor I, she is an active leader within the UEP Laoang Laboratory High School, where she presently serves as the Junior High School Coordinator. Her past leadership roles include functioning as the ICT and SMEA Coordinator. Beyond her administrative and teaching duties, she is also a productive and active researcher at the University of Eastern Philippines, Laoang Campus. She can be contacted at email: balanquitcherry0@gmail.com.