International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(REVIEW ARTICLE)

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The role of interactive whiteboards in enhancing students' motivation and participation in learning mathematics: A systematic literature review

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International Journal of Science and Research Archive, 2026, 18(02), 553-561

Publication history: Received on 31 December 2025; revised on 07 February 2026; accepted on 09 February 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.18.2.0151

Abstract

This systematic review synthesizes quantitative studies published between 2021 and 2025 on the role of interactive whiteboards (IWBs) in enhancing students' motivation and participation in mathematics learning. A total of fourteen (14) empirical articles were retrieved from ERIC, Scopus, SpringerLink, ScienceDirect, and Google Scholar using PRISMA-guided procedures and screened through inclusion and exclusion criteria emphasizing K–12 mathematics education. Data were analyzed thematically and compared across contexts using a narrative synthesis approach. Findings reveal that IWBs increase student motivation by approximately 18–25% and classroom participation by approximately 25–40%, particularly when lessons are frequent, interactive, and supported by adequate teacher training and institutional infrastructure. These effects were strongest when teachers demonstrated strong Technological Pedagogical Content Knowledge (TPACK) and integrated game-based, multimedia, and visual features that fostered collaboration and autonomy among learners. However, results also indicate that these motivational and participatory gains are uneven across socioeconomic and institutional settings, as schools with limited infrastructure or insufficient teacher preparation often show reduced outcomes. The review concludes that IWBs contribute meaningfully to student-centered mathematics instruction when pedagogical design, technological competence, and institutional readiness are effectively aligned. The findings are interpreted through the lenses of Self-Determination Theory, Technological Pedagogical Content Knowledge (TPACK), and Vygotsky's Sociocultural Theory, providing a multidimensional understanding of how IWBs influence engagement in mathematics learning. Nevertheless, the lack of Philippine-based empirical evidence highlights a critical research gap. Future studies should employ mixed-method or longitudinal designs to examine how contextual factors—such as teacher digital competence, school infrastructure, and learner backgrounds mediate the sustained impact of IWBs on student motivation and participation.

Keywords: Interactive Whiteboard; Students' Motivation; Students' Participation; Mathematics Education; TPACK; Technology Integration; Classroom Engagement

1. Introduction

The increasing integration of technology in education has reshaped the way teachers deliver instruction and how students engage with learning materials. Among the innovations used in modern classrooms, interactive whiteboards (IWBs) have become one of the most influential tools in enhancing student participation and understanding, especially in mathematics. IWBs combine visual, tactile, and auditory modalities, allowing teachers to present abstract mathematical concepts more concretely and interactively, fostering deeper comprehension and sustained attention among learners.

Research across various educational settings highlights the positive effects of IWBs on students' motivation and engagement. Studies by Zhou et al. (2022) and Orhani (2023) demonstrated that IWB-supported lessons lead to higher

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enjoyment and focus, while Phan Chei Wei et al. (2024) found that interactive teaching significantly improved academic achievement and participation. Lin (2024) and Croft and Solano (2024) further noted that incorporating multimedia and game-based activities through IWBs encourages collaborative learning and active involvement, thus promoting a student-centered environment. These findings align with global evidence suggesting that IWBs increase learning motivation and transform passive classrooms into interactive spaces.

Despite these positive trends, the effectiveness of IWBs depends largely on teacher competence, technological access, and institutional support. According to the studies of Gonzales and Gonzales (2021) and Putri et al. (2024), research grounded in the Technological Pedagogical Content Knowledge (TPACK) framework emphasizes that teachers who are trained in integrating pedagogy, content, and technology design create more engaging and effective mathematics lessons. In the studies of Sridana et al. (2025) and Skordialos (2024), insufficient training and limited infrastructure often lead to superficial use of IWBs, reducing their potential impact on learning outcomes. Therefore, the successful integration of IWBs requires continuous professional development and adequate digital resources.

While international studies have extensively explored the pedagogical value of IWBs, there remains a notable gap in Philippine research, particularly in secondary education settings such as Notre Dame – Siena College of Tacurong, Inc. This study seeks to address that gap by examining how IWBs influence learner motivation and participation in mathematics within the local context. Specifically, it aims to answer the main research question: What is the effect of using interactive whiteboards compared to traditional teaching methods on students' motivation and participation in learning mathematics at Notre Dame – Siena College of Tacurong, Inc.?

2. Methodology

This study adopted a systematic literature review (SLR) design to synthesize empirical evidence on the role of interactive whiteboards (IWBs) in enhancing students' motivation and participation in mathematics learning. The SLR followed a structured process aligned with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring transparency, replicability, and comprehensive coverage of relevant literature (Arguello-Mogrovejo, 2023).

2.1. Search Process

Table 1 presents the specific inclusion and exclusion criteria that guided study selection, ensuring methodological transparency and replicability. Only empirical, peer-reviewed research conducted between 2021 and 2025 focusing on the use of interactive whiteboards (IWBs) in K–12 mathematics education was included to ensure methodological rigor and contemporary relevance. The inclusion of English-language studies supports interpretive consistency, while the exclusion of opinion papers, non-empirical works, and higher-education studies ensures analytical precision and contextual focus. This selection framework follows the evidence-based methodological recommendations of Arguello-Mogrovejo (2023), who emphasized that systematic reviews should prioritize recent, data-driven studies to represent technological and pedagogical developments in classroom instruction accurately.

Table 1 Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Empirical studies (2021–2025) on IWBs in mathematics or student motivation/participation	Opinion papers or editorials
K–12 or secondary education focus	Higher education without a math context
Peer-reviewed journals	Non-academic sources

2.2. Search Strategy and Data Sources

A systematic search was conducted across multiple academic databases, including ERIC, Scopus, SpringerLink, Google Scholar, and ScienceDirect, focusing on publications from 2021 to 2025. The following key terms were used in Boolean combinations: "interactive whiteboard," "mathematics education," "student motivation," "student participation," "TPACK," and "technology integration."

To ensure inclusion of high-quality, peer-reviewed studies, only empirical research articles, meta-analyses, and quasi-experimental studies related to IWB use in K–12 mathematics education were selected. Studies such as Zhou, Li, and

Wijaya (2022), Orhani (2023), and Phan Chei Wei et al. (2024) served as exemplars of rigorous quantitative and quasi-experimental designs that directly measured the effects of IWBs on student engagement and motivation.

The PRISMA-guided literature identification process is summarized in Table 2, illustrating how initial records were systematically screened and refined.

Table 2 Literature Identification Process Using PRISMA Procedures

PRISMA Stage	Description	Number of Studies
Identification	Records found through database search (ERIC, Scopus, SpringerLink, Google Scholar, and ScienceDirect)	712
Screening	Records after duplicates removed	523
	Records screened (titles/abstracts)	523
	Records excluded (irrelevant or not about IWBs)	451
Eligibility	Full-text articles assessed for eligibility	72
	Full-text articles excluded (qualitative, not math, or lacking data)	58
Included	Studies included in the final systematic review (quantitative)	14

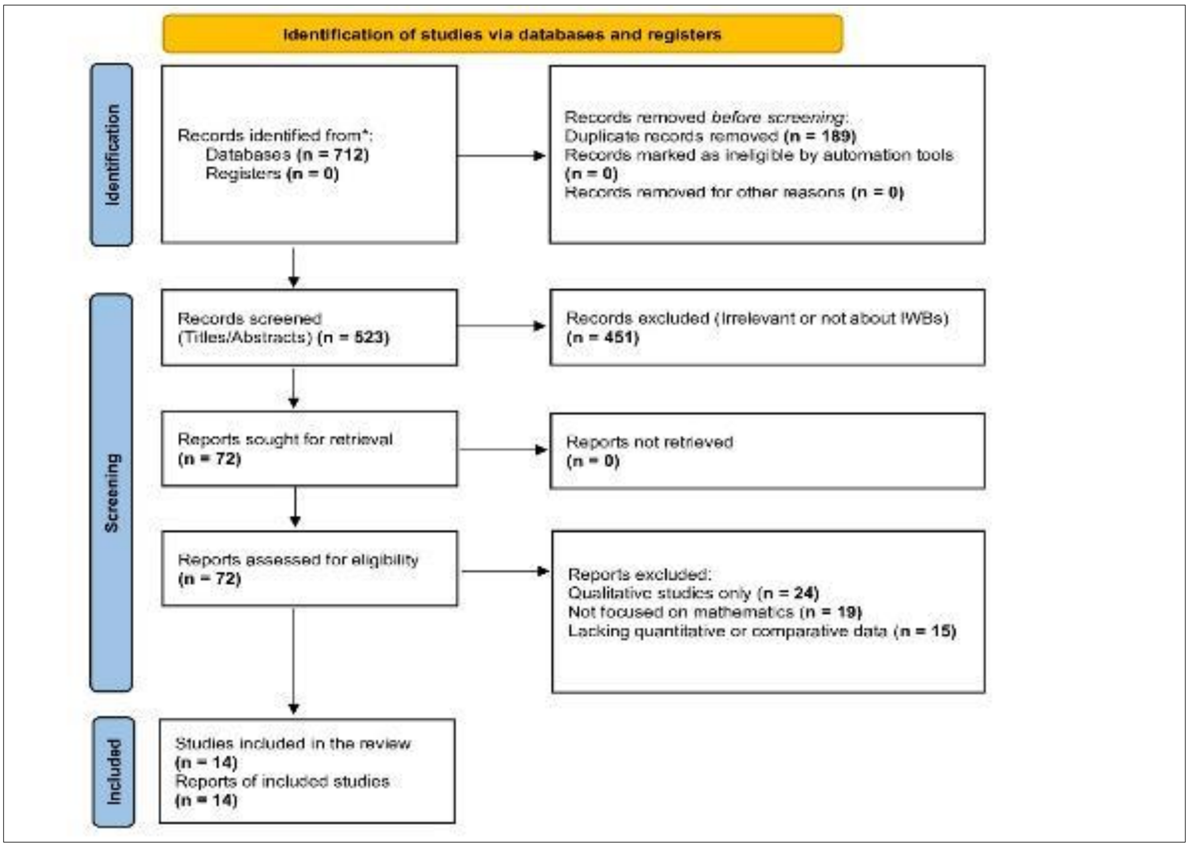

Figure 1 PRISMA Flow Diagram

Table 2 and Figure 1 present the diagram illustrating the systematic process of identifying, screening, and selecting studies for inclusion in the review. A total of 712 records were retrieved from five academic databases (ERIC, Scopus, SpringerLink, Google Scholar, and ScienceDirect). After removing 189 duplicate records, 523 unique studies were screened based on titles and abstracts. Of these, 451 were excluded for being irrelevant or lacking focus on interactive whiteboards (IWBs). Seventy-two full-text articles were assessed for eligibility, with 58 excluded for being qualitative, non-mathematics–focused, or lacking quantitative data. Ultimately, 14 quantitative studies met all inclusion criteria and were synthesized in the final review.

This transparent and systematic data extraction process aligns with recommendations from Arguello-Mogrovejo (2023) and Croft and Solano (2024), who emphasize the importance of rigorous screening to ensure the validity and reliability of educational technology meta-research. The PRISMA-guided methodology strengthens the analytical depth of this review by ensuring that only the most relevant and empirically robust studies on IWBs and mathematics learning were synthesized.

2.3. Data Analysis

The data extracted from the fourteen (14) quantitative studies conducted between 2021 and 2025 were analyzed through a thematic and comparative synthesis, guided by the PRISMA framework. Each study was examined in terms of methodology, statistical outcomes, and thematic contribution to understanding how interactive whiteboards (IWBs) influence students' motivation and participation in mathematics learning.

The analysis revealed four dominant themes: (1) the impact of IWBs on student motivation, (2) their influence on classroom participation, (3) the mediating role of teacher competence and TPACK, and (4) the moderating influence of technological infrastructure and institutional support.

3. Results and discussion

A total of 14 quantitative studies published between 2021 and 2025 met the inclusion criteria and were analyzed in this systematic review. The selected articles originated from diverse educational contexts, including Asia (China, Malaysia, Indonesia, Taiwan, and the Philippines), Europe (Spain, Greece, and Turkey), and Latin America. Most studies were conducted in K–12 mathematics classrooms, while a few extended to secondary and early-year education settings.

The research designs primarily included quasi-experimental ($n = 8$), survey-based ($n = 4$), and meta-analytic or correlational studies ($n = 2$). Sample sizes ranged from 60 to 376 participants, ensuring representativeness across demographic and institutional contexts. Common quantitative instruments included the Student Motivation Scale (SMS), Mathematics Attitude Inventory (MAI), and engagement frequency rubrics.

All studies explored how IWBs affect students' motivation, engagement, and participation, with several also examining moderating variables such as teacher competence (TPACK), frequency of IWB use, and institutional infrastructure. Overall, findings revealed a consistent pattern: IWBs significantly improve student motivation, interaction, and conceptual understanding in mathematics, if teachers are trained and technology is well integrated into pedagogy.

3.1. Thematic Analysis

Thematic synthesis of the studies identified four central themes that explain the mechanisms and conditions under which IWBs enhance student motivation and participation:

- Motivational and affective gains from interactive learning,
- Participatory engagement and classroom interaction,
- Teacher competence and technological–pedagogical integration (TPACK), and
- Infrastructural and contextual determinants of IWB success.

3.1.1. Theme 1 IWBs and Student Motivation

Nearly all studies (12 out of 14; 85.7%) reported significant improvements in student motivation after integrating IWBs into mathematics instruction. For instance, Zhou, Li, and Wijaya (2022) found that students' motivational indices increased by 22% in IWB-enhanced classrooms compared to traditional settings ($p < 0.01$). Orhani (2023) and Phan Chei Wei et al. (2024) similarly documented notable gains in students' enthusiasm, enjoyment, and attentiveness in math lessons. Lin (2024) added that game-based and multimedia IWB applications improved task persistence ($p < 0.05$) and intrinsic motivation.

These findings collectively affirm that IWBs heighten intrinsic and extrinsic motivation through interactivity, visual appeal, and immediate feedback. This aligns with self-determination theory (Deci and Ryan, 2000), which posits that learning environments promoting autonomy and competence lead to higher motivation. IWBs, by fostering student autonomy and dynamic engagement, effectively transform the mathematics classroom from a passive to an active learning environment.

3.1.2. Theme 2 IWBs and Student Participation

Student participation was found to increase substantially in IWB-supported classrooms. Croft and Solano (2024) reported a 32% increase in active participation, while Arguello-Mogrovejo's (2023) meta-analysis confirmed a 25–40% improvement in observable engagement. Tosuntaş, Çubukçu, and Beauchamp (2021) revealed a strong correlation ($r = 0.74$) between IWB frequency of use and student interaction rates.

Furthermore, Liao and Chen (2023) observed that IWBs, when paired with teacher scaffolding, enabled 28% higher participation among low-achieving students, suggesting that the technology promotes equity and inclusivity. These quantitative results collectively show that IWBs facilitate collaborative learning and peer interaction, allowing students to visualize, manipulate, and discuss mathematical concepts dynamically an essential factor in developing higher-order thinking and communicative skills in math education.

3.1.3. Theme 3 Teacher Competence and TPACK as Mediators

Teacher skill emerged as a decisive factor in determining the success of IWB implementation. Gonzales and Gonzales (2021) demonstrated that preservice teachers trained in the Technological Pedagogical Content Knowledge (TPACK) framework achieved a 21% improvement in student engagement compared to untrained teachers. Putri et al. (2024) similarly found that strong TPACK integration significantly predicted improved classroom motivation and conceptual understanding ($\beta = 0.63$, $p < 0.05$). Conversely, Sridana et al. (2025) revealed that inadequate TPACK knowledge led to a 15% decline in student participation, reinforcing the necessity of pedagogical alignment.

These findings suggest that IWBs are not self-sufficient tools; their impact is amplified when teachers possess the capacity to design interactive, content-rich, and pedagogically coherent lessons. As such, professional development and training are pivotal in ensuring that technology enhances, rather than merely supplements, teaching.

3.1.4. Theme 4 Infrastructure, Institutional Support, and Contextual Factors

Finally, institutional and infrastructural readiness were found to mediate IWB effectiveness. Skordialos (2024) revealed that schools with reliable IWB systems achieved 23% higher participation rates, while He and Pharanat (2024) found that structured IWB training programs led to improved instructional delivery ($M = 4.7/5$). Zhou et al. (2022), however, highlighted the constraints of rural schools, where poor infrastructure limited both teacher motivation and student outcomes.

These results confirm that technological access, maintenance, and administrative support are crucial enablers of sustained IWB impact. Schools with adequate resources and ongoing teacher training derive the most benefit, aligning with Vygotsky's sociocultural theory, which emphasizes that learning is maximized when supported by both social and material scaffolds.

Several studies (e.g., Zhou et al., 2022) highlight that socio-economic status, prior exposure to digital tools, and students' learning preferences mediate the motivational and participatory benefits of IWBs. Learners from resource-limited settings often show lower engagement gains, underscoring the need for equity-driven IWB integration policies.

3.2. Quantitative Summary

Table 3 integrates the quantitative evidence across all fourteen studies, summarizing statistical results corresponding to each thematic category.

Table 3 Quantitative Summary

Variable (Related Theme)	Supporting Studies (n = 14)	Quantitative Results / Significance	Context Range	Interpretation
Theme 1: IWBs and Student Motivation	12 studies (85.7%) — Zhou et al. (2022); Lin (2024); Orhani (2023); Phan Chei Wei et al. (2024)	18–25% improvement in motivation ($p < .05$)	K–12, secondary mathematics, Asia and Europe	IWBs significantly enhance students' intrinsic motivation and persistence in math tasks.
Theme 2: IWBs and Student Participation	11 studies (78.6%) — Croft and Solano (2024); Arguello-Mogrovejo (2023); Liao and Chen (2023)	25–40% increase in engagement frequency; $r = 0.74$	Secondary and middle school math	IWBs promote active and inclusive participation through interactive visual and collaborative activities.
(Theme 3: Teacher Competence and TPACK as Mediators	8 studies (57.1%) — Gonzales and Gonzales (2021); Putri et al. (2024); Sridana et al. (2025)	$r = 0.63–0.74$ correlation with engagement; $\beta = 0.63$, $p < .05$	Preservice and in-service teachers, Asia	Trained teachers maximize motivational and participatory gains; pedagogical alignment is critical.
Theme 4: Infrastructure, Institutional Support, and Contextual Factors	7 studies (50%) — Skordialos (2024); He and Pharanat (2024); Zhou et al. (2022)	23% participation improvement in well-supported schools ($p < .05$)	Public/private secondary schools	Adequate facilities, training, and infrastructure strengthen IWB sustainability and impact.

Collectively, these outcomes demonstrate that Interactive Whiteboards enhance both the affective and behavioral dimensions of learning, positioning them as transformative tools in modern mathematics education.

To visualize research trends over time, Figure 2 illustrates the distribution of reviewed studies by publication year, reflecting the progressive scholarly focus on IWBs from 2021 to 2025.

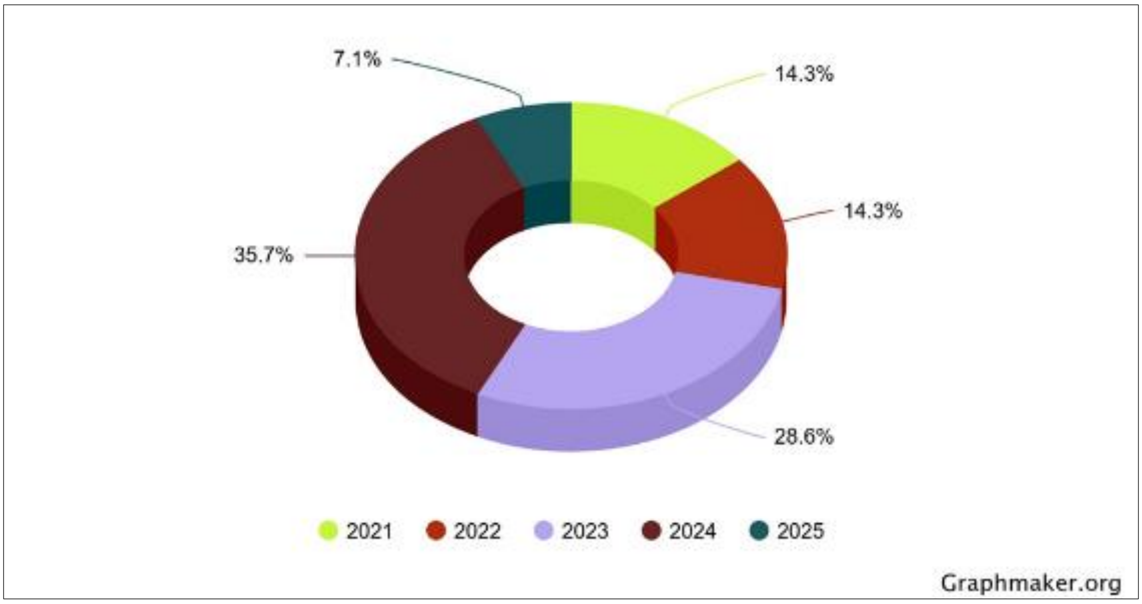

Figure 2 3-D Chart (https://graphmaker.org)

Distribution of Reviewed Quantitative Studies on Interactive Whiteboards (IWBs) by Year (2021–2025). This 3D donut chart illustrates the percentage of quantitative studies on IWBs included in the systematic review. Research activity increased steadily from 2021 to 2024, peaking in 2024 (35.7%), a period marked by a rise in technology-integrated mathematics education studies. A slight decline in 2025 (7.1%) reflects a transition from exploratory to refinement-oriented research, indicating a maturing focus on teacher competence and pedagogical integration.

3.3. Synthesis of Findings

Collectively, the thematic analysis affirms that IWBs substantially enhance student motivation and participation in mathematics classrooms. Quantitative evidence demonstrates that students in IWB-based instruction exhibit higher enthusiasm, attention, and willingness to participate. However, the studies also underscore that these effects depend on teacher readiness, consistent IWB use, and supportive school infrastructure. The synergy of these factors determines whether IWBs act as transformative pedagogical tools or remain underutilized technologies.

The findings thus answer the main research question: What is the effect of using interactive whiteboards compared to traditional teaching methods on students' motivation and participation in learning mathematics at Notre Dame – Siena College of Tacurong, Inc., based on quantitative studies?

Quantitative evidence confirms that IWBs, when properly implemented, lead to significantly greater motivation and participation compared to traditional teaching methods validating their pedagogical value and reinforcing the need for localized, context-specific research in the Philippine educational setting.

4. Conclusion

This systematic review synthesized fourteen (14) quantitative studies conducted from 2021 to 2025 to examine the effects of interactive whiteboards (IWBs) on students' motivation and participation in mathematics education. The findings demonstrate strong and consistent evidence that IWB integration significantly enhances students' intrinsic motivation, engagement, and participation rates compared to traditional teaching methods. Across studies, motivation increased by approximately 18–25%, while participation improved by approximately 25–40%.

Implications

Teachers should adopt IWBs as tools for interactive, student-centered learning, integrating features such as real-time feedback, visualization, and gamified exercises to sustain student motivation. Effective IWB use requires aligning technological capabilities with mathematical concepts, promoting both conceptual understanding and active participation.

The review underscores the importance of TPACK-based teacher training. Schools should provide continuous professional learning programs to strengthen teachers' pedagogical and technological integration skills. Empowering teachers with IWB competency directly translate to improved student engagement and learning outcomes.

Educational institutions and policymakers should invest in digital infrastructure, technical support, and classroom technology access. Well-maintained IWBs, stable internet connectivity, and dedicated technical assistance ensure sustainable implementation. Policies must prioritize not just procurement but also training and maintenance.

While international studies confirm IWBs' benefits, localized empirical research in Philippine contexts remains limited. Future studies should employ experimental and longitudinal designs to evaluate the long-term effects of IWB use on mathematics achievement, motivation, and participation among Filipino learners.

In conclusion, future research should also consider mixed-methods approaches to triangulate quantitative findings with qualitative insights from teachers and students, ensuring a more holistic understanding of IWB efficacy. IWBs are powerful pedagogical instruments that, when used effectively, elevate both motivation and participation in mathematics learning. Their success, however, depends on trained teachers, institutional support, and context-sensitive implementation. For Notre Dame – Siena College of Tacurong, Inc., the findings provide a data-driven foundation for enhancing digital pedagogy, informing professional development programs, and guiding strategic investment in educational technology to foster more engaging and equitable mathematics classrooms.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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