International Electronic Journal of Mathematics Education
2025, 20(2), em0810
e-ISSN: 1306-3030
https://www.iejme.com

MODESTUM

Research Article

OPEN ACCESS

Exploring demographic influences on digital technology integration in Chinese primary mathematics education

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Citation: Li, M., Vale, C., Tan, H., & Blannin, J. (2025). Exploring demographic influences on digital technology integration in Chinese primary mathematics education. *International Electronic Journal of Mathematics Education, 20*(2), em0810. https://doi.org/10.29333/iejme/15814

ARTICLE INFO

Received: 13 Jun. 2024

Accepted: 29 Nov. 2024

ABSTRACT

In the evolving landscape of primary mathematics education, this study investigates the impact of gender, age, teaching experience, educational background, and mathematics-specific education on the factors of integrating digital technology during the post-pandemic era in primary schools. Data from 554 primary mathematics teachers in China, were analyzed using Technological Pedagogical Readiness scale across eleven constructs with Kruskal-Wallis and Mann-Whitney *U* tests for statistical examination. Results indicate a significant difference in the Technological Pedagogical Content Knowledge (TPACK) construct based on gender, with female teachers exhibiting stronger integration. Contrary to findings from other studies, other constructs showed no substantial gender differences, suggesting an equalizing effect potentially propelled by widespread digital adaptation during the pandemic. Age and teaching experience did not present significant variations in technology integration, revealing a shift from previously understood dynamics where younger, less experienced educators were considered more technologically-inclined. Educational levels, including junior college, bachelor's degree, and master's degree, along with a mathematics-specific background, did not significantly influence digital integration, indicating a standardization of technological engagement regardless of academic specialization or mathematics background. The study's insights emphasize the necessity for inclusive professional development programs that consider these nuances and support sustained technology use in education beyond the pandemic.

Keywords: digital technology integration, primary mathematics education, TPACK, post-pandemic education practices, demographic influences in education

INTRODUCTION

In primary mathematics education, integrating digital technology is not merely a contemporary trend but a pivotal shift in pedagogical strategies that fundamentally transform teaching and learning (Drijvers et al., 2018). The impetus for technology integration in education is increasingly recognized, with research underscoring its potential to improve learning outcomes, create interactive and personalized learning environments, and equip students for a future in a technologically sophisticated society (Blannin, 2022; Ertmer & Ottenbreit-Leftwich, 2010; Selwyn, 2021). The integration of digital tools in teaching is particularly pertinent in China, where educational policies and initiatives increasingly advocate for the integration of digital tools in teaching to enhance the quality of education and foster innovation in learning methodologies, particularly after the COVID-19 pandemic impacted on in-person teaching (Li, 2022; Yao & Zhao, 2022). In primary mathematics education, digital technologies offer varied and dynamic representations of mathematical concepts, instrumental in enhancing students' understanding and problem-solving abilities (Alneyadi et al., 2023; Clements & Sarama, 2013). However, integrating such digital technologies in Chinese classrooms is influenced by unique demographic, cultural, educational, and infrastructure contexts that shape the adoption and utilization of digital resources in mathematics education. Understanding these contextual factors (CFs) is crucial for effectively leveraging technology to improve mathematics teaching and learning in Chinese primary schools.

The integration of technology in education is not a uniform or straightforward process. Previous studies found that technology integration in classroom teaching is influenced by various factors, including gender, age, teaching experience, and educational background, which can significantly affect teachers' abilities and willingness to integrate technology into their teaching practices (Li, 2023; Ottenbreit-Leftwich et al., 2010; Özgür, 2020). Gender differences, for instance, have been observed in teachers' self-efficacy and attitudes toward technology use in the classroom, suggesting that female and male teachers may experience and interact with technology in distinct ways that influence their teaching (Koh et al., 2010). Age and teaching experience also play a critical role in technology integration (da Silva Bueno & Niess, 2023). For example, younger teachers and those with fewer years of teaching experience are often perceived as more adept at and receptive to the use of digital technology in their teaching (DeCoito & Estaiteyeh, 2022). Educational background is another critical aspect, as teachers' formal training and exposure to technologyrich environments can significantly influence their proficiency and confidence in integrating technology into their teaching practices (Inan & Lowther, 2010). Teachers with a background in educational technology (Lawless & Pellegrino, 2007) or those who have received comprehensive professional development (PD) (Aguilar & Kang, 2023) in this area are more likely to effectively incorporate technology into their classrooms.

The integration of digital technology in primary mathematics education in China has garnered significant attention from educators, policymakers, and researchers, particularly in the post-pandemic era. The rapid shift to online and hybrid learning models during the pandemic has accelerated the adoption of digital technologies in education, highlighting the need to comprehend the nuanced effects of this transition. As educators navigate the integration of these technologies, they are dealing with a transitioning educational landscape characterized by evolving pedagogical approaches, shifting student expectations, and the ongoing adaptation to a blend of in-person and remote learning modalities (Yao & Zhao, 2022). However, there remains a notable gap in the literature regarding the collective impact of gender, age, teaching experience, and educational background on this integration. Recognizing the critical role of these demographic factors is essential for tailoring effective technology integration strategies. This study seeks to bridge this gap by examining how these factors influence teachers' competencies and attitudes toward technology integration, employing two pivotal frameworks: the technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006) and the technology acceptance model (TAM) (Davis, 1989). The TPACK framework is foundational to understanding the integration of digital technology in education, as it emphasizes the interplay of teachers' technological, pedagogical, and content knowledge (CK), highlighting that effective digital technology use in teaching requires a nuanced understanding of these components, tailored to specific educational contexts (Mishra & Koehler, 2006; Mishra et al., 2023; Niess, 2016). Complementing TPACK, TAM provides insights into the psychological aspects of technology adoption. It focuses on teachers' perceived usefulness (PU) and perceived ease of use (PEoU) of technological tools, which is seen as critical to their intentions to integrate them into their teaching practices (Davis, 1989).

By using these frameworks in the context of China's primary mathematics education, this research aims to uncover how demographic variables shape teachers' technology integration practices and attitudes. Such insights are crucial for developing targeted PD and policy strategies to enhance appropriate digital technology use in mathematics teaching, addressing the unique challenges and opportunities in the Chinese educational landscape. Also, this study strives to enrich the current understanding of primary mathematics education by delving into the intricate interplay of gender, age, teaching experience, and educational background on teachers' TPACK and attitudes toward technology integration in the post-pandemic era. This examination aims to unveil valuable insights that can bolster the effective integration of technology in mathematics instruction, thereby enhancing teaching effectiveness and student engagement. To achieve the research goal, the key research question was:

1. How do gender, age, teaching experience, and educational background influence primary mathematics teachers' TPACK and attitudes toward technology integration in primary mathematics education?

LITERATURE REVIEW

Technological Pedagogical Content Knowledge

Developed by Mishra and Koehler (2006), the TPACK framework delineates the complex interplay between three primary forms of knowledge: CK, pedagogy knowledge (PK), and technology knowledge (TK). Central to this framework is the notion that effective technology integration in education requires an intricate synthesis of these knowledge types, forming TPACK (Niess, 2016). TPACK guides educators to integrate technology in a manner that is pedagogically sound and content-specific, enhancing the learning experience (Akyuz, 2023; Hansen et al., 2016). The framework consists of seven components: CK, PK, TK, pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and the intersection of all three, TPACK. Each component plays a crucial role in how educators understand and implement technology in their teaching practices.

Porras-Hernández and Salinas-Amescua (2013) have contributed a substantial critique to the TPACK framework by highlighting its lack of explicit attention to contextual knowledge (XK). To address this shortfall, they expanded upon the original framework, drawing from Bronfenbrenner's ecological systems theory (Bronfenbrenner, 1979) to articulate the importance of context at multiple environmental levels. In their enhanced model, they incorporate a layered perspective of context: at the micro-level, they focus on the individual classroom and the immediate teaching environment; at the meso-level, attention shifts to encompass school-wide practices and collaborative efforts among educators; and at the macro-level, the framework extends to include the influence of overarching educational policies and broader societal factors. This multi-tiered approach is seen to provide a more comprehensive understanding of the environment in which technology integration takes place within the field of education (see **Figure 1**).

In this study, the TPACK framework is employed to explore not only the technological facets of educators' knowledge, TK, TPK, TCK, and TPACK, but also the influence of XK. Following Mishra et al. (2023), this investigation gives attention to how these components, in conjunction with environmental factors encapsulated by XK, interact with demographic factors such as gender, age, teaching experience, and educational background. These components collectively are pivotal in comprehending how teachers can effectively integrate digital technology into mathematics education. XK encompasses the broader environmental context within which technology integration occurs, including institutional, cultural, and policy-related dimensions, and thus provides a vital perspective for understanding the complexities of technology adoption in mathematics education (Li & Li, 2024).

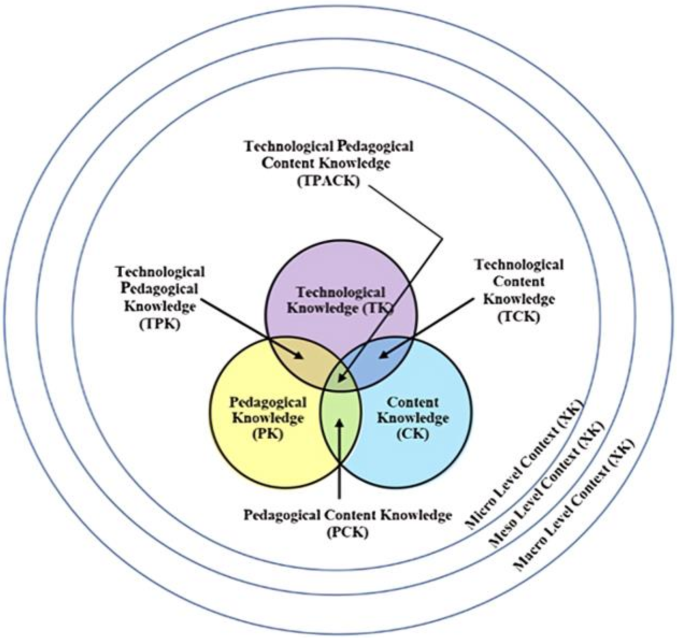

Figure 1. Self-created diagram based on the TPACK theory (Mishra & Koehler, 2006; Porras-Hernández & Salinas-Amescua, 2013)

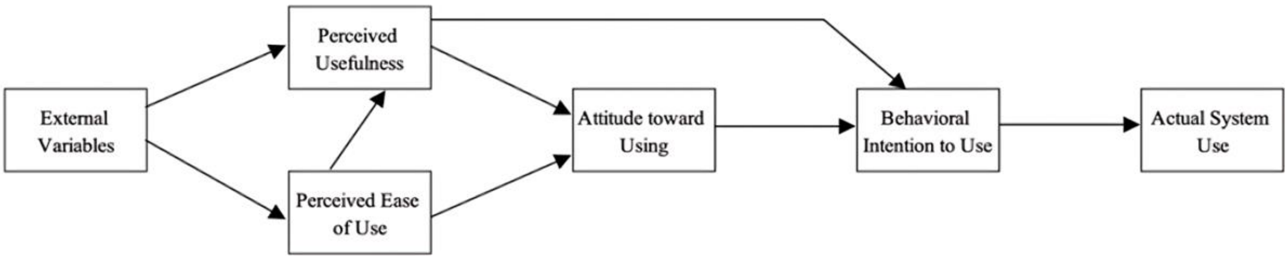

Figure 2. TAM (Davis et al., 1989)

Technology Acceptance Model

Introduced by Davis (1989), TAM is predicated on the belief that two specific beliefs, PU and PEoU, significantly influence an individual's decision to accept and use technology (see **Figure 2**). In the educational context, TAM has been employed to understand teachers' motivations and barriers to adopting digital technology in their teaching practices (Gurer & Akkaya, 2022; Holden & Rada, 2011). TAM's core assertion is that if educators find technology useful and easy to use, they are more likely to embrace it within their instructional practices. Numerous studies have employed TAM to explore various educational technologies' acceptance, finding that teachers' perceptions of usefulness and ease of use can significantly predict their technology integration behaviors (Gurer, 2021; Ibili et al., 2019; Teo et al., 2008). Linking TAM with demographic factors like gender, age, teaching experience, and educational background may therefore provide insights into different groups' technology acceptance patterns.

Theoretical Justification for Studying Technology Integration

The TPACK and TAM frameworks are suited to investigating the research questions posed in this study due to their comprehensive approach to dissecting the elements essential for effective technology integration in education. TPACK provides a holistic perspective on the necessary competencies educators need to integrate digital technology effectively, emphasizing the intersection of TK, PK, and CK (Li et al., 2024a; Mishra, 2019; Niess, 2011). TPACK's emphasis on the synergy between different types of knowledge resonates with the study's focus on how various factors, such as age, gender, teaching experience, and educational background, interact to shape a teacher's ability to integrate technology. Hence, TPACK serves as a valuable analytical framework that facilitates an in-depth exploration of the interplay between demographic factors and different components of TPACK. By utilizing TPACK, educators and researchers can gain a comprehensive understanding of the competencies necessary for effective technology integration, and this approach allows for a nuanced examination of how various demographic characteristics influence teachers' knowledge and skills in integrating technology with pedagogy and content (Jang & Tsai, 2012; Saltan et al., 2017).

TAM complements TPACK by offering insights into the attitudinal aspects of technology integration. While TPACK focuses on what educators need to know to integrate technology effectively, TAM delves into why they might choose to embrace or reject technological tools (Khong et al., 2023). By examining PU and PEoU, TAM sheds light on the underlying attitudes that influence teachers' decisions to adopt digital technology, which is crucial for understanding the full spectrum of factors impacting technology integration in mathematics education (Teo & Van Schalk, 2009). Together, TPACK and TAM provide a multifaceted lens through which to examine the complexities of technology integration, addressing both the ‘how’ and the ‘why’ of mathematics teachers’ engagement with digital tools (Çeşme & Çimen, 2023; Khong et al., 2023). This dual-framework approach enables a comprehensive investigation of the research questions, exploring not only the competencies mathematics teachers need to integrate technology effectively but also the attitudes that might facilitate or hinder this process. Thus, employing TPACK and TAM in tandem offers a robust theoretical foundation for understanding the multifaceted nature of technology integration in primary mathematics education.

Impact of Demographic Factors on Technology Integration in Primary Mathematics Education

The integration of digital technology in primary mathematics education has emerged as a critical area of research, reflecting broader shifts towards digitalization in educational practices (Dogan, 2012; Teo et al., 2017). The synthesis of existing literature suggests a complex landscape where demographic factors such as gender, age, teaching experience, and educational background are increasingly recognized by researchers as potentially significant in shaping the outcomes of technology integration in education. This review highlights key findings in these areas, underpinned by the TPACK and TAM frameworks, which have significantly contributed to the understanding of technology integration in education.

Gender impact on technology integration

In the realm of primary mathematics education, the influence of gender on technology integration has been a focal point of scholarly investigation (Koh et al., 2014; Ozudogru & Ozudogru, 2019; Vale & Leder, 2004). Initially, some studies have underscored gender differences, with findings indicating that female teachers might demonstrate lower self-efficacy in utilizing technology compared to their male counterparts, potentially affecting their readiness and attitudes in integrating digital technology within their pedagogical practices (Koh et al., 2010; Van Braak et al., 2004). This line of research suggests that gender plays a significant role in shaping educators’ interactions with digital tools. However, this viewpoint is not universally accepted, as other research challenges the notion of a clear-cut gender divide. For instance, Li (2023) contended that when investigating primary mathematics teachers’ TPACK and attitudes towards technology integration in China, the apparent gender gap in technology integration tends to narrow, or in some cases, vanish entirely. This discrepancy raises questions about the consistency of gender impact across different contexts, suggesting that external factors such as geographic location, demographic characteristics, and institutional support may also play influential roles in mediating the impact of gender and technology use in education.

The contrasting findings in the literature signal a research gap, pointing to the need for more nuanced investigations that consider a broader range of influencing factors. Understanding whether the perceived impact of gender differences are a universal phenomenon or contextually bound can offer deeper insights into the complexities of technology integration in education, guiding more effective, tailored strategies to support educators, irrespective of their gender.

Age and teaching experience impact on technology integration

In the domain of primary mathematics education, age and teaching experience are recognized as critical factors influencing the integration of digital technology in teaching and learning (Long et al., 2020). The research suggests that factors such as age and teaching experience may differentially influence educators’ willingness or capacity to adopt digital tools in different contexts (Ozudogru & Ozudogru, 2019).

Extensive research has delved into the relationship between teaching experience and technology integration, revealing that novice teachers often bring a fresh perspective and a willingness to embrace new technologies (Tondeur et al., 2017). Their enthusiasm is frequently driven by recent exposure to technology in teacher education programs, which highlights the importance of modern pedagogical strategies (Knezek & Christensen, 2016). Additionally, age, as a related but distinct factor, has also been a focus of research, with studies frequently pointing out that younger educators tend to have a more positive attitude towards the adoption of digital technologies in teaching and learning (DeCoito & Estaiteyeh, 2022). However, in the aftermath of the pandemic, the dynamics of technology adoption may have shifted. The rapid and necessary adoption of technology in China during the pandemic has forced Chinese teachers of all ages and levels of experience to integrate digital tools into their teaching, potentially altering previous patterns of technology use (Torry & Whalen, 2020). As a result, whether the correlations between age, teaching experience, and technology integration observed in pre-pandemic studies hold true in the current educational landscape remains an open question. It can be said that the dearth of substantial post-pandemic research on these interrelations constitutes a significant gap in the literature.

Educational background impact on technology integration

The educational background of teachers emerges as a pivotal factor in literature concerning the integration of technology in mathematics classrooms (Chen, 2015). Research in educational technology integration reveals differing viewpoints on the influence of formal educational levels. Long et al. (2020) presents evidence that higher educational attainment is associated with more sophisticated and effective use of technology in the classroom, suggesting that educators with higher degrees may have a more comprehensive understanding of how to blend technological tools with pedagogy. This correlation is posited to arise from the advanced critical thinking and learning strategies cultivated through prolonged academic study. Contrasting with this, however, are the findings of DeCoito and Estaiteyeh (2022), who contend that having a higher level of education does not necessarily translate to an increased or more innovative integration of technology. Their research suggests that factors such as access to resources, support systems, and personal attitudes towards technology can be more telling predictors of a teacher’s propensity to integrate digital tools than their level of formal education alone. These disparate findings signal a need for further exploration into the interplay between educators’ formal education and their practical application of technology in the classroom, especially in varied cultural and institutional contexts such as those found in China.

Delving into the complexities of technology integration within Chinese primary mathematics education, one finds a distinctive landscape: a considerable percentage of mathematics teachers come from other academic backgrounds, not exclusively from mathematics. This varied academic origin introduces a multifaceted dimension to their approach to integrating technology in their teaching. This diversity raises critical questions: Could a teacher's original field of study influence their efficacy and approach to integrating technology in mathematics education? Does a background in a technology-related field confer an advantage in this integration, or do the pedagogical skills developed through a mathematics-focused teacher education experience play a more decisive role? For instance, a teacher with an English background might approach the use of digital technology from a language enhancement perspective, utilizing tools that aid in communication and presentation within the mathematics context. Conversely, a teacher with a background in Information Technology might be more adept at employing software and online resources to create interactive learning experiences for students (Lawless & Pellegrino, 2007).

Despite these scenarios, the specific impact of non-mathematics teaching degrees on the integration of technology in mathematics instruction has not been systematically investigated, particularly within the unique context of the Chinese primary education system. This gap in research points to the need for studies that not only track the academic trajectories of mathematics teachers but also examine how these varied backgrounds might inform or impede the incorporation of digital tools in the classroom.

METHOD

Research Design

Within the context of a mixed-methods PhD program, this study employs a quantitative research design as a follow-up to an initial qualitative phase. By using a quantitative approach, this segment of the project aims to systematically examine the associations between demographic variables (e.g., gender, age, teaching experience, and educational background) and factors of technology integration within primary mathematics education.

The rationale for adopting a quantitative methodology in this phase rests on the capacity of statistical analysis to provide empirical evidence about the strength and direction of relationships between variables. Unlike qualitative data, which offers depth and context, quantitative data allows for the determination of the prevalence of traits and behaviors among a larger population (Creswell & Plano Clark, 2018). Through the utilization of a web-based questionnaire, this study gathered numerical data that allowed for robust statistical analysis. Such an approach enabled the researchers to identify significant patterns and relationships between demographic factors and technology integration and to assess the potential generalizability of these findings to the broader population of primary mathematics educators (Bryman, 2016). Furthermore, quantitative methods are particularly apt for testing the hypotheses derived from the qualitative phase. It is possible to measure the degree to which demographic variables predict technology integration practices, hence enabling the formulation of models that could guide future interventions (Johnson & Onwuegbuzie, 2004). This phase of research, therefore, builds upon the exploratory insights gained from the qualitative analysis, aiming to validate and extend these findings across a broader population (Creswell & Creswell, 2017).

Participants

The participant cohort in this study is composed of primary mathematics teachers from 46 schools across the Chongqing region of China. Chongqing's primary education system spans six grades, and the teachers in this sample teach across the full range of these grades, from grade one through grade six. The selection criteria for participants were structured to capture a diverse representation of primary mathematics teachers in terms of gender, age, teaching experience, and educational background. The sample of primary mathematics teachers was selected through stratified sampling with the cooperation of the Chongqing Education Commission, ensuring diverse representation across the region's schools. The resulting demographic profile of the sample is detailed in **Table 1**.

Table 1. Demographic information

Category	Subcategory	Frequency	Percentage (%)	Valid percentage (%)	Cumulative percentage (%)
Gender	Female	406	73.30	73.30	73.30
	Male	148	26.70	26.70	100
Age	20-29	123	22.20	22.20	22.20
	30-39	185	33.40	33.40	55.60
	40-49	162	29.20	29.20	84.80
	≥ 50	84	15.20	15.20	100
Teaching experience	0-5	89	16.10	16.10	16.10
	6-10	174	31.40	31.40	47.50
	11-15	107	19.30	19.30	66.80
	> 15	184	33.20	33.20	100
Education background	Junior college	105	19.00	19.00	19.00
	Bachelor's degree	387	69.90	69.90	88.80
	Master's degree	62	11.10	11.10	100
Mathematics background	Yes	334	60.30	60.30	60.30
	No	220	39.70	39.70	100
Total		554	100	100	

The participant sample's gender composition reflected the typical gender distribution in Chinese primary schools, with a predominance of female teachers (73.30%, *n* = 406) compared to male colleagues (26.70%, *n* = 148). Regarding age, the sample was distributed across four brackets. Those aged between 20 to 29 years constituted 22.20% of the sample, with 123 teachers. The 30-39 age group was the largest, with 185 teachers representing 33.40% of the sample. Teachers between the ages of 40 to 49 made up 29.20%, numbering 162, while those 50 years and older accounted for 15.20% with 84 teachers. In terms of teaching experience, the sample was equally diverse. Teachers with 0-5 years of experience made up 16.10% of the respondents (89 teachers). Those with 6-10 years of experience were the largest group, accounting for 31.40% (174 teachers). The 11-15 years of experience bracket comprised 19.30% of the sample, with 107 teachers. Finally, teachers with over 15 years of experience represented a significant portion, 33.20% (184 teachers). The educational background of participants varied from junior college degrees to master's degrees. Those holding junior college degrees accounted for 19% of the sample (105 teachers), bachelor's degree holders were the majority at 69.90% (387 teachers), and those with master's degrees formed 11.20% of the sample (62 teachers). Notably, the sample included teachers with both mathematics and non-mathematics academic backgrounds. A total of 334 teachers (60.30%) reported having a background in mathematics, while 220 (39.70%) indicated they did not specialize in mathematics.

The participant sample's diversity aligns well with the demographic landscape of primary school educators in China, encompassing a range of genders, ages, teaching experiences, and educational backgrounds. This variety mirrors the broader population of primary school teachers, offering a solid foundation for addressing the research questions and enhancing the generalizability of the study's findings.

Instrument

In this study, we designed and validated the technological pedagogical readiness (TPR) scale (see **Table 2**), an instrument aimed at assessing the readiness for technology integration among primary mathematics teachers in China. Based on the TPACK and TAM frameworks, the TPR scale incorporates 11 constructs. The validation process for the TPR scale is documented in Li et al. (2024b).

Table 2. Instrument information

Construct	Item number	Explanation
TPACK	4	Items relating to the integration of technology, pedagogy, and content knowledge.
TPK	3	Items focused on the knowledge of how to use digital technology to support pedagogical practices.
TCK	3	Items assessing the ability to apply digital technology specifically to teach content knowledge in mathematics.
PU	4	Items measuring the perceived usefulness of technology in enhancing mathematics instruction.
PEoU	4	Items evaluating how easy and user-friendly technology is perceived to be by educators.
TK	5	Items concerning beliefs about the role of technology in teaching and learning.
PD	4	Items reflecting on the impact of PD in the use of digital technologies.
CFs	5	Items examining CFs such as resources and school leadership support.
Educational challenges (ECs)	6	Items assessing factors influencing the adoption of technology, including standardized testing and school culture.
Students' technology literacy (STL)	5	Items related to teachers' perspective on students' technological literacy and their ability to use digital technologies for learning mathematics.
Parental and community involvement (PCI)	4	Items exploring the role of PCI in technology integration.

Data collected from 554 teachers through an online survey were subjected to rigorous analysis to validate the structure of the TPR scale. Exploratory factor analysis (EFA) revealed strong factor loadings, ranging from 0.771 to 0.899, which underscore each item's precise alignment with its intended construct (Field, 2013). Additionally, the scale demonstrated high internal consistency, with Cronbach's alpha coefficients ranging from 0.917 to 0.840 across the constructs. These coefficients indicate a high level of reliability in the scale items, ensuring that they are consistent measures of the underlying constructs and providing confidence in the scale's capacity to yield dependable and coherent results for further inferential analysis in this research domain (Cronbach, 1951). The subsequent confirmatory factor analysis (CFA) provided encouraging model fit indices: RMSEA at 0.014, SRMR at 0.027, GFI at 0.924, AGFI at 0.913, NFI at 0.935, CFI at 0.993, and TLI at 0.992. These indices collectively signify a good fit, affirming the scale's structural integrity and the validity of its constructs (Byrne, 2016).

This methodical validation process, encompassing both EFA and CFA, establishes the TPR scale as a comprehensive tool for assessing TPR across 11 distinct constructs (DeVellis, 2017; Hair et al., 2018). The scale's robust validation ensures its effectiveness for subsequent inferential analysis, making it a reliable instrument for examining technology integration's nuanced dynamics in educational settings. The alignment of the scale with the study's objectives enhances its relevance and utility in providing insightful data for this research, aiding in the exploration of how various factors influence technology integration among primary mathematics teachers.

Data Collection

Data gathering for this research was executed through an online survey distributed among a stratified random selection of primary mathematics educators throughout Chongqing, China. Distributed via the popular Chinese social media platform WeChat, chosen for its widespread accessibility and user-friendliness, the online survey included the questions from the TPR scale alongside demographic inquiries, all structured on a 5-point Likert scale (Boone & Boone, 2012). The distribution and outreach were significantly supported by the Chongqing Education Commission, whose support ensured the survey reached a broad audience within the targeted schools. Ensuring ethical processes were met, teacher participation was entirely voluntary, underscored by a detailed informed consent process (Cohen et al., 2018) that clearly communicated the study's intent and their involvement, aligning with approved ethical guidelines. A strategic promotional campaign via social media (WeChat) outlined the study's objectives and importance, encouraging participation. The survey was available for two months, providing educators with ample time to respond at their convenience, a strategy aimed at enhancing response rates and ensuring data quality.

Data Analysis

The data analysis for this study was structured to examine the data gathered from the online survey, utilizing a suite of statistical methods tailored to the data's characteristics. Given the nature of the collected data, which may not adhere to the normal distribution required for parametric testing, non-parametric tests have been chosen for their robustness and flexibility in handling such data (Ho, 2013).

To explore the differences between two independent groups, such as comparing responses from male and female teachers, the Mann-Whitney *U* test was employed. This test is particularly suitable for ordinal data or non-normally distributed interval data, providing a reliable method to discern any significant disparities between two distinct groups without the assumption of normality (Field, 2013). For analyzing differences among more than two groups, such as comparing various age brackets or levels of teaching experience, the Kruskal-Wallis test will be utilized. This test extends the functionality of the Mann-Whitney *U* test to multiple groups, offering a non-parametric alternative to the one-way ANOVA without the need for normal distribution or equal variances among the groups (Field, 2013). These non-parametric tests are particularly advantageous in the field of social sciences and education research, where data often deviates from normal distribution (Cohen et al., 2018). Their selection ensures that the study's findings are valid and reliable, notwithstanding the potential violation of the normality assumption in the data from mathematics teachers in Chongqing, China.

FINDINGS

Gender

The analysis of gender differences in the context of technology integration in mathematics education, as measured by the TPR scale, yielded varied results across different constructs. The Mann-Whitney *U* test was employed to assess the disparities between female and male teachers (see **Table 3**). For the TPACK construct, a significant difference was observed between genders, with female teachers (N = 406) having a mean rank of 285.65 and male teachers (N = 148) a mean rank of 255.14, resulting in a U value of 26735 and a Z score of -1.991. The asymptotic significance (2-tailed) was 0.046, and the effect size (r) was -0.085, suggesting a small but significant gender difference favoring female teachers in their TPACK integration.

Table 3. Mann-Whitney *U* test results on gender differences

	Gender	N	Mean rank	Sum of ranks	Mann-Whitney U	Wilcoxon W	Z	Asymptotic Sig. (2-tailed)	$r = \frac{Z}{\sqrt{n}}$
TPACK	Female	406	285.65	115,974.0	26,735.0	37,761.0	-1.991	0.046	-0.085
	Male	148	255.14	37,761.0					
	Total	554							
TPK	Female	406	279.46	113,461.0	29,248.0	40,274.0	-0.480	0.631	
	Male	148	272.12	40,274.0					
	Total	554							
TCK	Female	406	279.65	113,536.5	29,172.5	40,198.5	-0.526	0.599	
	Male	148	271.61	40,198.5					
	Total	554							
PU	Female	406	270.08	109,653.5	27,032.5	109,653.5	-1.811	0.070	
	Male	148	297.85	44,081.5					
	Total	554							
PEoU	Female	406	277.27	112,571.5	29,950.5	112,571.5	-0.056	0.955	
	Male	148	278.13	41,163.5					
	Total	554							
TK	Female	406	279.77	113,587.0	29,122.0	40,148.0	-0.554	0.579	
	Male	148	271.27	40,148.0					
	Total	554							
PD	Female	406	273.25	110,941.0	28,320.0	110,941.0	-1.037	0.300	
	Male	148	289.15	42,794.0					
	Total	554							
CF	Female	406	283.1	114,940.0	27,769.0	38,795.0	-1.367	0.172	
	Male	148	262.13	38,795.0					
	Total	554							
EC	Female	406	276.79	112,378.5	29,757.5	112,378.5	-0.172	0.863	
	Male	148	279.44	41,356.5					
	Total	554							

Table 3 (Continued). Mann-Whitney *U* test results on gender differences

	Gender	*N*	Mean rank	Sum of ranks	Mann-Whitney *U*	Wilcoxon *W*	*Z*	Asymptotic Sig. (2-tailed)	$r = \frac{Z}{\sqrt{n}}$
STL	Female	406	280.73	113,977.5	28731.5	39,757.5	-0.789	0.430	
	Male	148	268.63	39,757.5					
	Total	554							
PCI	Female	406	275.86	111,998.5	29,377.5	111,998.5	-0.401	0.688	
	Male	148	282.00	41,736.5					
	Total	554							

However, for other constructs such as TPK, TCK, PU, PEoU, TK, PD, CF, EC, STL, and PCI, no significant gender differences were found, as indicated by the higher *p*-values (all above the 0.05 threshold). For instance, in TPK, the mean ranks were 279.46 for females and 272.12 for males, with a *Z* score of -0.48 and a *p*-value of 0.631. Similarly, for TCK, the mean ranks were 279.65 for females and 271.61 for males, with a *Z* score of -0.526 and a *p*-value of 0.599. This suggests that, except for TPACK, there are no significant gender-based differences in how male and female teachers perceive and integrate various aspects of digital technology within their mathematics teaching practices.

Therefore, the results from the investigation into gender differences provide clear insights into the impact of gender on technology integration in mathematics education. Specifically, the data indicates that gender has a significant effect on the TPACK aspect, with female teachers showing stronger integration than their male counterparts. However, it's important to note that the $r = -0.085$ is small, suggesting that while the difference is statistically significant, the magnitude of this gender disparity in TPACK integration is modest. For the other constructs, the findings reveal no substantial gender-based differences.

Age

The analysis of age differences among primary mathematics teachers regarding technology integration, as reflected by various constructs of the TPR scale, was conducted using the Kruskal-Wallis *H* test (see **Table 4**). The results across multiple constructs, including TPACK, TPK, TCK, PU, PEoU, TK, PD, CF, EC, STL, and PCI, do not indicate significant differences based on age groups. The Kruskal-Wallis *H* results varied across the constructs with the highest observed in PU (6.083) and the lowest in PEoU (0.307). Despite the range in these values, the asymptotic significance levels for all constructs exceeded the 0.05 threshold, with values such as 0.892 for TPACK, 0.893 for TPK, and 0.764 for TCK, suggesting that there are no statistically significant differences in technology integration across different age brackets within this sample. The absence of marked age-related disparities in technology integration indicates that within the context of this study's sample, age is not a key determinant in technology adoption and use among primary mathematics teachers in Chongqing. This uniformity in response, irrespective of age, suggests that the selected sample may well represent the broader trends in technology integration among the larger population of primary educators, which points to a generational convergence in the use of educational technology in the post-pandemic teaching landscape.

Table 4. Kruskal-Wallis *H* test results on age differences

	TPACK	TPK	TCK	PU	PEoU	TK	PD	CF	EC	STL	PCI
Kruskal-Wallis *H*	0.621	0.616	1.155	6.083	0.307	3.174	0.588	0.481	0.697	2.512	1.031
df	3	3	3	3	3	3	3	3	3	3	3
Asymptotic Sig.	0.892	0.893	0.764	0.108	0.959	0.366	0.899	0.923	0.874	0.473	0.794

Teaching Experience

The investigation into the impact of teaching experience on technology integration among primary mathematics teachers was conducted using the Kruskal-Wallis *H* test, with further analysis on PU using the Mann-Whitney *U* test due to significant findings. In **Table 5**, the Kruskal-Wallis *H* test results for teaching experience across various constructs show that only PU presents a significant difference ($p = 0.027$) among different teaching experience groups. This indicates that teachers' perceptions of the usefulness of technology in enhancing mathematics instruction vary with their years of teaching experience.

Table 5. Kruskal-Wallis *H* test results on teaching experience

	TPACK	TPK	TCK	PU	PEoU	TK	PD	CF	EC	STL	PCI
Kruskal-Wallis *H*	2.367	3.783	3.271	9.16	5.322	2.259	3.699	2.558	0.771	0.34	2.175
Df	3	3	3	3	3	3	3	3	3	3	3
Asymptotic Sig.	0.5	0.286	0.352	**0.027**	0.15	0.52	0.296	0.465	0.856	0.952	0.537

Given this significant finding in PU, a deeper analysis was carried out, as presented in **Table 6**. This analysis delineated differences between specific teaching experience brackets. Notably, teachers with 0-5 years of experience ($N = 89$) and those with 11-15 years ($N = 107$) demonstrated significant differences in their PU, with a *p*-value of 0.004 and an *r* of -0.206, indicating a medium *r* according to Cohen's classification (Cohen et al., 2018). The finding elucidates that less experienced teachers (0-5 years) perceive technology as more useful compared to their more experienced counterparts (11-15 years). This could imply that newer teachers are possibly more receptive to integrating digital technology in the teaching of mathematics. Additionally, a comparison between teachers with 11-15 years and those with more than 15 years of experience yielded a *p*-value of 0.036 and an *r* of -0.123, suggesting a small *r*. The finding suggests that teachers with more than 15 years of experience perceive technology as marginally more useful for teaching mathematics than those with 11-15 years of experience, as evidenced by the significant *p*-value of 0.036

and a small *r* of -0.123. This suggests a subtle yet statistically significant variation in perception based on the length of teaching experience. While one might expect less experienced teachers to be more inclined towards technology integration, the data reveals a complex relationship where even more seasoned educators recognize the benefits of digital tools, although the difference in perception is minimal. This nuanced finding emphasizes the importance of considering the entire spectrum of teaching experience when designing and implementing PD programs focused on technology integration in mathematics education.

Table 6. Mann-Whitney *U* test results on PU

Groups	*N*	Mean rank	Sum of ranks	Mann-Whitney *U*	Wilcoxon *W*	*Z*	Asymptotic Sig. (2-tailed)	$r = \frac{Z}{\sqrt{n}}$
0-5	89	141.93	12,631.5	6,859.5	22,084.5	-1.518	0.129	
6-10	174	126.92	22,084.5					
Total	263							
0-5	89	111.27	9,903.0	3,625.0	9,403.0	-2.882	**0.004**	-0.206
11-15	107	87.88	9,403.0					
Total	196							
0-5	89	147.67	13,143.0	7,238.0	24,258.0	-1.558	0.119	
> 15	184	131.84	24,258.0					
Total	273							
6-10	174	147.80	25,716.5	8,126.5	13,904.5	-1.792	0.073	
11-15	107	129.95	13,904.5					
Total	281							
6-10	174	179.46	31,226.0	16,001.0	31,226.0	-0.007	0.994	
> 15	184	179.54	33,035.0					
Total	358							
11-15	107	132.49	14,176.0	8,398.0	14,176.0	-2.095	**0.036**	-0.123
> 15	184	153.86	28,310.0					
Total	291							

Educational Background

The analysis of the impact of primary teachers' educational background (junior college, bachelor's degree, or master's degree) on technology integration in mathematics education, specifically focusing on mathematics teachers' perspectives on CF, reveals significant variances among different educational levels. The Kruskal-Wallis *H* test results from **Table 7** show a notable difference in CF across mathematics teachers' education backgrounds, with an *H* value of 7.057 and a *p*-value of 0.029, indicating significant disparities.

Table 7. Kruskal-Wallis *H* test results on education background

	TPACK	TPK	TCK	PU	PEoU	TK	PD	CF	EC	STL	PCI
Kruskal-Wallis *H*	0.918	0.261	4.731	1.193	0.766	0.263	3.409	7.057	0.754	2.989	3.334
df	2	2	2	2	2	2	2	2	2	2	2
Asymptotic Sig.	0.632	0.878	0.094	0.551	0.682	0.877	0.182	**0.029**	0.686	0.224	0.189

To delve deeper into these differences, **Table 8** presents the results of the Mann-Whitney *U* test, comparing pairs of education groups concerning their perceptions of the CF. There were significant differences between junior college and bachelor's degree holders (U = 17572.5, p = 0.033, r = -0.096) and between junior college and master's degree holders (U = 2511.5, p = 0.014, r = -0.191). However, comparing bachelor's and master's degree holders did not yield significant results (U = 10850, p = 0.226). These findings suggest that teachers' perceptions of CFs, including aspects like institutional support, resource availability, and school culture, vary significantly based on their highest level of education. Teachers with a junior college education perceive CFs differently compared to their counterparts with bachelor's or master's degrees, suggesting that the level of educational attainment may shape educators' perspectives on the role and impact of the technological and institutional environment in their teaching practices. Specifically, the data indicates that teachers with higher educational qualifications place more emphasis on the importance of environmental factors when integrating digital technology into their classrooms. This distinction suggests that educators with more advanced degrees might have a heightened awareness or greater appreciation of how contextual elements influence their ability to leverage digital technology effectively in mathematics education.

Table 8. Mann-Whitney *U* test results on CFs

Groups	*N*	Mean rank	Sum of ranks	Mann-Whitney *U*	Wilcoxon *W*	*Z*	Asymptotic Sig. (2-tailed)	$r = \frac{Z}{\sqrt{n}}$
Junior college	105	220.36	23,137.5	17,572.5	23,137.5	-2.128	**0.033**	-0.096
Bachelor's degree	387	253.59	98,140.5					
Total	492							
Junior college	105	76.92	8,076.5	2,511.5	8,076.5	-2.467	**0.014**	-0.191
Master's degree	62	95.99	5,951.5					
Total	167							
Bachelor's degree	387	222.04	85,928.0	10,850.0	85,928.0	-1.121	0.226	
Master's degree	62	243.50	15,097.0					
Total	449							

Mathematics Education Background

The analysis of the impact of mathematics education background on the integration of digital technology was conducted using the Mann-Whitney *U* test (see **Table 9**). This test compared the perceptions of teachers with a mathematics background (group 1) to those without (group 2) across various constructs of the TPR scale.

Table 9. Mann-Whitney *U* test results on mathematics background

	Gender	*N*	Mean rank	Sum of ranks	Mann-Whitney *U*	Wilcoxon *W*	*Z*	Asymptotic Sig. (2-tailed)
TPACK	1	334	285.69	95,420.5	34,004.5	58,314.5	-1.489	0.137
	2	220	265.07	58,314.5				
	Total	554						
TPK	1	334	283.27	94,612.0	34,813.0	59,123.0	-1.050	0.294
	2	220	268.74	59,123.0				
	Total	554						
TCK	1	334	281.07	93,878.0	35,547.0	59,857.0	-0.651	0.515
	2	220	272.08	59,857.0				
	Total	554						
PU	1	334	283.03	94,531.5	34,893.5	59,203.5	-1.004	0.315
	2	220	269.11	59,203.5				
	Total	554						
PEoU	1	334	279.93	93,496.0	35,929.0	60,239.0	-0.441	0.659
	2	220	273.81	60,239.0				
	Total	554						
TK	1	334	280.48	93,680.5	35,744.5	60,054.5	-0.541	0.588
	2	220	272.98	60,054.5				
	Total	554						
PD	1	334	276.37	92,309.0	36,364.0	92,309.0	-0.205	0.838
	2	220	279.21	61,426.0				
	Total	554						
CF	1	334	276.18	92,243.0	36,298.0	92,243.0	-0.240	0.810
	2	220	279.51	61,492.0				
	Total	554						
EC	1	334	275.51	92,021.0	36,076.0	92,021.0	-0.361	0.718
	2	220	280.52	61,714.0				
	Total	554						
STL	1	334	279.95	93,503.0	35,922.0	60,232.0	-0.445	0.657
	2	220	273.78	60,232.0				
	Total	554						
PCI	1	334	284.25	94,940.5	34,484.5	58,794.5	-1.227	0.220
	2	220	267.25	58,794.5				
	Total	554						

In the context of TPACK, teachers with a mathematics background ($N = 334$) had a mean rank of 285.69, while those without ($N = 220$) had a mean rank of 265.07. The resulting Mann-Whitney *U* value was 34004.5 with an asymptotic significance of 0.137, indicating no statistically significant difference between the two groups in terms of their TPACK. Similar non-significant results were observed across other constructs such as TPK, TCK, PU, PEoU, TK, PD, CF, EC, STL, and PCI, with all *p*-values exceeding the 0.05 threshold, suggesting that having a mathematics education background does not significantly impact teachers' perceptions and integration of digital technology in various dimensions. For instance, in the domain of PU, the mean ranks were 283.03 for group 1 and 269.11 for group 2, with a Mann-Whitney *U* value of 34893.5 and a *p*-value of 0.315, reinforcing the trend of no discernible impact based on mathematics education background.

These findings suggest that, within this sample of primary mathematics teachers in Chongqing, the possession of a mathematics education background does not significantly influence their perceptions or practices regarding technology integration in their teaching. This insight might prompt further investigation into what factors, beyond academic background, could be influencing these perceptions and practices, thereby aiding in the development of more targeted and effective PD initiatives.

DISCUSSION

Impact of Gender on Technology Integration

The investigation into gender differences in technology integration within primary mathematics education has highlighted a significant variance in the TPACK construct, where female teachers exhibit enhanced integration levels compared to male teachers during the post-pandemic era. This observation is pivotal, particularly when juxtaposed with prior literature, which predominantly suggests that male educators often exhibit higher confidence and aptitude in technology-related domains such as TPACK, TK, TCK, and TPK (Koh et al., 2010; Koh et al., 2014; Ozudogru & Ozudogru, 2019). For example, Koh et al. (2014) found significant gender differences in technology-related constructs, where male teachers rated themselves higher in TK, TCK, and TPACK, albeit with small effect sizes. By contrast, our study's unique contribution is its divergence from traditional findings, positing female teachers ahead in TPACK integration, which might be attributed to the accelerated adoption of digital tools during the pandemic, altering conventional gender dynamics in educational technology usage.

Furthermore, no significant differences were found in other constructs (TPK, TCK, PU, PEoU, TK, PD, CF, EC, STL, and PCI). This absence of gender disparity across most constructs may indicate an equalizing trend in technology integration between genders, potentially driven by the universal push toward digital engagement in recent educational contexts. Indeed, Koh et al. (2014) found similar trends, where despite men showing greater confidence in certain TPACK areas, such differences in confidence had small effect sizes and were not broadly reflected across all technological integration skills, suggesting a movement towards gender parity in technological proficiency within education. This aligns with our findings and hints at an evolving and changing gender dynamic in technology integration, particularly in the context of primary mathematics education. The unique circumstances of the recent global pandemic have likely accelerated this shift, fostering a more balanced engagement with digital tools among both male and female teachers (Li, 2023). Recognizing this trend is vital for designing PD programs that are attuned to the current educational landscape, ensuring they are inclusive and effectively address the nuanced needs related to technology integration in primary mathematics education. Such programs should leverage this understanding of gender dynamics to create more effective and equitable educational technology strategies.

Influence of Age and Teaching Experience on Technology Integration

The debate over age-related influences on technology integration in education is longstanding (Koh et al., 2010; Song et al., 2021). Prior studies have often posited that younger teachers are more inclined to embrace digital technology in their instructional practices (Aldunate & Nussbaum, 2013; Yao & Zhao, 2022), with age being seen as a determinant of technology adoption and integration. However, this study presents an alternative narrative, particularly within the context of primary mathematics education post-COVID-19 in China, suggesting that age does not have a significant impact on the integration of technology across various dimensions, including TPACK, TPK, TCK, PU, PEoU, TK, PD, CF, EC, STL, and PCI. The uniformity in technology integration regardless of age could be attributed to the unique demands and the accelerated digital transition necessitated by the COVID-19 pandemic. This transition may have catalyzed an environment where teachers of all ages had to engage with technology to maintain instructional continuity, leading to a leveling effect that diminishes the significance of age as a variable. Understanding the reasons behind this lack of age-related disparity is critical. It may reflect a broader cultural shift within the educational sector, one where PD and technological infrastructure have been standardized across teacher age groups, thereby equalizing educational technology integration practices. Alternatively, it could suggest that the pandemic has served as an equalizer in terms of digital technology usage, overriding traditional age-related preferences and resistances.

In this exploration of the relationship between teaching experience and technology integration in mathematics education, the study reveals a consistent attitude across multiple constructs, including TPACK, TPK, TCK, PEoU, TK, PD, CF, EC, STL, and PCI, with no significant differences tied to the length of teaching experience. However, a particular pattern emerges within the construct of PU, where both novice teachers (0-5 years) and those with extensive experience (> 15 years) exhibit a stronger valuation of technology's role in mathematics education. This observation deviates from previous studies that typically underscore the higher technological enthusiasm of less experienced educators and the relative caution among more seasoned teachers (Ertmer et al., 2012). This finding indicates that the pandemic-induced shift to digital education may have prompted a re-evaluation of technology's benefits across the entire spectrum of teaching experience (Li, 2022). While newer teachers might inherently value digital tools, experienced teachers, adapting to pandemic constraints, have potentially developed a greater appreciation for technology's capacity to meet diverse educational needs (van der Spoel et al., 2020). Thus, the findings suggest that, particularly in the post-pandemic context, there's a broad recognition among Chinese primary mathematics teachers of technology's utility, notably among those at the early and later stages of their careers, implying a need for further investigation into the perspectives of teachers with intermediate experience levels.

Role of Education Background in Technology Integration

The exploration of educational background in relation to technology integration in primary mathematics education presents a complex picture. When examining overall technology integration practices including TPACK, TPK, TCK, PU, PEoU, TK, PD, EC, STL, and PCI, no significant differences emerge across varying teacher educational levels. However, an exception is noted within the perception of CFs, where significant variances appear among teachers with highest educational qualifications. This finding may be rooted in the broader scope and depth of understanding that often accompanies higher levels of education. Educators with bachelor's and master's degrees are likely to have a more nuanced understanding of the political, institutional, and resource aspects that influence the use of digital technologies, and therefore attach greater importance to CF than their peers with a junior college background.

Furthermore, in the specific context of primary mathematics education in China, the study examined the influence of having a background in mathematics education on teachers' integration of digital technology in mathematics teaching. The results revealed that a specialized mathematics education background does not significantly affect teachers' technology integration practices. This finding might be due to a standardized approach to technology training and use within the educational system, which has levelled the playing field for all teachers regardless of their academic specializations. It also suggests that in primary mathematics education, practical experience with technology, rather than academic background in mathematics, may be more critical to the effective integration of digital tools in the classroom. These insights are particularly important when considering the PD of mathematics teachers. They imply that focusing solely on CK in mathematics may not be sufficient for enhancing technology integration skills. Instead, broader strategies that also address practical, pedagogical, and technological competencies, irrespective of teachers' formal mathematics education, could be more beneficial. This finding is consistent with literature emphasizing the necessity for comprehensive PD programs and policies that address not just CK but also pedagogical and technological knowledge, teacher attitudes, and the enhancement of micro, meso, and macro educational environments (Holden & Rada, 2011; Mishra et al., 2023; Niess, 2016; Porras-Hernández & Salinas-Amescua, 2013).

Implications

This study reveals that traditional demographic factors like gender, age, teaching experience, education background, and mathematics background have a limited impact on technology integration by primary mathematics teachers in the post-pandemic era. These findings indicate a significant shift in the educational landscape, suggesting a new paradigm in how technology is integrated into teaching practices.

This shift implies that the pandemic has catalyzed a levelling effect where previously observed differences in technology integration due to these demographic factors have diminished. Such a convergence could be due to universal, forced, and accelerated adoption of technology across the board, driven by the necessity of maintaining educational continuity during school closures (DeCoito & Estaiteyeh, 2022). The implication here is profound: PD and support strategies must now move beyond addressing demographic disparities and focus on enhancing the technological competencies of all teachers. Moreover, the pervasive adoption of technology across various educator demographics suggests a potential levelling in the field of educational technology use. While the pandemic has likely compelled educators, including those previously reluctant, to engage more with digital tools, it raises questions about whether this constitutes democratization or merely a forced alignment due to extraordinary circumstances (Torry & Whalen, 2020; Wang et al., 2023). This nuanced distinction is crucial for understanding the long-term implications of this shift and for designing targeted PD programs that address not just the increased use but also the depth and quality of technological integration in teaching practices (Pappa et al., 2023).

The lack of significant variances in technology integration across demographic factors provides pivotal insights for policymakers and educational leaders, highlighting the necessity to reassess and realign strategies in the realm of technology integration in primary mathematics education. The emphasis on equitable policy-making is crucial to ensure that all teachers, irrespective of their demographic characteristics, have access to the necessary technological resources, professional training, and support systems. While the pandemic highlighted the critical role of digital technology in education, it also revealed broader systemic issues that go beyond a mere crisis response (Reuge et al., 2021). The swift transition to online teaching, driven by the need to sustain educational processes and prevent student learning loss, showcases a broader spectrum of factors influencing this digital shift. It's not solely the pandemic but a confluence of societal, educational, and governmental motivations that have propelled the integration of technology in education (Li, 2022; Song et al., 2021). Therefore, moving forward, it is vital to sustain and build upon this momentum, not just as a reactionary measure but as a strategic approach to fortify primary mathematics teachers for the evolving digital landscape in education, ensuring they are well-equipped to navigate future challenges and technological advancements.

Limitations and Future Research

The present investigation, while contributing valuable insights into the factors influencing technology integration in primary mathematics education post-pandemic, has certain limitations that should be acknowledged. The study's findings are based on a sample from Chongqing, China, which may not be representative of other regions with different educational systems and cultural contexts. Future research could extend this study's scope to include a more diverse range of geographical locations, providing a broader understanding of the global trends in educational technology integration in mathematics teaching. While this study has provided insights into demographic factors influencing technology integration in mathematics education, it has not directly addressed other digital divides that may persist in the post-pandemic era. Future research could focus on exploring the digital divides and the implications for equitable access to technology-enhanced learning in mathematics. Such research could examine the availability of resources across different school settings, the socioeconomic status of students, and the regional disparities that could affect technology integration in Chinese mathematics education. Lastly, the current research underscores a generalized trend of technology integration across various demographic factors. Subsequent studies might explore more granular aspects, such as specific types of technology used in mathematics teaching, pedagogical approaches in technology integration, and the interplay between digital technology use and student outcomes in mathematics. This could help in identifying precise areas for improvement and development in teacher training programs.

CONCLUSION

This research embarked on an empirical journey to discern the impact of various demographic factors such as gender, age, teaching experience, educational background, and mathematics background, on the factors of integrating digital technology in primary mathematics education.

A cornerstone of this research was the investigation into gender differences, where a notable finding was that female teachers exhibited a greater propensity for TPACK compared to male mathematics teachers. This finding challenges traditional gender stereotypes and signals a shift in the educational landscape potentially influenced by the widespread digital transition during the COVID-19 pandemic. The study further probed the role of age and teaching experience, uncovering that neither was a determinant of technological integration within the surveyed group. This suggests an alignment in the use of educational technology across generational or age-based divides, an alignment that speaks to a collective progressiveness and adaptability amongst educators in the face of emergent digital norms. In terms of educational background, the research found that, aside from perceptions of CFs, the highest level of education attained did not significantly alter the integration of digital technology in teaching practices.

Conversely, the specific skills and experience in mathematics education did not significantly affect teachers' application of technology, underscoring the importance of practical, hands-on experience with digital tools over a more theoretical mathematical background. These insights underscore the democratization of digital tool integration in Chinese mathematics education post-pandemic, revealing an increasingly egalitarian trend across demographics previously thought to influence technological integration.

This research contributes to the field of mathematics education by highlighting the nuances of technology integration across various demographic lines. It emphasizes the importance of continued PD tailored to the current educational climate. It also provides a foundational understanding for policymakers and educators seeking to maximize the effectiveness of digital technology in Chinese mathematics teaching, calling attention to the need for an inclusive teacher-education strategy that transcends traditional demographic boundaries.

Author contributions: ML, CV, HT, & JB: conceptualization, design, material preparation, data collection, and analysis & **ML:** writing the initial draft. All authors have agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgments: The authors would like to thank Monash University for providing the resources, facilities, and support that made this research possible. The authors would also like to thank the education faculty, staff, and fellow students for their valuable encouragement and inspiration.

Ethical statement: The authors stated that the study was approved by the Monash University Human Research Ethics Committee on 17 October 2022 with approval ID 35148. Written informed consents were obtained from the participants.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Aguilar, J. J., & Kang, S. (2023). Innovating with in-service mathematics teachers' professional development: The intersection among mixed-reality simulations, approximation-of-practice, and technology-acceptance. *International Electronic Journal of Mathematics Education, 18*(4), Article em0750. https://doi.org/10.29333/iejme/13628

Akyuz, D. (2023). Exploring contextual factors for pre-service teachers teaching with technology through planning, teaching, and reflecting. *International Electronic Journal of Mathematics Education, 18*(1), Article em0721. https://doi.org/10.29333/iejme/12624

Aldunate, R., & Nussbaum, M. (2013). Teacher adoption of technology. *Computers in Human Behavior, 29*(3), 519-524. https://doi.org/10.1016/j.chb.2012.10.017

Alneyadi, S., Wardat, Y., Alshannag, Q., & Abu-Al-Aish, A. (2023). The effect of using smart e-learning app on the academic achievement of eighth-grade students. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(4), Article em2248. https://doi.org/10.29333/ejmste/13067

Blannin, J. (2022). *Beginning teaching with digital technology*. SAGE.

Boone, H., & Boone, D. (2012). Analyzing Likert data. *Journal of Extension*, *50*(2). https://doi.org/10.34068/joe.50.02.48

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press. https://doi.org/10.4159/9780674028845

Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press.

Byrne, B. M. (2016). *Structural equation modeling with Amos basic concepts, applications, and programming* (3rd ed.). Routledge. https://doi.org/10.4324/9781315757421

Çeşme, H., & Çimen, B. (2023). The relationships among TPACK, the TAM and online education satisfaction: Structural equation modelling. *Journal for Educators,Teachers and Trainers, 14*(5), 281-289. https://doi.org/10.47750/jett.2023.14.05.027

Chen, B. (2015). Exploring the digital divide: The use of digital technologies in Ontario public schools. *Canadian Journal of Learning and Technology, 41*(3). https://doi.org/10.21432/T2KP6F

Clements, D. H., & Sarama, J. (2013). Rethinking early mathematics: What is research-based curriculum for young children? In L. D. English, & J. T. Mulligan (Eds.), *Reconceptualizing early mathematics learning* (pp. 121-147). Springer. https://doi.org/10.1007/978-94-007-6440-8_7

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. https://doi.org/10.4324/9781315456539

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334. https://doi.org/10.1007/BF02310555

da Silva Bueno, R. W., & Niess, M. L. (2023). Redesigning mathematics preservice teachers' preparation for teaching with technology: A qualitative cross-case analysis using TPACK lenses. *Computers & Education, 205*, Article 104895. https://doi.org/10.1016/j.compedu.2023.104895

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user accptance of information technology. *MIS Quarterly, 13*(3), 319-340. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003. https://doi.org/10.1287/mnsc.35.8.982

DeCoito, I., & Estaiteyeh, M. (2022). Transitioning to online teaching during the COVID-19 pandemic: An exploration of STEM teachers' views, successes, and challenges. *Journal of Science Education and Technology, 31*(3), 340-356. https://doi.org/10.1007/s10956-022-09958-z

DeVellis, R. F. (2017). *Scale development theory and applications* (4th ed.). SAGE.

Dogan, M. (2012). Prospective Turkish primary teachers' views about the use of computers in mathematics education. *Journal of Mathematics Teacher Education, 15*(4), 329-341. https://doi.org/10.1007/s10857-012-9214-3

Drijvers, P., Tabach, M., & Vale, C. (2018). Uses of technology in K-12 mathematics education: Concluding remarks. In L. Ball, P. Drijvers, S. Ladel, H.-S. Siller, M. Tabach, & C. Vale (Eds.), *Uses of technology in primary and secondary mathematics education tools, topics and trends* (pp. 421-435). Springer. https://doi.org/10.1007/978-3-319-76575-4

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284. https://doi.org/10.1080/15391523.2010.10782551

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. SAGE.

Gurer, M. D. (2021). Examining technology acceptance of pre-service mathematics teachers in Turkey: A structural equation modeling approach. *Education and Information Technologies, 26*(4), 4709-4729. https://doi.org/10.1007/s10639-021-10493-4

Gurer, M. D., & Akkaya, R. (2022). The influence of pedagogical beliefs on technology acceptance: A structural equation modeling study of pre-service mathematics teachers. *Journal of Mathematics Teacher Education, 25*(4), 479-495. https://doi.org/10.1007/s10857-021-09504-5

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2018). *Multivariate data analysis* (8th ed.). Cengage Learning.

Hansen, A., Mavrikis, M., & Geraniou, E. (2016). Supporting teachers' technological pedagogical content knowledge of fractions through co-designing a virtual manipulative. *Journal of Mathematics Teacher Education, 19*(2-3), 205-226. https://doi.org/10.1007/s10857-016-9344-0

Ho, R. (2013). *Handbook of univariate and multivariate data analysis with IBM SPSS* (2nd ed.). CRC Press. https://doi.org/10.1201/b15605

Holden, H., & Rada, R. (2011). Understanding the influence of perceived usability and technology self-efficacy on teachers' technology acceptance. *Journal of Research on Technology in Education, 43*(4), 343-367. https://doi.org/10.1080/15391523.2011.10782576

Ibili, E., Resnyansky, D., & Billinghurst, M. (2019). Applying the technology acceptance model to understand maths teachers' perceptions towards an augmented reality tutoring system. *Education and Information Technologies, 24*(5), 2653-2675. https://doi.org/10.1007/s10639-019-09925-z

Inan, F. A., & Lowther, D. L. (2010). Laptops in the K-12 classrooms: Exploring factors impacting instructional use. *Computers & Education, 55*(3), 937-944. https://doi.org/10.1016/j.compedu.2010.04.004

Jang, S. J., & Tsai, M. F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers & Education, 59*(2), 327-338. https://doi.org/10.1016/j.compedu.2012.02.003

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26. https://doi.org/10.3102/0013189X033007014

Khong, H., Celik, I., Le, T. T. T., Lai, V. T. T., Nguyen, A., & Bui, H. (2023). Examining teachers' behavioural intention for online teaching after COVID-19 pandemic: A large-scale survey. *Education and Information Technologies, 28*(5), 5999-6026. https://doi.org/10.1007/s10639-022-11417-6

Knezek, G., & Christensen, R. (2016). Extending the will, skill, tool model of technology integration: Adding pedagogy as a new model construct. *Journal of Computing in Higher Education, 28*(3), 307-325. https://doi.org/10.1007/s12528-016-9120-2

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning, 26*(6), 563-573. https://doi.org/10.1111/j.1365-2729.2010.00372.x

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2014). Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK. *Educational Technology & Society*, *17*(1), 185-196. https://www.jstor.org/stable/jeductechsoci.17.1.185

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575-614. https://doi.org/10.3102/0034654307309921

Li, B. (2022). Ready for online? Exploring EFL teachers' ICT acceptance and ICT literacy during COVID-19 in mainland China. *Journal of Educational Computing Research, 60*(1), 196-219. https://doi.org/10.1177/07356331211028934

Li, M. (2023). Chinese mathematics teachers' TPACK and attitudes toward ICT integration in the post-pandemic era. *Eurasia Journal of Mathematics, Science and Technology Education, 19*(7), Article em2301. https://doi.org/10.29333/ejmste/13346

Li, M., & Li, B. (2024). Unravelling the dynamics of technology integration in mathematics education: A structural equation modelling analysis of TPACK components. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-12805-w

Li, M., Vale, C., Tan, H., & Blannin, J. (2024a). A systematic review of TPACK research in primary mathematics education. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-024-00491-3

Li, M., Vale, C., Tan, H., & Blannin, J. (2024b). Exploring Technological Pedagogical Readiness (TPR) in China's primary mathematics teachers: TPR scale validation. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7), Article em2469. https://doi.org/10.29333/ejmste/14727

Long, T., Zhao, G., Li, X., Zhao, R., Xie, K., & Duan, Y. (2020). Exploring Chinese in-service primary teachers' technological pedagogical content knowledge (TPACK) for the use of thinking tools. *Asia Pacific Journal of Education, 42*(2), 350-370. https://doi.org/10.1080/02188791.2020.1812514

Mishra, P. (2019). Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education, 35*(2), 76-78. https://doi.org/10.1080/21532974.2019.1588611

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. https://journals.sagepub.com/doi/abs/10.1111/j.1467-9620.2006.00684.x

Mishra, P., Warr, M., & Islam, R. (2023). TPACK in the age of ChatGPT and generative AI. *Journal of Digital Learning in Teacher Education, 39*(4), 235-251. https://doi.org/10.1080/21532974.2023.2247480

Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research, 44*(3), 299-317. https://doi.org/10.2190/EC.44.3.c

Niess, M. L. (2016). *Technological pedagogical content knowledge (TPACK) framework for K-12 teacher preparation: Emerging research and opportunities*. IGI Global. https://doi.org/10.4018/978-1-5225-1621-7

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*(3), 1321-1335. https://doi.org/10.1016/j.compedu.2010.06.002

Özgür, H. (2020). Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: A structural equation modeling. *Computers in Human Behavior*, *112*. https://doi.org/10.1016/j.chb.2020.106468

Ozudogru, F., & Ozudogru, M. (2019). Technological pedagogical content knowledge of mathematics teachers and the effect of demographic variables. *Contemporary Educational Technology, 10*(1), 1-24. https://doi.org/10.30935/cet.512515

Pappa, C. I., Georgiou, D., & Pittich, D. (2023). Technology education in primary schools: Addressing teachers' perceptions, perceived barriers, and needs. *International Journal of Technology and Design Education, 34*(2), 485-503. https://doi.org/10.1007/s10798-023-09828-8

Porras-Hernández, L. H., & Salinas-Amescua, B. (2013). Strengthening TPACK: A broader notion of context and the use of teacher's narratives to reveal knowledge construction. *Journal of Educational Computing Research, 48*(2), 223-244. https://doi.org/10.2190/EC.48.2.f

Reuge, N., Jenkins, R., Brossard, M., Soobrayan, B., Mizunoya, S., Ackers, J., Jones, L., & Taulo, W. G. (2021). Education response to COVID 19 pandemic, a special issue proposed by UNICEF: Editorial review. *International Journal of Educational Development*, *87*. https://doi.org/10.1016/j.ijedudev.2021.102485

Saltan, F., Arslan, K., & Wang, S. (2017). A comparison of in-service and pre-service teachers' technological pedagogical content knowledge self-confidence. *Cogent Education*, *4*(1). https://doi.org/10.1080/2331186x.2017.1311501

Selwyn, N. (2021). *Education and technology: Key issues and debates*. Bloomsbury Academic. https://doi.org/10.5040/9781350145573

Song, Y., Qian, C., & Pickard, S. (2021). Age-Related digital divide during the COVID-19 pandemic in China. *International Journal of Environmental Research and Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111285

Teo, T., & Van Schalk, P. (2009). Understanding technology acceptance in pre-service teachers: A structural-equation modeling approach. *The Asia-Pacific Education Researcher, 18*(1), 47-66. https://doi.org/10.3860/taper.v18i1.1035

Teo, T., Lee, C. B., & Chai, C. S. (2008). Understanding pre-service teachers' computer attitudes: Applying and extending the technology acceptance model. *Journal of Computer Assisted Learning, 24*(2), 128-143. https://doi.org/10.1111/j.1365-2729.2007.00247.x

Teo, T., Milutinovic, V., Zhou, M. M., & Bankovic, D. (2017). Traditional vs. innovative uses of computers among mathematics pre-service teachers in Serbia. *Interactive Learning Environments, 25*(7), 811-827. https://doi.org/10.1080/10494820.2016.1189943

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development, 65*(3), 555-577. https://doi.org/10.1007/s11423-016-9481-2

Torry, T., & Whalen, J. (2020). Should teachers be trained in emergency remote teaching? Lessons learned from the COVID-19 pandemic. *Journal of Technology and Teacher Education*, *28*(2), 189-199. https://www.learntechlib.org/primary/p/215995

Vale, C. M., & Leder, G. C. (2004). Student views of computer-based mathematics in the middle years: Does gender make a difference? *Educational Studies in Mathematics, 56*, 287-312. https://doi.org/10.1023/B:EDUC.0000040411.94890.56

Van Braak, J., Tondeur, J., & Valcke, M. (2004). Explaining different types of computer use among primary school teachers. *European Journal of Psychology of Education, 19*(4), 407-422. https://doi.org/10.1007/BF03173218

Van der Spoel, I., Noroozi, O., Schuurink, E., & van Ginkel, S. (2020). Teachers' online teaching expectations and experiences during the COVID-19 pandemic in the Netherlands. *European Journal of Teacher Education, 43*(4), 623-638. https://doi.org/10.1080/02619768.2020.1821185

Wang, Z., Zhang, L., Wang, X., Liu, L., & Lv, C. (2023). Navigating Technostress in primary schools: A study on teacher experiences, school support, and health. *Frontiers in Psychology, 14*. https://doi.org/10.3389/fpsyg.2023.1267767

Yao, X., & Zhao, J. (2022). Chinese mathematics teachers' use of digital technologies for instruction: A survey study. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(8), Article em2135. https://doi.org/10.29333/ejmste/12209