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Mapping Conceptual Domains and Bridging Concepts in Technology-Enhanced Mathematics Learning: A Bibliometric Study

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ABSTRACT
This study examines the research landscape of recent studies in students' acceptance in technology-enhanced mathematics learning, an increasingly important issue as digital technologies become more widely integrated into mathematics education. Although research in this area has expanded in recent years, previous studies have often treated technological, pedagogical, and cognitive–psychological factors separately, leading to a fragmented understanding of students' acceptance. This study aimed to map the development of the field, identify its major conceptual domains, examine the interactions among these domains, and explain their implications for future mathematics education research and practice. A bibliometric design was employed using data from the Scopus database. After a systematic screening process, 883 publications published between 2015 and 2026 were analyzed. Publication trend analysis and keyword co-occurrence mapping were conducted using VOSviewer. From 5,259 extracted keywords, 196 met the minimum occurrence threshold and were included in the final analysis. Findings reveal that publication output grew substantially, from 35 articles in 2015 to a peak of 248 in 2025. Furthermore, three major conceptual domains were examined: technology-enhanced mathematics pedagogy, instructional practices and teacher professional development, and cognitive–psychological aspects of mathematics learning. The analysis also reveals bridging concepts, particularly problem solving, motivation, student engagement, learning, and cognition. The novelty of this study lies in its integrative mapping of these domains and their bridging concepts, contributing to a more holistic understanding of students' acceptance and informing the design of more meaningful technology-enhanced mathematics learning environments.
Keywords: Bibliometric Analysis, Digital Mathematics Learning, Students' Acceptance.

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Introduction

The rapid development of digital technologies has transformed mathematics education through the use of online learning platforms, dynamic visualization tools, gamified environments, and artificial intelligence applications in classroom practice (Hillmayr et al., 2020; Sinaj & Xhabafti, 2025). In mathematics learning, these technologies are significant for their support of conceptual understanding, problem solving, and mathematical communication when they are effectively integrated into pedagogy (Borba et al., 2016; Drijvers, 2015). However, problems might arise when teachers have no professional training on the pedagogical integration of technologies or when the tools do not consider the students' cognitive load and emotional states.

These factors can widen learning gaps, foster shallow engagement, and discourage students from embracing technology in learning (Hillmayr et al., 2020; Sweller, 1988).

However, the successful use of technology in mathematics learning depends not only on the availability, but also on students' acceptance of these technological tools. Students' attitudes, motivation, engagement, and perceived value of technology influence whether technology-enhanced learning can be meaningfully adopted in mathematics education (Alegre, 2023; Venkatesh et al., 2003). This problem is particularly crucial because mathematics learning is closely related to cognitive and affective factors, such as conceptual understanding, confidence, and mathematics anxiety, which may shape how students respond to technology-supported instruction (Barroso et al., 2021; Namkung et al., 2019). Technology-enhanced mathematics learning can improve students' acceptance (Fajar Ramadhan et al., 2022), problem-solving ability (Fadila et al., 2025; Supono et al., 2024), and cognitive processes (Uripno et al., 2024).

Although research on technology integration in mathematics education has grown substantially, the literature remains fragmented. Previous studies have examined digital tools, pedagogical strategies, engagement, and cognitive processes from separate perspectives, such as educational technology, instructional design, teacher development, or cognitive psychology (Hillmayr et al., 2020; Trung & Giang, 2023). As a result, limited attention has been given to how technological, pedagogical, and cognitive–psychological factors are conceptually interconnected in shaping students' acceptance of technology-enhanced mathematics learning. This limitation creates an important unresolved issue, because the expansion of digital learning in mathematics education requires not only technological innovation but also a clearer understanding of the factors that support meaningful, engaging, and cognitively appropriate learning environments (Hillmayr et al., 2020; Sinaj & Xhabafti, 2025).

Prior bibliometric works have begun to address this space. Two of the recent studies mapped technological innovation in mathematics learning (Retnawati & Hidayat, 2025), and examined trends across technology-enhanced mathematics education more broadly (Yohannes & Chen, 2025). However, neither study focused specifically on students' acceptance as a central construct, nor did they systematically identify the conceptual bridges linking pedagogical, technological, and cognitive–psychological dimensions of the field. Without such mapping, it remains difficult to understand how these dimensions interact to collectively shape students' acceptance. Therefore, this study directly addresses that gap by providing an integrative bibliometric analysis of the domain, tracing both its major conceptual clusters and the bridging concepts that connect them.

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To address this gap, this study employs a bibliometric approach. It is a well-established method for identifying publication trends, conceptual structures, and thematic relationships within a research field (Aria & Cuccurullo, 2017; Donthu et al., 2021). In particular, keyword co-occurrence analysis can reveal dominant conceptual domains and the relationships among topics in a knowledge network (Van Eck & Waltman, 2010; Zupic & Čater, 2015). The novelty of this study lies in its integrative mapping of students' acceptance in technology-enhanced mathematics learning by identifying not only the major conceptual domains of the field, but also the bridging concepts that connect them. In this way, the study contributes to mathematics education research by providing a more holistic understanding of how technology-enhanced pedagogy, instructional practices, and cognitive–psychological factors interact within the research landscape.

This study is also informed by technology acceptance and innovation perspectives, which emphasize that adoption is shaped by users' perceptions as well as by the broader instructional context in which technology is embedded (Davis, 1989; Rogers, 2003; Venkatesh et al., 2003). Therefore, this study aims to map the research landscape of students' acceptance in technology-enhanced mathematics learning through bibliometric analysis by addressing the following: (RQ1) how the research has evolved over time; (RQ2) what conceptual domains structure the field; (RQ3) how technology-enhanced pedagogy, instructional practices, and cognitive–psychological factors interact; and (RQ4) what implications these interactions have for the development of mathematics education research and practice.

Methods

Research Design

This study employed a bibliometric approach to map the research landscape of students' acceptance in technology-enhanced mathematics learning. A bibliometric analysis was used to examine publication trends, conceptual structures, and relationships among research topics (Aria & Cuccurullo, 2017; Donthu et al., 2021). The overall workflow of the study is presented in Figure 1 comprising 4 stages. The first stage involves data retrieval from the Scopus database using a structured Boolean search string covering three keyword groups: mathematics education, student acceptance, and learning-related concepts. The second stage covers data screening, in which articles were filtered by language, document type, and subject area. The third stage encompasses bibliometric analysis using VOSviewer, including publication trend analysis and keyword co-occurrence mapping to identify conceptual clusters and bridging keywords. Lastly, the fourth stage involves interpretation of findings in relation to the four research questions, culminating in a discussion of implications for mathematics education research and practice. Together, these stages form an integrated pipeline that moves from data collection to conceptual mapping and interpretation.

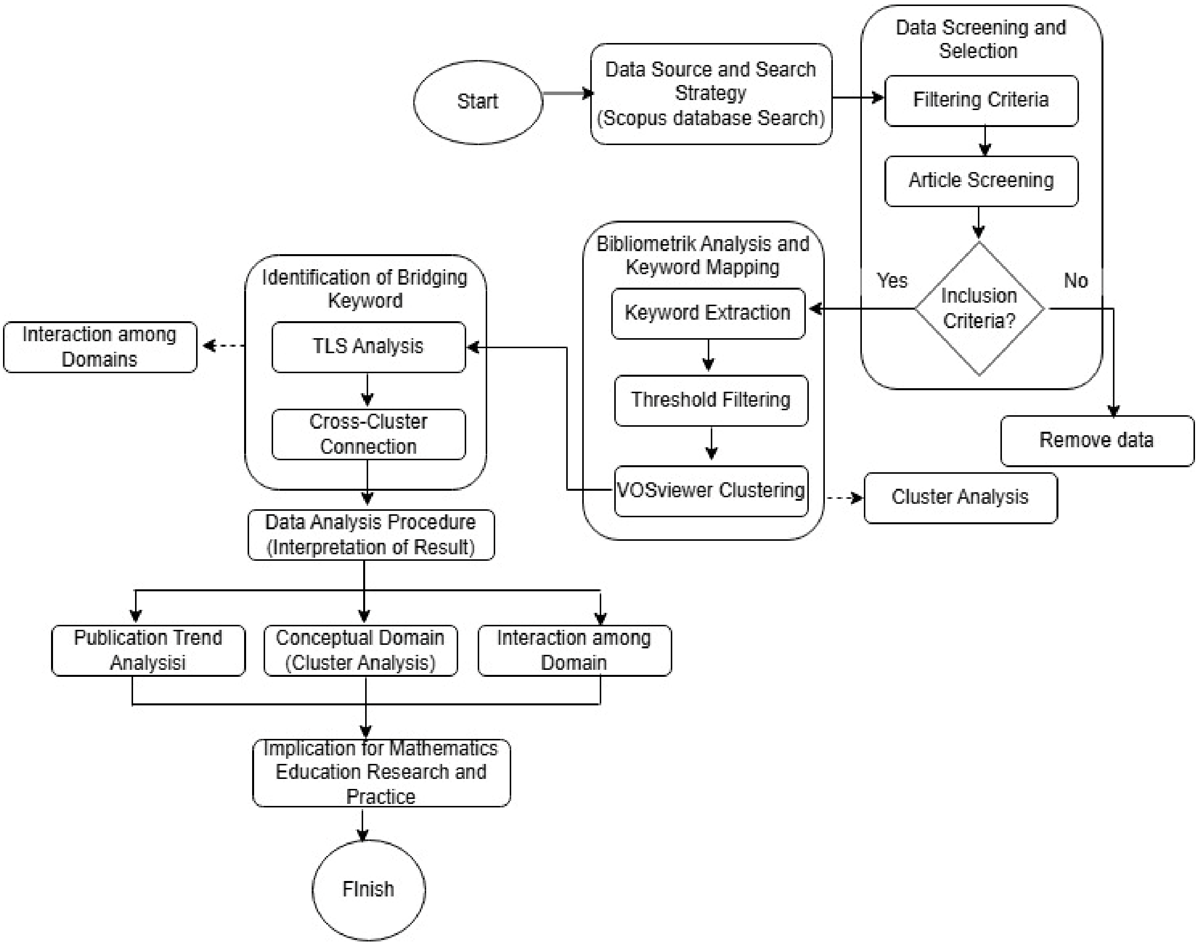

Figure 1. Research Workflow of Bibliometric Analysis

Data Sources and Search Strategy

The data were retrieved from the Scopus database, selected for its broad coverage of peer-reviewed international publications and compatibility with bibliometric tools (Mongeon & Paul-Hus, 2016). The search was conducted in the title, abstract, and keyword sections with Boolean operators covering three groups of terms: mathematics education (mathematics education, mathematics learning, learning mathematics), student acceptance (student acceptance, acceptance, perception, attitude, engagement, motivation), and learning-related aspects (mathematical thinking, conceptual understanding, problem solving, cognition). The Scopus search used the following Boolean query: TITLE-ABS-KEY (("mathematics education" OR "mathematics learning" OR "learning mathematics") AND ("student acceptance" OR "acceptance" OR "perception" OR "attitude" OR "engagement" OR "motivation") AND ("mathematical thinking" OR "conceptual understanding" OR "problem solving" OR "cognition")). On top of that, the inclusion criteria were: (1) to be written in English; (2) to be published between 2015 and 2026; (3) to be classified under Social Sciences, Mathematics, Psychology, Computer Science, or Arts and Humanities; and (4) to be substantively focused on mathematics learning. After filtering, 1,275 publications were identified.

Data Screening and Selection

After applying the inclusion and exclusion criteria, the initial pool of records was screened to retain only those publications directly relevant to students' acceptance in technology-enhanced mathematics learning. The selection procedure is summarized in the PRISMA flow diagram shown in Figure 2 (Page et al., 2021).

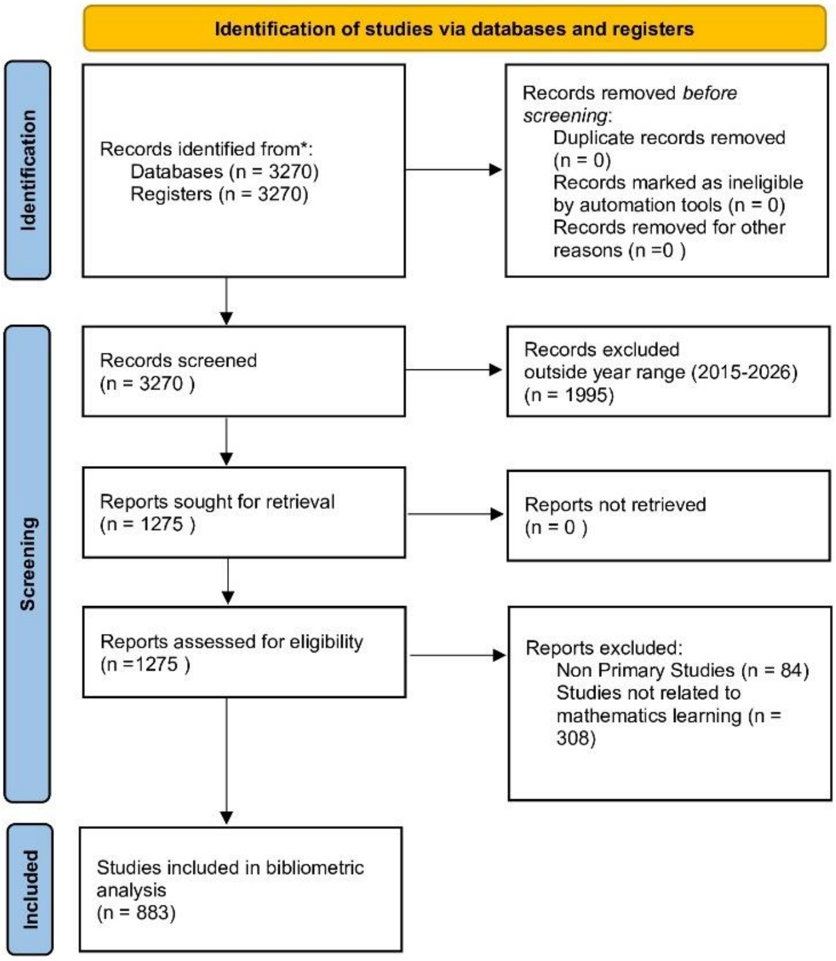

Figure 2. Prisma Flow Diagram of Article Selection (Haddaway et al., 2022)

Closer inspection of the retrieved records showed that a substantial portion fell outside the scope of this study. Of the 1,275 records initially identified through the Scopus database search, all were screened based on title, abstract, and keyword content. A total of 392 records were excluded as they were not related to mathematics learning contexts and were categorized as systematic literature reviews, meta-analyses, or bibliometric studies, or fell outside the designated subject areas. Meanwhile, the remaining 883 publications met all inclusion criteria and were retained for bibliometric analysis. This transparent reporting of the selection procedure ensures the reproducibility of the study and allows readers to assess the representativeness of the final dataset.

Bibliometric Analysis and Keyword Mapping

The bibliometric analysis was conducted using VOSviewer (version 1.6.20) to construct and visualize the keyword co-occurrence network (Van Eck & Waltman, 2010). A total of 5,259 keywords were initially extracted, of which 734 met the preliminary threshold for analysis. To improve network clarity, a minimum occurrence threshold of 15 was applied, resulting in 196 keywords for final mapping. These keywords were used to identify conceptual clusters and relationships among research topics related to students' acceptance in technology-enhanced mathematics learning.

Identification of Bridging Keywords and Data Analysis Procedure

To examine interactions among conceptual domains (RQ3), bridging keywords were identified based on high Total Link Strength (TLS) values and their cross-cluster connections. After removing overly general or less relevant terms, nine bridging keywords were selected to represent the links among the pedagogical, technological, and cognitive–psychological domains. The analysis was then done in four stages aligned with the research questions: publication trend analysis for RQ1, keyword clustering for RQ2, bridging keyword analysis for RQ3, and interpretation of implications for RQ4. This integrative approach enabled the study to examine not only publication growth and conceptual domains, but also the interactions that shape the research landscape of students' acceptance in technology-enhanced mathematics learning.

Result and Discussions

Publication Trends (RQ1)

This section addresses the first research question by tracing how publication output has changed between 2015 and 2026. A line graph was selected to display the annual distribution of publications because it effectively visualizes temporal trends and the rate of change over time (Donthu et al., 2021). Figure 3 shows the annual distribution of publications on students' acceptance of technology-enhanced mathematics learning from 2015 to 2026, reflecting not only steady growth but also the influence of broader disruptions, particularly the shift to online learning during the COVID-19 pandemic. In the early period (2015–2018), publications rose gradually from 35 to 51 articles, followed by a slight decline in 2019 (41 articles). A stronger increase was evident in

2020 with 77 publications and continued in the following years, reaching 107 articles in 2024 and peaking at 248 articles in 2025. The relatively low number in 2026 (19 articles) is likely due to incomplete indexing for the current year. Overall, these findings indicate a substantial growth of research interest in this field.

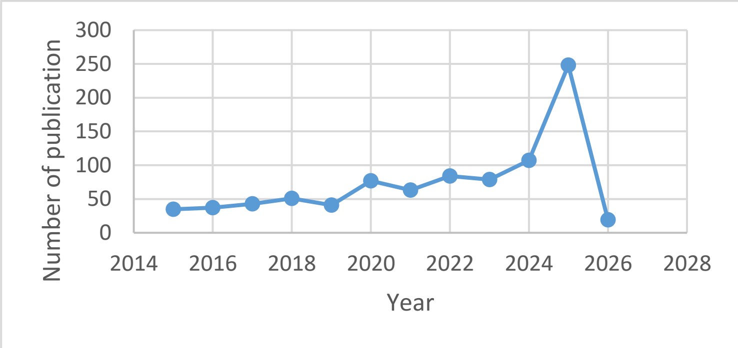

Figure 3. Distribution of publication on acceptance of technology

The increasing trend of publications indicates growing scholarly interest in how students accept and interact with technology-enhanced mathematics learning environments. This trend is likely driven by the rapid integration of digital technologies into educational practices, particularly in mathematics education (Retnawati & Hidayat, 2025; Yohannes & Chen, 2025). The marked increase after 2020 may also be linked to the global shift toward online and technology-mediated learning during the COVID-19 pandemic, which accelerated the use of digital platforms and encouraged further research on students' acceptance of technology in mathematics learning(Chu et al., 2021; Dey et al., 2021; Singh & Sharma, 2022; Thapaliya & Hrytsuk, 2023).

Furthermore, the continued rise in recent years reflects the growing importance of innovative technologies, such as artificial intelligence, digital learning platforms, and computational tools, in mathematics education. These technologies not only support instructional practices but also influence students' motivation, engagement (Alsarayreh, 2025; Fadda et al., 2022; Sinaj & Xhabafti, 2025; Wong & Yip, 2022), and cognitive processes in learning mathematics (Ruamba et al., 2025; Sofroniou et al., 2025). This upward trend suggests that students' acceptance of technology-enhanced mathematics learning has become an important research agenda for improving the effectiveness of mathematics education in the digital era. Based on this pattern, the publication trend can be divided into three phases: the initial stage (2015–2018), the growth stage (2019–2021), and the rapid expansion stage (2022–2025).

Visualization of Research on Student Acceptance in Mathematics Learning (RQ2)

The first and largest cluster groups research that connects digital technology with how students experience and respond to mathematics learning. The first cluster (red) in Figure 4, consisting of 76 keywords, represents technology-enhanced mathematics pedagogy and is centered on terms such as students, motivation, educational technology, e-learning, and computational thinking. Additional keywords, including artificial intelligence, gamification, flipped classroom, Geogebra, virtual reality, and online learning, indicate a strong emphasis on integrating digital technologies and innovative instructional strategies to enhance students' engagement and acceptance.

The second cluster (green) in Figure 4, with 63 keywords, represents mathematics instruction and teacher professional development. It includes terms such as mathematics education, mathematics instruction, problem-solving, thinking skills, and pedagogical content knowledge, along with keywords related to mathematics teachers, teacher education programs, teaching methods, and technology integration. This cluster highlights the importance of instructional practices, teacher competencies, and curriculum development in mathematics education.

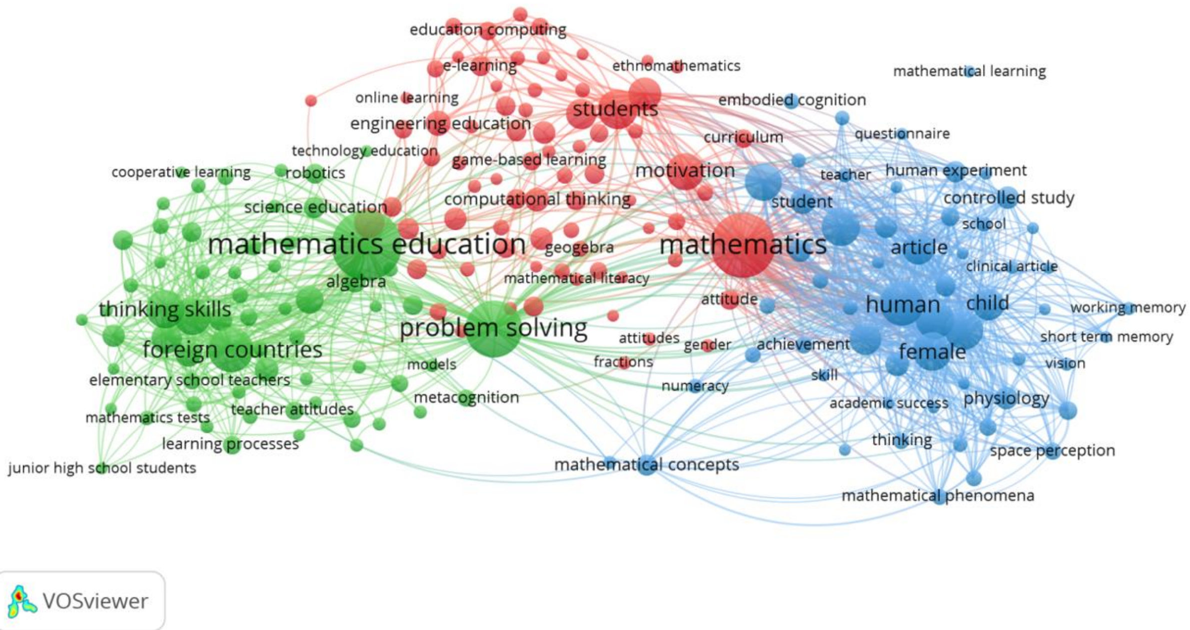

Figure 4. Visual development map based on shared words

The third cluster (blue) in Figure 4, containing 57 keywords, illustrates the cognitive and psychological foundations of mathematics learning. Key terms such as cognition, learning, achievement, working memory, attention, and numerical cognition, together with mathematical concepts, academic success, and anxiety, explain that this domain focuses on how cognitive and affective factors shape students' learning processes and performance in mathematics.

These three clusters show that the research landscape of students' acceptance in mathematics learning is structured around three main domains: technology-enhanced pedagogy, instructional and teacher-related practices, and cognitive–psychological aspects of mathematics learning. Figure 4 presents the keyword co-occurrence network generated by VOSviewer, in which each node represents a keyword and each edge reflects a co-occurrence relationship between two keywords across the analyzed publications, while Table 1 presents the three conceptual structures identified via keyword co-occurrence analysis.

Cluster 1 (Green) illustrates the mathematics pedagogy cluster, including the co-occurring keywords mathematics education, problem-solving, and thinking skills. Cluster 2 (Red) is the mathematics pedagogy cluster representing student-centered and technology-integrated learning, represented by students, motivation, educational technology, and computational thinking. Lastly, cluster 3 (Blue) is the mathematics pedagogy cluster representing the cognitive-psychological sphere, including learning, achievement, and working memory.

Table 1. Main Keywords in Each Cluster

Cluster	Conceptual Domain	Representative Keywords
Cluster 1 (Green)	Mathematics Pedagogy	mathematics education, problem solving, thinking skills, learning processes, teacher attitudes
Cluster 2 (Red)	Student-Centered & Technology-Enhanced Learning	students, motivation, educational technology, computational thinking, e-learning
Cluster 3 (Blue)	Cognitive–Psychological Domain	cognition, learning, achievement, working memory, mathematical concepts

The identification of three conceptual domains indicates that research on students' acceptance in mathematics learning is shaped by the interplay of pedagogical, technological, and psychological perspectives. The technology-enhanced mathematics pedagogy domain reflects the growing integration of digital tools into mathematics instruction, as shown by keywords such as educational technology, e-learning, artificial intelligence, and gamification (Drijvers, 2015; Hock et al., 2025). These technologies are increasingly utilized to enhance students' motivation, engagement (Alegre, 2023; Sinaj & Xhabafti, 2025), and interaction with mathematical concepts (Bednorz & Bruhn, 2023; Rosli et al., 2024), which are essential factors influencing students' acceptance of technology-supported learning environments.

The mathematics instruction and teacher professional development domain emphasizes the role of instructional practices and teacher competence. A number of keywords, such as pedagogical content knowledge, teaching methods, and teacher education programs, suggest that successful technology integration depends not only on the tools themselves, but also on teachers' ability to design and implement meaningful learning experiences (Mishra & Koehler, 2006; Priyanda et al., 2025; Shulman, 1986; Vinodhini et al., 2025).

The cognitive and psychological domain highlights that mathematics learning involves complex cognitive processes, including cognition, working memory, attention, and numerical cognition (Baddeley & Hitch, 1974; Fuchs et al., 2019; Passolunghi et al., 2014). In addition, psychological factors such as mathematics anxiety and self-concept may influence how students perceive and accept different learning approaches (Moustafa et al., 2017; Živković et al., 2023). Overall, these findings show that students' acceptance of mathematics learning environments cannot be explained by technology alone, but by the interaction of technological innovation, instructional practices, and students' cognitive–psychological characteristics, extending prior studies' results. In this regard, the study offers a more integrated conceptual map of the field.

Interaction among Technology-Enhanced Mathematics Pedagogy, Instructional Practices, and Cognitive–Psychological Factors (RQ3)

The three clusters do not operate in isolation — several keywords sit at the boundaries between them, linking what might otherwise appear as separate research concerns. The interaction among the three conceptual domains was analyzed through the co-occurrence network and the bridging keywords presented in Table 2. As shown in Figure 5, several keywords connect the domains of technology-enhanced mathematics pedagogy, instructional practices, and cognitive–psychological factors.

Table 2 shows the nine bridging keywords identified in the analysis, along with their occurrence frequency, Total Link Strength (TLS), cluster membership, and cross-cluster role. The two keywords with the highest TLS values are mathematics education (TLS = 2,516) and problem solving (TLS = 2,539), both of which connect across all three conceptual clusters. Learning (TLS = 1,578), thinking skills (TLS = 1,453), and cognition (TLS = 1,304) follow, reflecting the centrality of cognitive processes in bridging the pedagogical and technological domains. Motivation and student engagement, while lower in TLS, connect the technology-enhanced pedagogy cluster with the broader network, highlighting the affective dimension of students' acceptance. On top of that, achievement and technology serve more localized bridging roles, linking specific pairs

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of clusters rather than spanning all three. Together, these nine keywords map the conceptual connections that hold the three domains in relation to one another.

In particular, problem-solving appears as a major bridging concept linking the instructional domain with both the technology-enhanced and cognitive–psychological domains. It connects pedagogical terms, such as mathematics education and thinking skills, with cognitive-related terms, including learning, cognition, and achievement. In addition, motivation and student engagement connect technology-enhanced learning environments with instructional practices, while learning, cognition, and achievement highlight the link between instructional strategies and cognitive outcomes. The findings show that the interaction among the three domains is primarily mediated by problem solving, motivation, learning, and student engagement, which collectively shape students' acceptance of mathematics learning environments.

Table 2. Bridging Keywords

No	Keyword	Occurance	TLS	Cluster	Role
1	Mathematic Education	496	2516	2	Connected in 3 clusters
2	Problem Solving	335	2539	2	Connected in 3 clusters
3	Learning	149	1578	3	Connected in 3 clusters
4	Thinking Skill	156	1453	2	Connected with Cognitive–Psychological Domain
5	Cognition	106	1304	3	Connected in 3 clusters
6	Motivation	140	946	1	Connected in 3 clusters
7	Achievement	32	352	3	Conntected with Student-Centered & Technology-Enhanced Learning
8	Student engagement	37	164	1	Connected in 3 clusters
9	Technology	36	171	1	Connected with Mathematics Pedagogy

Figure 5 visualizes the keyword co-occurrence network with particular emphasis on the bridging role of problem solving. In the network, problem solving occupies a central position, with edges extending into all three clusters, connecting pedagogical terms such as mathematics education and thinking skills in the green cluster, affective and technological terms such as motivation and educational technology in the red cluster, and cognitive terms such as cognition, learning, and achievement in the blue cluster. The connecting edges' thickness shows the co-occurrence strength, where the thickest edges connect problem-solving to the pedagogical and cognitive clusters. This visual pattern corroborates the findings of Table 2 and shows the role of problem solving as the foremost conceptual bridge across the three domains of the students' acceptance in technology-enhanced mathematics learning.

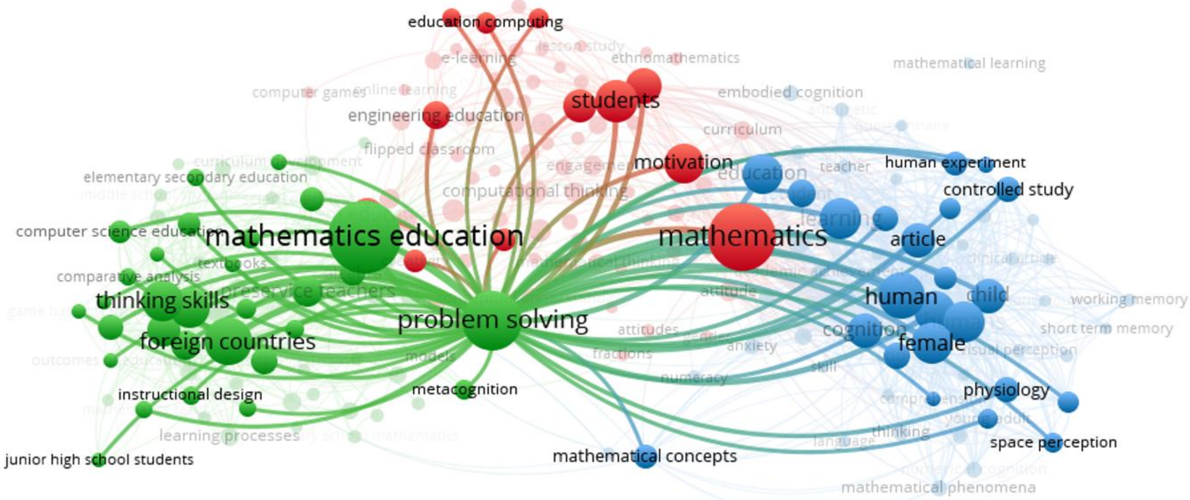

Figure 5. Interaction Through Problem Solving

The findings show that students' acceptance of mathematics learning environments is shaped by the interaction among pedagogical strategies, technological integration, and cognitive–psychological factors. First, the prominent role of problem solving indicates that instructional practices function as a key link between pedagogical design and students' cognitive development. As one of the strongest bridging keywords, problem solving connects pedagogical and cognitive domains, suggesting that instructional approaches emphasizing reasoning, conceptual understanding, and higher-order thinking is able to support meaningful mathematics learning (National Council of Teachers of Mathematics, 2000; Polya, 1957; Rahmawatiningrum et al., 2019; Schoenfeld, 1985). In addition, the role of cognitive processes identified in this study is supported by research indicating that AI-based tools, such as ChatGPT and Photomath, can improve students' problem-solving ability (Fadila et al., 2025) and support error reflection in mathematics learning (Uripno et al., 2024).

Second, the emergence of motivation and student engagement as bridging keywords highlights the importance of affective factors in technology-enhanced mathematics learning. Digital technologies are increasingly used to create interactive and engaging learning experiences in mathematics education (Borba et al., 2016; Drijvers, 2015; Sinaj & Xhabafti, 2025). When integrated through collaborative, interactive, or gamified activities, these tools may strengthen students' motivation and participation, which in turn support their acceptance of technology-enhanced learning (Fadda et al., 2022; Sinaj & Xhabafti, 2025). As indicated by the network structure, these affective responses appear to mediate the relationship between technology-enhanced pedagogy and students' acceptance of mathematics learning.

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Third, the strong links among learning, cognition, and achievement emphasize the role of cognitive processes in shaping learning outcomes. Mathematics learning requires instructional support for working memory, attention, and conceptual understanding (Baddeley & Hitch, 1974; Fuchs et al., 2019; Geary, 2011; Sweller, 1988). In this regard, cognitive processes appear to function as an important mechanism through which pedagogical practices and technological tools influence students' learning performance.

Overall, these findings indicate that students' acceptance of technology-enhanced mathematics learning cannot be explained by technology alone. Rather, it is shaped by the interaction of pedagogical design, affective responses, and cognitive learning processes. Therefore, mathematics learning environments are more likely to be effective when technology integration is supported by problem-solving activities, student motivation, and cognitive engagement.

The identification of bridging keywords also provides a more detailed explanation of how these domains are conceptually linked within the research landscape. In particular, the presence of problem solving, motivation, student engagement, learning, and cognition as bridging concepts highlights the novelty of this study in revealing the interactive structure underlying students' acceptance of technology-enhanced mathematics learning.

Implications for the Development of Mathematics Education Research and Practice (RQ4)

The findings imply that research on students' acceptance in mathematics learning is structured by the interaction of three major domains: technology-enhanced mathematics pedagogy, instructional practices, and cognitive–psychological factors. The network analysis further identified several bridging keywords, namely problem solving, motivation, student engagement, learning, and cognition, which connect these domains and shape the conceptual structure of the field.

Among these keywords, problem solving appears as a central concept linking pedagogical strategies with students' cognitive processes. Motivation and student engagement connect technology-enhanced learning environments with students' affective responses, while the strong links among learning, cognition, and achievement highlight the role of cognitive processes in effective mathematics learning. These findings suggest that students' acceptance of technology-enhanced mathematics learning is influenced by the combined role of pedagogy, technology, and cognitive–psychological factors.

The findings have significant implications for the development of mathematics education research and practice. From a research perspective, they highlight the need for more integrative research frameworks that combine pedagogical, technological, and psychological perspectives, since previous studies have often examined these aspects separately (Borba et al., 2016; Drijvers, 2015). Moreover, the identified network structure suggests that students' acceptance of technology-enhanced mathematics learning emerges from the interaction among these domains rather than from technological factors alone.

From a practical perspective, the central role of problem solving indicates the importance of designing technology-enhanced mathematics learning environments that support reasoning, conceptual understanding, and higher-order thinking skills of students (National Council of Teachers of Mathematics, 2000; Polya, 1957; Schoenfeld, 1985). In addition, the prominence of motivation and student engagement shows that technology integration should not focus only on functionality, but also on creating interactive and meaningful learning experiences that encourage active participation (Borba et al., 2016; Drijvers, 2015; Hillmayr et al., 2020; Sinaj & Xhabafti, 2025).

The strong connections among learning, cognition, and achievement also suggest that technology-enhanced mathematics learning should be designed in ways that support students' cognitive development, including working memory, attention, and conceptual understanding (Baddeley & Hitch, 1974; Fuchs et al., 2019; Geary, 2011; Sweller, 1988). These findings imply that the future development of mathematics education should move toward more holistic learning environments that integrate technological innovation, effective instructional strategies, and students' cognitive–psychological characteristics.

Taken together, these findings address the fragmented nature of previous studies by demonstrating that students' acceptance of technology-enhanced mathematics learning is shaped by the interaction among technological, pedagogical, and cognitive–psychological domains. A notable contribution of this study lies in identifying bridging concepts that connect these domains within the bibliometric structure of the field. This integrative perspective extends current mathematics education research by providing a more holistic understanding of the research landscape and by offering a conceptual basis for designing technology-enhanced learning environments that are pedagogically meaningful, cognitively supportive, and responsive to students' affective needs.

This study has some limitations that should be addressed. It was apparent that the analysis was performed on the Scopus database only. Scopus is a broad indexing database. However, it is still limited when compared to other databases such as Web of Science and ERIC. The study also performed keyword co-occurrence analysis. This form of analysis is useful for creating visual maps for the proximity of concepts, but not for the analysis of various arguments and the theory behind each publication. The mentioned limitations can be addressed in future studies by using multiple databases, and implementing citation-based network analyses and systematic reviews that include the study of concepts such as AI-based mathematics instruction and personalized adaptive digital learning environments.

Conclusion

The analysis of 196 keywords from 883 publications identified three major conceptual domains—technology-enhanced mathematics pedagogy, instructional practices and teacher professional development, and cognitive–psychological aspects of mathematics learning—and revealed that these domains are interconnected through five bridging concepts: problem solving, motivation, student engagement, learning, and cognition. The novelty of this study lies in mapping not only the topical structure of the field but also the conceptual bridges that link its major domains, thereby offering a more holistic framework for understanding students' acceptance in technology-enhanced mathematics learning. In this way, the study contributes to mathematics education research by offering a more holistic understanding of students' acceptance in technology-enhanced mathematics learning and by providing a conceptual basis for designing more meaningful learning environments. Nevertheless, this study is limited by its reliance on a single database and keyword-based bibliometric analysis. Future research may extend this work by incorporating multiple databases, citation-based analyses, or systematic reviews, particularly to examine emerging issues such as artificial intelligence-supported mathematics learning and adaptive digital learning environments.

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Author's Declaration

Author Contribution	:	Author 1: Conceptualization, Methodology, Data Curation, Formal Analysis, Visualization, Writing – Original Draft Author 2: Validation, Writing – Review & Editing
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Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	-

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