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From Access to Impact: Rethinking Digital Integration in Philippine Mathematics Education

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Abstract: This commentary examines the integration of digital technologies in secondary and tertiary mathematics education in the Philippines. Although tools such as Desmos, GeoGebra, and Maple Calculator offer opportunities for enhanced visualization, exploration, and student engagement, their classroom use remains largely superficial and inconsistent. The paper draws on the Technological educational Content Knowledge (TPACK) framework to highlight the persistent gap between access and meaningful pedagogical integration. It points out barriers like limited teachers' training, poor infrastructure, misaligned curriculum, and deep-rooted conventional mindsets. This paper draws lessons from the move to digital learning during the COVID-19 pandemic. The paper calls for a clear and purposeful approach to using digital technologies. This advocates for policies that prioritize fairness, infrastructure investment, ongoing professional development, and curriculum alignment. The study concludes that digital technologies must be strategically and thoughtfully embedded within pedagogy to foster deeper understanding, collaboration, and a more future-ready mathematics education system in the Philippines.

Keywords: curriculum alignment; digital technologies in mathematics education; Philippine mathematics curriculum; teacher digital competence

INTRODUCTION

The digital era has transformed educational practices across disciplines, and mathematics instruction is no exception. Today, a variety of digital tools, such as subject-specific mobile applications, Desmos, and Maple Calculator, provide dynamic and interactive ways to support differentiated instruction, encourage exploratory learning, and visualize abstract concepts (Laborde, 2019; Aguilar et al., 2021). In particular, the increasing familiarity of Filipino students with mobile technology may lead to these digital tools as a promising instrument to address challenges in math education.

However, in the Philippine context, it still poses a question: Are these technologies truly being used to maximize learning, or are we falling short in tapping their full potential? Despite being widely available, the integration of these digital tools remains superficial and inconsistent (Celeste & Osias, 2025). While many students are digitally literate in using these tools, many teachers struggle with issues like a lack of trainings, insufficient reliable infrastructure, and deep-rooted dependence on traditional, lecture-based teaching approaches (Buendia & Bautista, 2022; Cabero-Almenara et al., 2020).

The effective use of technology in mathematics education requires more than just availability. It demands pedagogical transformation. In order to integrate technology with the learning objectives, teachers must possess both technical know-how and innovative teaching strategies. Even the most sophisticated instruments are at risk of misuse and underutilization without institutional support and ongoing professional growth. Moreover, the disparity in student opportunities further widened by the digital divide between the rural and urban schools, highlighting the need for equitable policies and resource allocations.

The authors frame this commentary using the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK emphasizes that effective integration of technology requires teachers to blend the domains: (a) technology knowledge (TK), (b) pedagogical knowledge (PK), and content knowledge (CK). TPACK offers a lens through which to view teacher competencies, curriculum alignment, infrastructural issues, and systemic concerns. This will help explain why access alone does not ensure meaningful learning outcomes.

Consequently, by using TPACK as a guiding framework, this commentary explores how mathematics teachers in the Philippines navigate the intersection of the three domains. It determines gaps in teacher preparedness, systemic alignment, and institutional support. Also, proposes strategies for purposeful and equitable digital integration.

This commentary looks closely at how well digital technologies are used in secondary and tertiary mathematics education in the Philippines. It examines both the advantages and disadvantages of the present practices. It draws attention to the infrastructure, instructional, and systemic issues that hinder the successful integration of these methods. Additionally, this commentary offers actionable recommendations for transforming digital tools from passive supplements into vital components of meaningful and equitable math education.

METHOD

This commentary paper employed a narrative commentary approach. It uses both conceptual analysis and a focused review of existing literature to examine how digital technologies fit into mathematics education in the Philippines. Since this is a commentary rather than a systematic or scoping review, the goal was not to list all available studies. Instead, it aims to synthesize relevant studies that highlight the gaps, current challenges, and opportunities in the field.

To ensure transparency, the authors conducted a focused search using research databases, including journal articles, conference papers, and other indexed scholarly literature. Particularly, the authors used Google Scholar, ERIC, and Scopus as primary platforms. The search was carried out from January to March 2025. The search utilized key terms such as “ Desmos”, “GeoGebra”, “digital technologies in mathematics”, “educational technology”, “digital learning”, and “teacher digital competence”. The included sources met these criteria: (a) published between 2015 and 2024; (b) peer-reviewed journal articles, policy reports, or recognized research publications; and (c) studies that addressed mathematics instruction, teacher preparation, digital tool integration, or technology-enabled learning. Materials such as blog posts, opinion pieces that gave no empirical support, and studies not related to the Philippine or wider Southeast Asian educational context were excluded.

Furthermore, titles and abstracts were screened to identify literature and studies aligned with the commentary's focus on systemic issues and pedagogical implications. The selected articles were examined for their research quality, relevance, and how well they fit into the Philippine context. This process helped the authors identify common themes and determine structural barriers shaping the use of digital tools in math classrooms. By combining this focused literature review with conceptual insights and context analysis, the commentary provides a foundation for reevaluating how digital technology is integrated into mathematics instruction in the Philippines.

RESULTS AND DISCUSSIONS

The Promise vs. the Practice

The purpose of digital tools in math education is not only to speed up computations. They intend to improve the visualization of students in learning mathematics. These digital tools can also boost engagement in the classroom and, most importantly, deepen their understanding of the subject matter. For example, to better understand algebraic and geometric relationships, a student may use GeoGebra to have a dynamic representation of them. Similarly, to assist students with complex computation of differential equations, algebra, and calculus, they may use Maple Calculator and Desmos.

However, evidence from classrooms shows that digital tools are often used only at a basic level. It is often used as a substitute for conventional methods, rather than an innovative tool for promoting critical thinking, mathematical reasoning, and collaborative problem solving. Though many educators recognize the potential of GeoGebra in mathematics education, its practical use is not fully seen due to the lack of expertise and difficulties in incorporating the tool into the lesson design and delivery (Mangubat and Batucan, 2024). Thus, this gap between the tool's potential and its actual use in the classroom leads to a greater issue that having access to these digital tools does not directly mean they will be used effectively. Without intentional integration into teaching methods, these tools cannot reach their full potential.

Applying the TPACK framework, many Filipino mathematics teachers demonstrate technological knowledge (TK), as they know how to use digital tools, but show gaps in technological pedagogical knowledge (TPK) and pedagogical content knowledge (PCK). Therefore, limiting their ability to integrate digital tools effectively in the classroom.

Recent Philippine studies offer critical insights into digital tool integration, teacher agency, and pedagogical reform. Reyes et al. (2024) provide empirical evidence on digital laboratory integration and its associated challenges, paralleling issues in mathematics classrooms. Reyes, Regala, and Co (2024) discuss pandemic-driven technological adaptation, supporting this paper's arguments regarding teacher readiness and uneven access. Likewise, Reyes & Villanueva (2025) and Reyes & Regala (2025) highlight AI-driven shifts in STEM education, offering a deeper theoretical grounding for rethinking digital integration in Philippine mathematics education.

Barriers to Effective Integration

Below are some of the barriers that hinder the effective integration of digital tools in the Philippine mathematics education.

1. Teacher Confidence and Digital Pedagogy

Many teachers do not have enough training in digital teaching methods. While some know how to use specific tools, they often struggle to incorporate them effectively into their lesson plans. For example, a GeoGebra activity works best when included in an inquiry-based or exploratory framework instead of just being a visual aid. Without focused training in teaching strategies, teachers may not fully use the tools meant to improve learning.

Moreover, the lack of pedagogical support and collaborative opportunities further limit the teachers to adjust to digital tools. Often, teachers have to figure out new technologies on their own. They do not get enough help on how to connect these tools with their curriculum goals or student learning outcomes. In order to fully utilize digital technologies, schools must make investments in software and technology as well as continuous training that emphasizes reflection, peer learning, and instructional design.

International literature supports these findings. Mishra & Koehler's (2006) TPACK framework emphasizes the relationship between technological, pedagogical, and content knowledge, which alignment is often missing in many teacher-training programs in the Philippines. Similarly, Filiz (2025) and Kilic & Baydin (2024) highlight global trends in digital technology integration and learning improvements. They suggest that the situation in the Philippines reflects global challenges in transforming technological opportunities into measurable learning outcomes.

2. Infrastructure and Access

In public schools, particularly in rural areas, inadequate infrastructure restricts the consistent use of digital technologies. Constraints such as unreliable internet, unstable platforms, insufficient and outdated devices, and power cuts reduce the effectiveness of even the best software. Further, unequal access among students shows the issues of the digital divide and educational fairness. In many classrooms, the lack of basic hardware, like working projectors or updated computers, makes digital instruction not practical.

Aside from hampering the delivery of lessons, this situation widens the learning gap between students in a well-equipped urban school and those in under-resourced communities in rural areas. Teachers often have to go back to traditional methods even when digital resources are available, because the infrastructure cannot sustain their regular use. In return, the potential of digital technologies in education stays out of reach for many, which makes the current education system worse.

3. Curriculum and Assessment Misalignment

The current curriculum heavily emphasizes procedural skills and standardized tests. This often discourages teachers from including technology-based exploratory learning. Digital technologies facilitate experimentation, visualization, or problem solving can be seen as extras rather than essentials in the system. This gap limits students' opportunities to use technology to think critically in mathematics.

Despite teachers being aware of the benefits of digital technologies, they still feel compelled to prioritize test preparation over implementing innovative teaching strategies. Because of the strict framework of the curriculum it makes it difficult to incorporate technology in ways that encourage research, teamwork, or practical application. The revolutionary promise of educational technology in the mathematics classroom is still largely unrealized without the institutional changes that prioritize digital fluency and conceptual understanding in addition to procedural proficiency.

With this, from a TPACK perspective, curriculum and assessment often limit teachers' ability to integrate content knowledge and pedagogical knowledge with technological knowledge, which leads to superficial digital use. Aligning curriculum with TPACK-informed practices ensures technology supports conceptual understanding, problem solving, and inquiry-based learning.

4. Time Constraints and Teacher Workload

Another barrier for teachers in using digital tools is the time. Preparing a lesson plan that incorporates technology is a challenge for teachers. With this, they have to design meaningful tasks, explore digital content, align materials with learning objectives, and diagnose technical problems. In addition, educators find it hard to balance their administrative tasks and teaching multiple subjects with integrating technology into teaching.

A motivated teacher may hesitate to regularly adopt new ways of teaching through technology. Especially when there is a limited time for planning, and there is no immediate support from the school. The pressure to meet curriculum deadlines, manage classroom behavior, and fulfill reporting requirements leaves little room for experimenting with new approaches. Without institutional support—such as co-planning time, reduced workloads, or access to ready-made, high-quality digital resources—teachers are unlikely to prioritize technology integration, regardless of its potential benefits to student learning.

5. Traditional Mindsets

Some teachers still view digital technologies as alternative or a distraction and prefer lecture-based, text-focused teaching methods. This resistance to innovative teaching and comfort with traditional teaching approaches may relate to their limited exposure to effective technology models. These kind on mindsets contribute to a culture of resistance that slows the transition towards to more technologically advanced, student-centered learning environment.

Institutional norms and professional development programs that prioritize content delivery over pedagogical innovation frequently serve to further this reluctance. Many educators are still skeptical of the benefits of technology because they have not seen concrete, research-backed examples of how it can improve student engagement and teaching effectiveness. Schools can help teachers develop a growth mindset through encouraging peer collaboration, demonstrating effective technology integration, and providing a safe and secure environment for experimentation and self-reflection.

From Possession to Purpose: Rethinking Integration

Recent studies highlight how effective well-designed digital intervention can be. The study of Malabayabas, et.al. revealed that the understanding of statistics and probability of Grade 11 students significantly improved with the integration of gamified apps like Math-GALING. Through interactive digital exercises, the study found a very high learning gains and improved engagement.

The main challenge in bringing digital technologies into math education is not just having them in the classroom, but rather how we utilize them. Access to devices or apps does not automatically lead to better learning. Instead, we need to use these tools thoughtfully to create meaningful learning experiences.

The theoretical survey by González-González and Borba (2023) and Arzarello et al. (2024) supports this call for purposeful integration. They emphasize the shift from tool-centered to knowledge-centered digitized mathematics learning environments.

To integrate technology effectively, we need to change our perspective. We should not see technology as just an extra resource. Instead, we should blend it into teaching and learning smoothly. This requires designing activities and assessments that take advantage of digital tools. For instance:

> *Task Design.* Teachers can create interactive simulations that let students explore patterns, make guesses, and test their ideas, which encourages discovery-based learning.
>
> *Digital Assessment.* Tools that give instant feedback can help shape instruction, allowing teachers to adjust their methods based on how students are performing and what they need.
>
> *Collaborative Problem Solving.* Shared digital platforms can encourage teamwork and discussion among peers, helping students build both their subject knowledge and communication skills.
>
> *Alignment with Learning Goals.* Lessons that use technology need to be based on clear learning goals, making sure that the tools help rather than distract from understanding concepts.

This change from passive to active use requires more than just technical skills. It also involves thoughtful teaching and self-reflection. Teachers need support to rethink their roles. In this 21st century learning, teachers should not solely see themselves as the source of knowledge, but as a guide for exploration and inquiry in a technology-rich environment.

Recent studies from the Philippines (Reyes, Regala, & Co, 2024) provide a similar view of digital shifts during the pandemic. They highlight how the sudden use of tools led to moments of teacher innovation, even with existing structural challenges. Their findings affirm that success relies on the institutional planning rather than technology alone.

Learning from the Pandemic: A Missed Opportunity or a Wake-Up Call?

Modular and online learning modality demanded more ICT training and infrastructure to support effective instruction (Bautista and Valtoribio, 2024). Their study emphasizes the importance of institutional planning, infrastructure, and responsive teaching design in transitioning to digital learning.

The COVID-19 pandemic forced a rapid shift to digital learning and placed technology at the center of education almost overnight. For mathematics instruction, this period was both a challenge and an opportunity. Teachers quickly adjusted to online platforms like Google Classroom, Microsoft Teams, and various mobile learning apps, many of which they had not used much before.

This sudden change revealed major limitations, such as digital fatigue, unequal access, and a lack of preparation. However, it also opened up new possibilities. Some educators tried the Desmos Activity Builder to encourage real-time engagement. In contrast, others used flipped classroom models, allowing students to explore content on their own before diving into deeper discussions during live sessions.

The pandemic taught us two important lessons. First, with the institutional support, teachers can enable innovative practices in the use of technology. Second, learning will not be driven by digital technologies alone. Their effectiveness still relies on significant factors such as pedagogical strategies, continuous professional development, and institutional support. Without these factors, the progress made could disappear or will return to pre-pandemic habits. Therefore, the pandemic should be seen as a wake-up call rather than just a disruption. It presents an opportunity to reconsider how digital technology may be used in mathematics education in a way that is both equitable and effective.

The broader literature consistently highlights that systemic alignment leads to meaningful digital integration. This systemic alignment includes curriculum, policy, teacher development, and infrastructure (Reyes & Villanueva, 2025; Mishra & Koehler, 2006). Further, global evidence demonstrates that ongoing professional development and regular assessment significantly boost long-term instructional impact (Reyes & Villanueva, 2025; Mishra & Koehler, 2006).

CONCLUSION

It is a pressing and complex task to bridge the gap between the potential and real effects of digital technology in Philippine mathematics education. Despite significant efforts in integrating various digital tools into the classroom, the implementation of technology frequently falls short. Primarily, because of the inadequate infrastructure, deficiencies in instructional strategies, and lack of opportunities for professional development. These issues show that the real problem is not just the lack of technology, but how we implement it in a strategic and meaningful way.

Using digital tools to improve mathematical thinking requires more than just providing access to them; instruction must go beyond this. Not only should technology replace traditional educational methods, but it should also stimulate new ones that promote greater understanding, visualization, inquiry, and collaboration. This change requires an environment that supports schools, gives teachers more authority, and aligns policies with the learning goals of the 21st century.

Digital technology integration in mathematics classrooms should not ultimately be viewed as a temporary solution or trend. It ought to be seen as an investment in delivering equitable and superior education over the long run. Digital tools have the potential to reinvent mathematics education in the Philippines and serve as a bridge to improved instruction with careful application and sustained dedication.

Table 1. Strategic Framework Addressing Barriers to Digital Technology Integration in Philippine Mathematics Classrooms

Barrier	Recommended Strategy	Operational Details
Teacher confidence and digital pedagogy	Sustained Professional Development	-Lesson study cycles supported by edtech teachers/experts -Conduct seminars/trainings on TPACK domains -Sample K–12 lessons integrating GeoGebra, Desmos, Maple Calculator: ◎◎◎◎◎◎Grade 7: Geometric transformations ◎◎◎◎◎ Grade 10: Probability simulations ◎◎◎◎◎ Senior High: Functions & differential equations
Infrastructure & access	Invest in school connectivity & devices	-LGUs/DepEd to ensure minimum standards: 1 device per 5 students, projector/smartboard, interactive apps. -Provide reliable internet and power backup. - Routine software/hardware maintenance
Curriculum & assessment misalignment	Curriculum Integration & Alignment	-Embed technology in learning competencies. -Develop TPACK-aligned sample lessons per grade. -Align assessments to digital learning outcomes
Time constraints & teacher workload	School-Based Support Systems	-Establish peer-learning communities, mentorship programs, ICT coordinators. -Provide ready-to-use digital lesson templates. - Facilitate co-planning & peer collaboration
Traditional mindsets / resistance	Policy & Equity Frameworks	- DepEd/CHED: policy guidance, Professional Development funding, monitoring digital integration. -LGUs: maintain connectivity, devices, local teacher support. - Include monitoring and continuous improvement plans

RECOMMENDATION

To make sure digital technologies effectively improve mathematics education in the Philippines, we need focused and ongoing efforts. The following recommendations provide a comprehensive and actionable roadmap for enhancing the integration of digital technology in the Philippine mathematics education. This looks at important areas: professional development, infrastructure, curriculum design, school support, and educational policy. These areas must be strengthened to transition from simple access to meaningful integration that is effective, equitable, and student-centered mathematics instruction.

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