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REVIEW PAPER

Digital equity in mathematics education: Technology use in academic and vocational tracks

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Abstract

Digital equity in mathematics education is shaped not only by the availability of devices but also by the quality and purposes of technology use in learning. This study maps how technology is used in mathematics learning across academic and vocational tracks and examines its implications for digital equity. A systematic literature review was conducted following PRISMA 2020 guidelines using the Scopus database, covering publications from 2015 to 2025. A total of 44 selected articles were analyzed through descriptive mapping and thematic analysis to identify technology categories and patterns of use in both tracks. The findings show a clear divide: in the academic track, technology is more often used as cognitive tools to support visualization, conceptual exploration, and higherorder learning. In contrast, in the vocational track, technology is more commonly used for communication, learning management, and strengthening basic skills or remediation. In addition, the evidence base is concentrated in developed countries, while studies focusing on vocational tracks and developingcountry contexts, including Indonesia, remain limited. These results highlight a gap that may reduce vocational students' learning opportunities. Future research should expand evidence from vocational settings and developing countries, while policy should strengthen pedagogical support so that technology use in vocational education also promotes conceptual understanding and mathematical reasoning.

Keywords: academic track, digital equity, educational technology, mathematics education, vocational track

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INTRODUCTION

The global education system is undergoing a paradigm shift in the Society 5.0 era. Digital technology plays a crucial role in mathematics learning at the secondary school level. The abstract nature of mathematical concepts requires strong representation and visualization to support students' learning processes (Arcavi, 2003). Mathematics teachers use visual representations to help students build deeper conceptual understanding. Dynamic geometry software supports visualization and conceptual exploration in mathematics classrooms. The use of Dynamic Geometry Software (DGS) such as GeoGebra has demonstrated strong effectiveness in mathematics education practices globally (Wilder & Berry, 2016; Nagar et al., 2022).

The use of digital technology has evolved from a supporting tool into a learning system that expands students' learning opportunities. Schools use digital technology to support broader learning access for all students (Erdener et al., 2022). The literature also indicates differences in digital technology implementation between academic and vocational tracks in mathematics education. Research more often places exploratory technology innovations in the academic track. Studies more frequently report the use of GeoGebra for geometry exploration and mathematical modelling in the academic track. Vocational schools more often use technology as communication platforms and Learning Management Systems for class delivery. Vocational schools rely more on Microsoft Teams and Zoom for communication and learning management (Alabdulaziz, 2021; Segal & Biton, 2024).

Differences in software choices shape a gap in technology-based learning experiences between the academic and vocational tracks. This gap does not mainly lie in device ownership, but rather in the quality and purposes of technology use in learning. The literature conceptualizes this pattern as the Second Level Digital Divide, which emphasizes inequalities in usage and outcomes rather than access alone (Warschauer & Matuchniak, 2010). Digital equity in mathematics education is difficult to achieve when schools provide exploratory software for the academic track while vocational students are supported mainly with administrative technologies. Vocational students need strong visualization tools to support the development of technical skills and conceptual understanding relevant to workplace demands.

Table 1. Comparative map of adjacent reviews and the positioning of the present study.

Review (author, year)	Type and scope	Unit of comparison	Track disaggregation (academic vs vocational)?	Second level digital divide / equity lens?
Warschauer & Matuchniak (2010)	Narrative review of research on equity in technology (access, use, and outcomes); general education, US focused	Equity across access, use, and outcomes	No	Yes, a foundational statement of the use/outcome (second level) divide, but not math or track specific
Bray & Tangney (2017)	Systematic review of technology usage trends in secondary mathematics education research; 139 studies classified by a bespoke framework	Technology types, learning theories, SAMR level of integration, and pedagogical purpose	No	No
Letchumanan et al. (2024)	SLR of self regulated learning in online mathematics learning; 17 studies (2014–2022); mostly high school and undergraduate samples	SRL strategies, research purposes, outcomes, limitations	No	No
Rodriguez Segura (2021)	Review of causal EdTech evidence in developing countries; 81 core studies across 36 low and middle income countries; cross subject	Effectiveness of EdTech intervention types	No	Partial equity framed by development context, not by withinsystem track
This study	SLR of technology use in mathematics education across academic and vocational tracks; 44 studies (2015–2025)	Technology categories and purposes of use, disaggregated by track	Yes	Yes central analytic lens (applies the second level divide across tracks)

Prior reviews have advanced the field along two lines but have left the track dimension unexamined. On equity, Warschauer and Matuchniak (2010) synthesised evidence that inequality persists not only in access to technology but in how it is used and what outcomes follow the second level digital divide yet their review spans education broadly rather than mathematics or specific tracks. On mathematics technology, Bray and Tangney (2017) mapped usage trends and pedagogical purposes across secondary mathematics education research, and Letchumanan et al. (2024) synthesised self regulated learning in online mathematics environments; both, however, aggregate findings across student populations without distinguishing academic from vocational tracks. Reviews of educational technology in developing countries, such as RodriguezSegura (2021), foreground equity but frame it by national development context and across subjects, rather than by the differing purposes of technology use within an education system. Table 1 maps these adjacent reviews against the present study. As the final two columns show, none disaggregates evidence by academic versus vocational track, and none applies a second level divide lens to compare the purposes of technology use across tracks the gap this review addresses.

The literature that systematically compares technology use in mathematics education across academic and vocational tracks remains limited. Therefore, this study conducts a Systematic Literature Review to map technology use in mathematics learning in both tracks. This study is guided by the following research questions: (1) How do the ways and purposes of technology use in mathematics learning differ between the academic and vocational tracks? (2) What types of technology are most commonly used in mathematics learning in the academic and vocational tracks? (3) How do publication trends and geographical distribution appear in research on technology use in mathematics learning across the academic and vocational tracks?

RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) to systematically collect and evaluate prior research on a specific topic in order to obtain objective findings. The review process followed the PRISMA 2020 guidelines. The PRISMA framework is important for ensuring that article selection is transparent and accountable, rather than arbitrary (Page et al., 2021).

Database and publication period

The Scopus database was selected as the primary data source because of its rigorous indexing and quality control, which reduces the risk of including predatory or low quality outlets. The publication period was limited to 2015–2025; Haleem et al. (2022) noted that this decade represents a period of rapid digital transformation, making it suitable for capturing recent developments. The review was further restricted to peer reviewed journal articles published in English. These bounding choices strengthen methodological consistency and retrievability, but they also carry a coverage limitation that bears directly on the equity focus of this review: relying on a single English language database may under represent vocational education studies and research from the Global South, which are frequently disseminated in national language journals and conference proceedings. This limitation is acknowledged when interpreting the findings, and future reviews should complement Scopus with sources such as ERIC and regional or grey literature databases to widen coverage.

Keywords and Boolean operators

Keywords were derived from the review questions and combined with Boolean operators, following Gough et al. (2017), who emphasise that appropriate keyword selection is critical to ensuring that retrieved articles match the research focus. The search was carried out through Watase Uake, a systematic review platform that retrieves its records from Scopus, so the corpus consists of Scopus indexed articles. Ten Boolean strings were used, each pairing an education level or track term with the term mathematics and a technology term, and each searched against the title, abstract, and keyword fields; the complete list of strings and the number of records retrieved for each is reported in Table 2. The final search was completed on 9 December 2025. No filters were applied at the search stage, because Scopus was not queried directly; the restrictions on publication period (2015–2025) and journal quality tier were applied afterwards during deduplication and cleaning, as reported in the study selection counts and Figure 1.

Table 2. Keywords for database searching

No	Search string (searched in title, abstract, and keywords)	Records (raw)
1	"high school" AND mathematics AND "digital technology"	37
2	"high school" AND mathematics AND "educational technology"	35
3	"secondary school" AND mathematics AND "digital technology"	42
4	"upper secondary" AND mathematics AND "digital technology"	3
5	"senior high school" AND mathematics AND "digital technology"	3
6	"vocational high school" AND mathematics	37
7	"vocational school" AND mathematics	57
8	"secondary vocational school" AND mathematics	2
9	"technical high school" AND mathematics	6
10	"high school" AND mathematics AND "online learning"	54
	Total records identified	276

Inclusion and exclusion criteria

The inclusion and exclusion criteria are summarized in Table 3.

Table 3. Inclusion and exclusion criteria

Aspect	Inclusion Criteria	Exclusion Criteria
Data source	Scopus database	Low quality journals (Tier Q4/Outlier/Predatory)
Document type	Peer-reviewed journal articles	Conference proceedings, book chapters, editorial reviews
Time range	2015 – 2025 (most recent decade)	Articles published outside 2015–2025
Language	English	Other languages
Subject focus	Mathematics education at secondary level (general & vocational)	Other subjects
Other	N/A	Duplicate records

Analysis technique

The study applied thematic analysis (Braun & Clarke, 2006), organised deductively around the CIMO framework (Context, Intervention, Mechanism, Outcome); the CIMO based data extraction is presented in Table 4. Coding was supported by the Watase Uake System (Wahyudi, 2024), a systematic review support tool that provides coding and thematic categorisation features; it was used to structure and speed up extraction, not to generate interpretations.

Table 4. CIMO-based data extraction framework

Aspect	Specific indicators (extracted data)
Context	- Education track (academic vs vocational) - Country status (developed vs developing) - Student background (if explicitly reported)
Intervention	- Types of digital technologies (e.g., GeoGebra, LMS, AI, mobile apps) - Hardware used (PC, tablet, smartphone)
Mechanism	- Whether technology use supports conceptual deepening/exploration (exploratory) or basic improvement/remediation.
Outcome	- Learning impacts and the equity gap (whether technology use narrows or widens the quality gap between tracks).

For each included study, evidence was extracted into the CIMO categories and then grouped into higherorder themes on technology category and purpose of use across the academic and vocational tracks. Because this coding was performed by a single researcher supported by the Watase Uake System, which operationalises the SPAR4SLR protocol for article extraction and classification (Paul et al., 2021) and applies a structured inductive deductive procedure to promote coding clarity and consistency rather than by two independent coders, a formal interrater reliability coefficient (e.g., Cohen's κ) was not computed; the absence of independent doublecoding is acknowledged as a limitation. The coding scheme and coded extracts are provided as supplementary material.

Study selection

The PRISMA workflow adapted from WATASE UAKE comprises three stages: identification, screening, and inclusion as illustrated in Figure 1. The study selection process is summarised in Figure 1. In the identification stage, the initial Scopus search returned 276 records. Before screening, 100 records were removed: 29 duplicates, 36 published outside the 2015–2025 window, and 35 appearing in lowtier (Q4) outlets, leaving 176 records. In the screening stage, all 176 records were screened on title and abstract, and 90 were excluded for topic mismatch, leaving 86 reports sought for retrieval. Of these, 40 could not be retrieved because the full text was unavailable, so 46 reports were assessed for eligibility. At the eligibility stage, 2 reports were excluded as case studies falling outside the review scope, and 44 studies met all inclusion criteria and were included in the final synthesis.

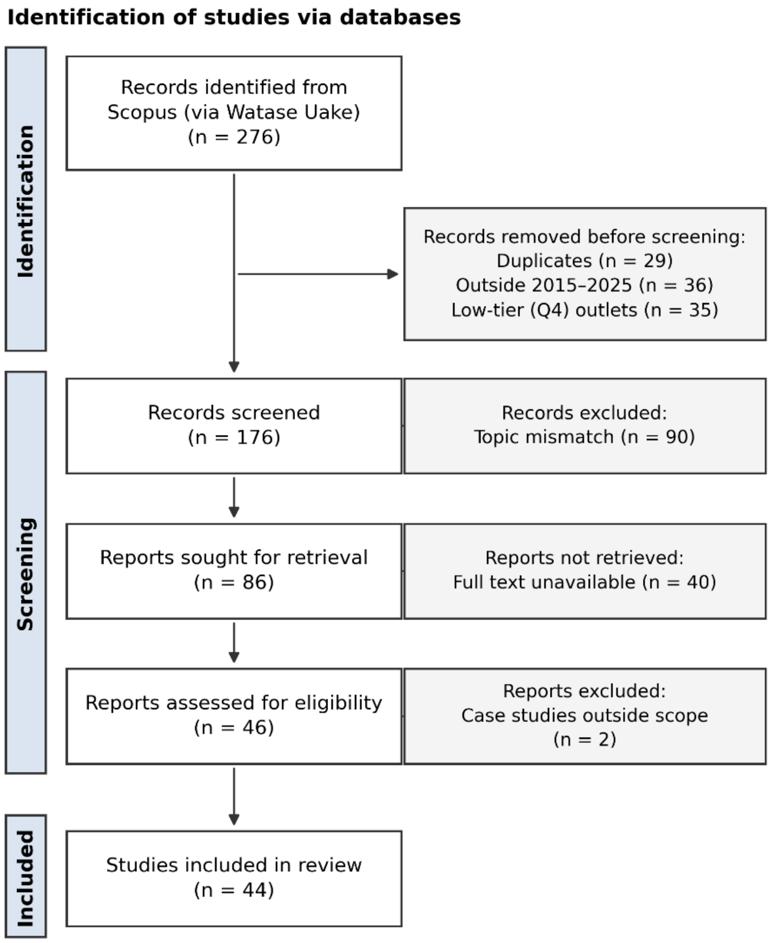

Figure 1. PRISMA flow diagram protocol

Quality appraisal

Because the corpus combined qualitative, quantitative, and mixedmethods designs, the methodological quality of the included primary studies was appraised with the Mixed Methods Appraisal Tool (MMAT), version 2018 (Hong et al., 2018), which provides designspecific criteria for each study type. Of the 44 included studies, 19 used qualitative designs, 11 were quantitative descriptive, 7 were mixed methods, and 6 were quantitative nonrandomized; the remaining study was a systematic review, which falls outside the scope of MMAT and was appraised separately. Journal indexing and tier screening served only as inclusion filters and are not a substitute for studylevel appraisal. Following the MMAT guidance, an overall quality score was not computed and lowerquality studies were not automatically excluded; instead, criterionlevel ratings were recorded for each study and used to weight the confidence placed in individual findings during synthesis. Full text was available for 40 of the 44 included studies at the appraisal stage; the remaining four could not be retrieved and were therefore not appraised. Excluding the one systematic review in the corpus (appraised separately, outside MMAT), the 39 primary studies were rated as follows: 24 met four or five of the five criteria, 14 met two or three, and one met one or none, indicating moderate to high methodological quality overall. In line with MMAT guidance, no study was excluded on quality grounds; the criterionlevel ratings (provided as supplementary material) informed the weight placed on each study during synthesis, with greater confidence given to higherrated studies. The limited reporting of response rates and of procedures for handling confounding in several survey and quasiexperimental studies is the main quality caveat and is reflected in the interpretation of the corresponding findings.

RESULTS AND DISCUSSION

This section reports the main findings from the 44 selected studies and discusses them in relation to digital equity in mathematics education across academic and vocational tracks.

Differences in the ways and purposes of technology use in academic and vocational tracks

In academic and track studies, technology is used as a tool for conceptual exploration and higherorder learning. In vocationaltrack studies, technology is used to support task completion, strengthen basic skills, and provide remediation. These differences in the purposes of technology use indicate an inequality in the quality of technologymediated learning experiences across the two tracks. Differences in the types of technologies used influence how learning is implemented. A summary is presented in Table 5.

Table 5. Summary of the comparison of dominant research focus

Aspect	Dominant Research Focus		The Equity Gap
	General Secondary	Vocational Secondary	
Teaching Style	Exploratory: Students are encouraged to derive formulas independently and engage in higherorder thinking.	Practical & improvementoriented: Students more frequently practice basic problems and focus on grade improvement (remedial).	Academictrack students are positioned as knowledge builders, while vocationaltrack students are positioned mainly as targets of improvement.
Key Terms	InquiryBased Learning, Visualization.	Remedial Instruction, Basic Proficiency.	Vocational research rarely discusses innovation, often focuses on how to “catch up.”
Content Topics	Dominant: Frequently discusses advanced themes such as STEM and Creative Problem Solving.	Limited: Very rarely discusses creativityoriented or higherlevel topics.	The potential for vocational students’ creativity through technology tends to be overlooked.
Learning Theory	Deep learning orientation: Uses constructivism (building understanding).	Surfacelevel orientation: Focuses mainly on “whether learners are willing to use the tool” (technology acceptance).	Academictrack research evaluates depth/quality of understanding, while vocationaltrack research often stops at the adoption stage.

Based on Table 5, the academic and vocational tracks show different patterns of technology use. These differences are visible in the learning goals emphasized and in the types of learning activities facilitated by technology. The academic track more often applies higher order learning approaches such as inquiry and STEM that promote conceptual exploration and reasoning. Meanwhile, the vocational track emphasizes remediation and strengthening basic skills.

Table 6. Classification of technology categories

Category	Math-spesific digital tools	Mobile and social media	Online/LMS-based environments	Other/mixed ICT and STEM technologies	Total
Mixed/not specified	- NA (Erdener, 2022)	- NA (Abidin, 2017)	- NA (Letchumanan, 2024) - SPSS 25 (Dai, 2022) - SPSS 22, Google form, Whatsapp, Webex, Google classroom, other learning platforms and websites (Azhari, 2021) - Internet web browsers, spreadsheet, Geogebra, Matlab, Python, Octave, Ipython, Google Maps, and presentation software (Villareal, 2018) - ASSISTments and CAPAExplore (Ocumpaugh, 2016)	- Geogebra, MS Excel (with solved add-in), Mentimeter, powerpoint, prezi (Taranto, 2022) - Geogebra, Wolfram Alpha, Padlet (Santos-Trigo, 2018) - Google Classroom Khan Academy, Wikipedia, Youtube, iBooks Author and communication applications on tablets and smartphone (Gui, 2018) - NA (Sherin, 2017)	11
General secondary	- Geogebra and Tracker (Bounou, 2025) - Geogebra and recoding tools (Bach, 2024) - NA (Snead, 2023) - HyperRESEARCH 4.5.3 (Agyei, 2023) - Geometer Sketchpad and Sketchpad explorer (Nagar, 2022) - Maple (Jankvist, 2021) - Desmos (Chorney, 2021) - Geogebra (Bozkurt, 2020) - Geogebra (Bozkurt, 2018) - Classroom network control (Prodromou, 2017) - Interactive whiteboard (Bozkurt, 2016)	Not reported (Segal, 2024)	- R (Wang, 2024) - R VERSION 4.3.3 (Xu, 2024) - SPSS 26, AMOS 25.0 (Cortez, 2023) - R with lme4 package (Wang, 2023) - NA (Adhikari, 2023) - Online assessment platform (Lim, 2018) - ALEKS (Wilder, 2016)	- MATLAB R2019a, (Govender, 2025) - Star online survey platform (Zhang, 2024) - IBM SPSS Statistics (Stilin, 2023) - MS Teams, Geogebra, MS Excel, Solver Mentimeter (Collajani, 2023) - MS Teams and Zoom (Alabdulaziz, 2021) - R with pheatmap package (Hosein-Mohand, 2021) - Rasch software (Bretscher, 2021) - Geogebra (Ratnayake, 2020) - MathAid (Viberg, 2020) - NA (Zeynivandnezhad, 2020)	29
Vocational secondary		- R version 4.3.3 (Yang, 2025) - Facebook, Geogebra, digital video and online tools (Barros, 2022)	- SPSS 23, MS EXCEL, ALEKS (Mills, 2021) - NA (Dai, 2015)		4

This pattern indicates different technology use foci: technology as a means to deepen understanding (deep learning) in the academic track, and technology as a tool to support tasks in the vocational track. These differences imply unequal opportunities to learn with technology, highlighting the need for strategies and instructional support that enable vocational students to use technology for conceptual understanding and higherorder mathematical reasoning as well.

Technology category gap: Exploratory vs administrative tools

In addition to differences in the number of studies, the analysis also indicates differences in the *categories of technology* used in the academic and vocational tracks. This section compares the types of technologies reported across both tracks (See Table 6).

Based on Table 6, there are clear differences in the technology categories used in the academic and vocational tracks. Quantifying the corpus, online/LMS-based environments and other or mixed ICT and STEM technologies are the most frequent categories, each reported in 14 of the 44 studies (31.8%), followed by mathspecific digital tools in 12 studies (27.3%) and mobile or socialmedia applications in 4 studies (9.1%). The crosstabulation of technology category by education track is presented in Table 7.

Table 7. Cross tabulation of technology category by education track

Education track	Math specific digital tools	Mobile & social media	Online/LMS-based	Other/mixed ICT & STEM	Total
Academic	11	1	7	10	29
Vocational	0	2	2	0	4
Mixed/not specified	1	1	5	4	11
Total	12	4	14	14	44

Table 7 also makes the exceptions visible and guards against overgeneralisation. No vocational track study in this corpus reported the use of math specific visualisation or cognitive tools; the four vocational studies used mobile or socialmedia applications (two studies) and online or LMS-based environments (two studies). This is an absence of evidence in a very small subset rather than proof that such tools are never used in vocational settings, and the conclusion should be read with that caution. Conversely, the academic track is not uniformly oriented towards conceptual tools: 7 of the 29 academictrack studies (24.1%) examined online or LMSbased environments, in several cases for administrative or delivery purposes such as distributing materials and managing assignments. The contrast between tracks is therefore a matter of degree and emphasis rather than an absolute divide, and the small number of vocational studies (n = 4) limits the strength of any claim about that track.

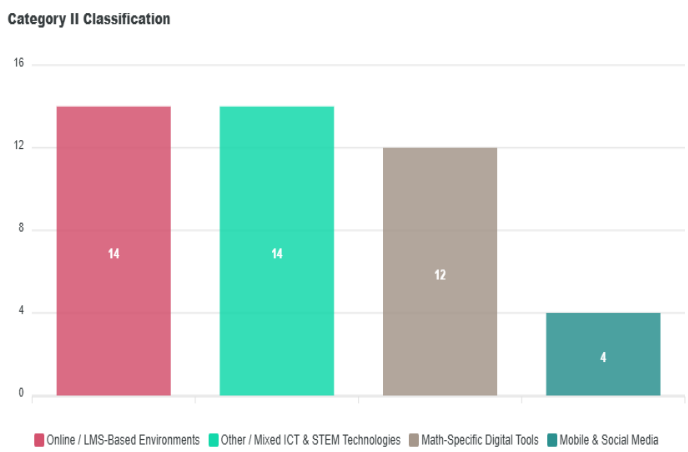

Figure 2. Distribution of technology categories used in the studies

The academic track is dominated by mathspecific digital tools, such as GeoGebra and Desmos. These tools help students directly visualize graphs and geometric objects to understand difficult concepts. In the vocational track, the reviewed studies report an absence of mathspecific tools for vocational students. Technology use in this track is mostly limited to Learning Management Systems (LMS) such as Microsoft Teams or general smartphone applications.

Based on Figure 2, technology in the academic track is primarily used to support visualization and concept exploration, whereas technology in the vocational track is more often used for communication and learning management, such as collecting assignments and coordinating classes. To examine the link between technology categories and the learning focus discussed in the literature, the summary is presented in Table 8.

Table 8. Summary of technology trends and research focus (2015–2025)

Category	Technology examples	Primary research focus
Math Specific Digital Tools	- GeoGebra - Desmos - Graphing calculators	Visualization & concept exploration: Used to visualize abstract geometric objects and algebraic functions, facilitating inquirybased learning where students explore interactively.
Online/LMSBased Environments	- Microsoft Teams - Moodle - Google Classroom - Zoom	Accessibility & virtual class management: Focus shifts from a mere repository of materials to distanceclass interaction, online collaboration, and flexibility of learning time/place.
Other / Mixed ICT & STEM	- ALEKS - Intelligent Tutoring Systems (ITS) - Learninganalytics platforms	Personalization & automated remediation: Examines how technology can adapt learning pathways based on individual performance, provide instant feedback, and detect learning difficulties early through logdata analysis
Mobile & Social Media	- Smartphone Apps - WhatsApp	Informal learning & access bridge: Often studied to address infrastructure constraints (especially in developing countries), enable quick teacher–student communication, and support learning beyond school hours.

Table 8 suggests that technology use in the vocational track tends to be more administrative than cognitive. The absence of visualization tools may constrain vocational students to procedural understanding, in contrast to academic track students who have broader opportunities to explore abstract concepts. This functional gap helps explain differences in instructional approaches discussed in the subsequent section.

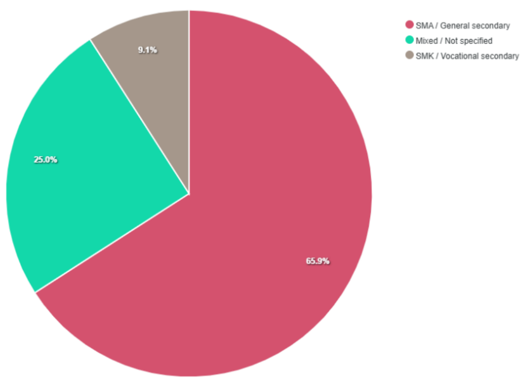

Figure 3. Distribution of studies by education track context

Publication trends and geographic distribution

This section maps the evidence base on technology use in mathematics learning across academic and vocational tracks. The mapping helps identify areas that have been widely studied and areas that remain underexplored, both in terms of education tracks and research locations.

Based on Figure 3, 65.9% (29 studies) focus on students in the academic track. In contrast, studies that specifically examine the vocational track are very limited, accounting for only 9.1% (4 studies). The remaining studies do not specify track or include mixed contexts. This imbalance suggests that vocational students are still an underserved population in research on technology innovation in mathematics education, and that current narratives of "effective technology use" are largely shaped by evidence from academic and track contexts. In addition to track imbalance, the review reveals a notable geographic gap. Research production is dominated by developed countries.

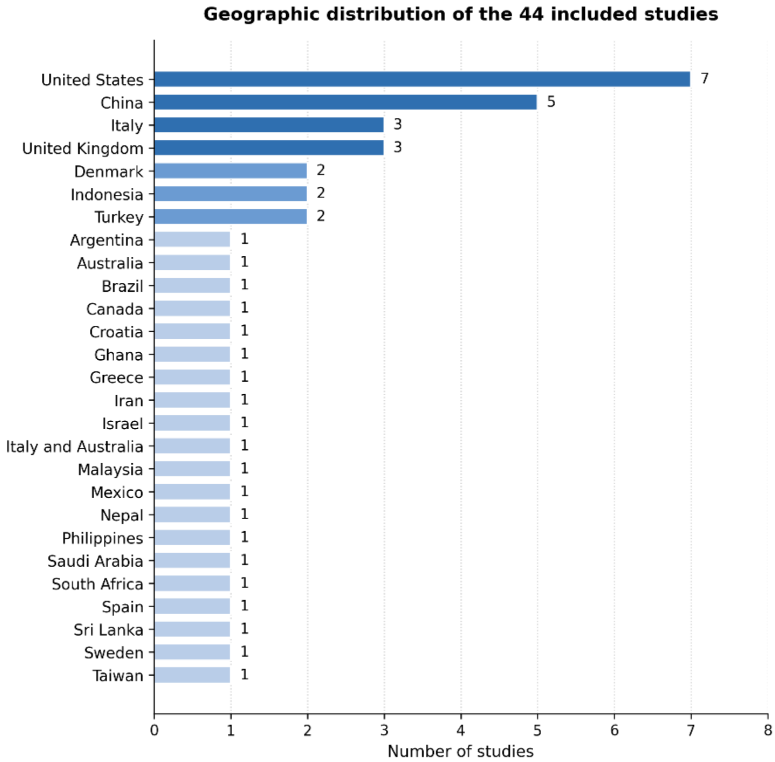

Figure 4. Geographic distribution

Based on Figure 4, the United States leads with 7 studies (15.9% of the 44 studies; recorded in the source data as "United States", 6 studies, and "USA", 1 study, which denote the same country), followed by China with 5 studies (11.4%) and Italy with 3 studies (6.8%). The United Kingdom accounts for 3 studies when England (2 studies) and the United Kingdom (1 study) are counted together. Meanwhile, studies from developing countries remain very limited: Indonesia contributes 2 studies (4.5%), while Argentina, Brazil, Ghana, Iran, Malaysia, Mexico, Nepal, the Philippines, Saudi Arabia, South Africa, and Sri Lanka contribute one study each. This pattern indicates that global EdTech trends in mathematics education are strongly influenced by standards and conditions in wellresourced settings. Consequently, technology solutions that work in those contexts may not be directly transferable or easy to implement in developingcountry contexts with different infrastructure constraints.

Overall, the evidence base is concentrated in the academic track and in specific regions. Limited evidence from vocational contexts and from more diverse locations may affect the readiness of equityoriented recommendations. Therefore, future research should expand coverage of vocationaltrack settings and underrepresented geographic contexts to strengthen digital equity discussions in mathematics education.

These trackbased patterns describe dominant tendencies rather than strict rules, and several cases run counter to them, which guards against overgeneralisation. Online and LMSbased environments often associated with administrative and access functions rather than conceptual exploration are in fact the most frequently studied technology category across the corpus (17 studies), appearing in both academic and vocational contexts; this shows that administrative or accessoriented use is not exclusive to the vocational track. Conversely, mathspecific exploratory tools such as GeoGebra and Desmos (12 studies) are not confined to wellresourced academic settings but also appear in vocational and developingcountry studies. Such exceptions indicate that the equity gap is driven less by which technology category is adopted than by how a given technology is used within a track exploratory and higherorder versus procedural and remedial so the academicexploratory versus vocationalremedial contrast should be read as a prevailing tendency with meaningful withintrack variation.

Implications for digital equity in mathematics education

To integrate these findings, this study proposes the TrackDifferentiated TechnologyUse Model (Figure 5), which formalises the secondlevel digital divide as a function of technology category, learning mechanism, and track context, derived from the CIMObased extraction (Table 3). The model locates inequality not at the level of device access, which is largely comparable across tracks, but along the pathway from the category of technology allocated to a track, through the learning mechanism it affords, to the resulting learning outcome. The following paragraphs examine each component of this pathway in turn.

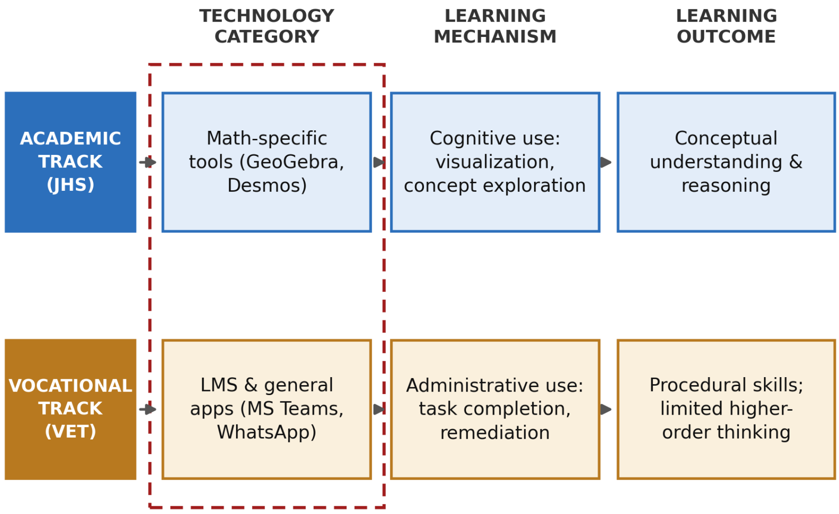

Figure 5. Track differentiated technology use model

This review updates how digital inequality is understood in mathematics education. The gap is no longer primarily determined by who owns devices, but by who has the skills and learning support needed to use technology effectively (National Digital Inclusion Alliance [NDIA], 2025). The gap may become larger when technology implementation does not adequately consider school conditions and students' learning needs. Evidence from EdTech reviews in developingcountry contexts suggests that providing technology alone is insufficient; effectiveness is influenced by pedagogical readiness, implementation design, and alignment with school and learner conditions (Rodriguez Segura, 2021). UNESCO similarly emphasizes that technology should be used with attention to relevance alignment with learning goals and students' needs and that without appropriate governance and learning support, technology implementation may widen inequality (UNESCO, 2023). In terms of the proposed model, this shifts the locus of inequality away from device access and toward the category of technology that each track is given, which is the entry point of the divide (Figure 5).

The gap is also evident in the quality of technology use between academic and vocational tracks. Walkington (2025) argue that technology should function as a thinking tool in mathematics learning. Salami and Spangenberg (2024) show that software can be effective in the academic track to help students understand complex concepts. In contrast, Segal and Biton (2024) report that vocationaltrack technology is more often used for communication and task management rather than as a medium for analysis and reasoning. As a result, vocational students have fewer opportunities to develop critical reasoning through technologysupported learning activities. This challenge is linked to vocational learning that often prioritizes practical/operational skills, which can reduce technology use to "how to operate tools" rather than a means to develop conceptual reasoning and decisionmaking (López et al., 2023). Yet the workplace requires problem solvers, not merely operators (Taranto et al., 2022). Consistent with this concern, creativemethod innovation in the vocational track is also reported to be less frequent than in the academic track (Govender & Amevor, 2025). This corresponds to the categorytomechanism link in the proposed model: math specific tools in the academic track afford a cognitive, exploratory use, whereas the administrative technologies available in the vocational track afford mainly procedural use (Figure 5).

If this quality gap persists, the vocational track risks losing opportunities to develop higherorder thinking when technology functions more as an administrative tool than as a cognitive tool. This condition may widen learningoutcome gaps because students with limited learning resources at home tend to rely more on pedagogical support from school; when such support is weak, achievement disparities may increase (Warschauer & Matuchniak, 2010). This is the mechanismtooutcome link in the proposed model: predominantly administrative use constrains vocational students to procedural understanding, while cognitive use supports conceptual understanding and mathematical reasoning, so that a difference in technology category ultimately translates into a difference in learning outcomes (Figure 5).

CONCLUSION

Based on a systematic literature review of 44 studies (2015–2025), this paper shows that digital equity in mathematics education is shaped primarily by the quality and purposes of technology use. Academictrack studies more often report technology as cognitive tools that support visualization, conceptual exploration, and higherorder learning, while vocationaltrack studies more often report technology for communication and learning management/basic reinforcement. The evidence base is also concentrated in developed countries, with limited research focusing on vocational contexts and developing countries, including Indonesia, indicating the need to strengthen evidence and practice to ensure more equitable technologysupported mathematics learning opportunities across tracks.

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DECLARATION

Author contribution

All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Hesti Ummi Wulandari	Conceptualizing the research idea, leading the investigation, setting up the methodology, analyzing the data, and writing the original draft.
Farida Nurhasanah	Assisting the investigation, reviewing the validity of the methodology, and enriching the data analyisis.
Dhidhi Pambudi	Assisting the investigation, reviewing the validity of the methodology, and enriching the data analyisis.

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Conflict of interest

All authors declare that they have no competing interests.

Ethics declaration

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The use of artificial intelligence

We do not use any generative AI tools to write any part of this paper.

Additional information

Not available.

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