Needs Analysis of Digital Technology in University Mathematics Classrooms in Shandong Province, China

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Abstract: *Digital technology has become increasingly significant within the educational sphere, gradually evolving into an indispensable component of teachers' daily instructional practices. This paper aims to analyse, through questionnaire surveys, the digital literacy of teachers and their needs for digital technology within higher education mathematics classrooms. The paper first provides a background statement on the research topic, then employs a literature review methodology to collect and analyse over ten references concerning digital technology and teaching. Finally, a questionnaire survey is conducted to examine university mathematics teachers' requirements for digital teaching. The findings reveal that the majority of teachers are willing to utilise digital technology in teaching and demonstrate a high level of demand for digital teaching methods.*

Key Words: *Digital Technology, University Mathematics Classrooms, Needs Analysis, Education, Questionnaire, t-test, ANOVA*

1. Introduction

With the rapid advancement of the internet and the impact of the COVID-19 pandemic, the role of computer tools in education has become increasingly prominent. This shift has propelled educational systems to transition swiftly from traditional classroom models towards a reliance on electronic devices and online applications (Rosak-Szyrocka et al., 2022).

At present, digital technology has been widely adopted within the education sector as a crucial cornerstone for electronic educational delivery and the transformation of traditional learning models. This shift has not only expanded the scope of education but also introduced entirely new learning opportunities and methodologies. The convergence of emerging technologies—including smart devices, artificial intelligence (AI), augmented reality (AR), virtual reality (VR), the Internet of Things (IoT), blockchain, and diverse educational software—continues to broaden the scope and potential of teaching (Gaol & Prasolova-Førland, 2022).

In recent years, from the rise of online education platforms to the widespread adoption of immersive AR and VR technologies, digital technologies are progressively reshaping traditional teaching models. Furthermore, the application of technologies such as cloud computing and big data analytics in education has enriched teaching methods and enhanced the flexibility of instructional approaches (Yuan, 2023).

The regional nature of educational resources and the uneven distribution of teaching staff continue to create disparities in learning opportunities. The concentration of high-calibre teachers in major cities persists, leading to an unequal allocation of educational resources and further exacerbating educational inequity. The application of digital technology presents an opportunity to mitigate educational disparities (Peruzzo & Allan, 2024). It overcomes the constraints of physical space, enabling instantaneous communication between individuals and distant entities (Gourlay, 2021).

Through online resources and digital learning environments, students can access high-quality courses and learning support beyond geographical boundaries, thereby promoting educational equity while driving educational innovation (Wilcox & Lawson, 2022; Ramirez-Montoya, 2020). For instance, pupils may view instructional videos from high-performing schools online or search for answers to queries via digital platforms to obtain learning support. This approach not only enhances self-directed learning outcomes but also facilitates personalised education and differentiated development.

Digital technologies have brought unprecedented opportunities to education, fundamentally transforming traditional teaching and learning practices (Stelmah & Vasylyuk-Zaitseva, 2024). Consequently, the application of digital technologies has become a vital pathway for driving the transformation of education systems and building innovative learning ecosystems. Such educational systems empower students both inside and outside the classroom, helping them cultivate independent learning and proactive exploration whilst fully realising their potential (Chai, Hu, & Niu, 2023).

Research further indicates that integrating digital technologies into curricula has become an inevitable trend. Not only does it create flexible and diverse learning environments for students (Haleem, Javaid, Qadri, & Suman, 2022), but it also stimulates their interest in learning, enhances creativity and engagement, thereby significantly improving learning experiences and outcomes. Concurrently, digital technologies enable personalised learning, offering students more opportunities tailored to their individual needs.

2. Literature Review

Against the backdrop of contemporary educational development, educational digitisation has emerged as a research theme attracting widespread attention from scholars both domestically and internationally, giving rise to diverse research perspectives.

Godin and Terekhova (2021) note that education as an industry is undergoing profound digital transformation. Existing research primarily focuses on open education, the design and quality assurance of online education, and the application of educational technology and digital tools within teaching and learning processes. Particularly at the pedagogical level, researchers concentrate more on the effective integration and implementation of educational technology, digital resources, and media tools.

The digitalisation of education is a long-standing process, impacting all levels of education and directly influencing the activities of students, teachers, administrators, and stakeholders. Petrusevich (2020) categorises digital education initiatives into four types: educational services and platforms; services supporting educational administration and content delivery; diverse digital tools applied in teaching practice (such as virtual reality, proctoring systems, and gamification tools); and projects driving pedagogical innovation.

Among emerging technologies, the rapid advancement of artificial intelligence holds significant implications for learning and teaching. Indeed, AI-supported pedagogy holds promise to transform education (Zawacki-Richter, Marín, Bond & Gouverneur, 2019). Multiple studies indicate that developmental issues in digital education are closely intertwined with the application of AI technologies (Seldon, Abidoye, 2018).

Baker and Smith (2019) emphasise that artificial intelligence is not a single technology, but rather a category of computer technologies capable of performing cognitive tasks associated with human thought, such as learning and problem-solving. Artificial intelligence is applied to education in diverse ways.

The Learning Management System (LMS) stands as a crucial tool for educational digitisation, enabling communication and interaction between teachers and students within virtual spaces (Oliveira, Cunha, & Nakayama, 2016). A Learning Management System (LMS) is a software application or platform that assists educators in managing, reporting, tracking, documenting, and delivering educational courses or training programmes (Balkaya & Akkucuk, 2021).

In China, Chaoxing Learning Pass stands as one of the most widely adopted learning management platforms. It also functions as a mobile learning platform, with the Chaoxing Learning Pass system being a learning platform designed and developed by Chaoxing Company, featuring diverse learning functionalities such as knowledge dissemination and management sharing (Yu, 2023). The Chaoxing Learning Pass system possesses multiple functionalities that can enhance learning and teaching outcomes. Numerous educators consider Chaoxing Learning Pass to be one of the most practical learning tools, owing to its user-friendly operation and comprehensive features (Wang & Wang, 2018).

The use of digital technologies is impacting education at all levels, including higher education, where their application is driving profound transformations in university teaching.

Minina (2020) identified four trends associated with the digitalisation of higher education: the emergence of blended learning models, the development of online education, the creation of virtual (digital) educational environments, and changes in how educational organisations are managed. Teaching and learning now incorporate digital tools such as learning management systems (LMS), chatbots, and interactive Web 2.0 technologies.

Moreover, online education, as a vital component of educational digitisation, is increasingly regarded as a learning approach offering advantages over traditional teaching models. Research indicates that online learning not only provides greater access to higher education but, supported by digital technologies, renders the educational process more flexible, interactive, and engaging (Akbar, 2016).

3. Questionnaire Survey

3.1 Study Sample

The study sample refers to a subset of individuals selected from the population by the researcher using specific sampling methods, intended for conducting detailed analysis and investigation (Creswell & Creswell, 2017). As it is often impractical to survey the entire population, research frequently relies on samples to draw inferences (Andrade, 2020). Consequently, the scientific rigour and representativeness of sample selection are paramount, as they determine whether research findings can be generalised to broader populations (Creswell & Creswell, 2017).

Sample selection is typically based on random sampling, stratified sampling, purposive sampling, or other sampling methods to ensure the scientific rigour and validity of the research (Babbie, 2020). This study opted for purposive sampling.

This research aims to enhance the quality of mathematics classroom teaching in private undergraduate institutions and further foster students' problem-solving abilities. Consequently, this phase of the study will be conducted among private undergraduate institutions in Shandong Province, China, with in-service mathematics teachers as the research subjects.

As Shandong Province is divided into four regions—Northwest Shandong, Central Shandong, South Shandong, and the Peninsula—the researcher employed purposive sampling to select one private undergraduate institution from each region, totalling four institutions. A questionnaire survey was administered to 165 mathematics teachers across these four institutions.

3.2 Questionnaire Validity

Validity refers to whether a measurement instrument accurately assesses its intended content, i.e., whether questionnaire results authentically reflect research objectives (Anastasi & Urbina, 1997). It primarily encompasses content validity, construct validity, and surface validity (Singh, 2017). This study will examine the questionnaire's validity following its design completion. Consequently, the researcher will only assess the questionnaire's content validity and surface validity.

3.2.1 Content Validity

The researchers invited five experts from diverse disciplinary backgrounds to assess the questionnaire's validity using the Content Validity Index (CVI) (Polit & Beck, 2006). The five experts comprised: a mathematics education specialist, a digital teaching specialist, an educational assessment and psychology specialist, a university mathematics lecturer, and an expert in information technology and educational integration. The CVI assessment primarily operates at two levels: the Item-CVI (I-CVI) and the Scale-CVI (S-CVI) (Polit & Beck, 2006).

To evaluate content validity, the researchers designed an expert review form comprising three dimensions: content relevance, clarity of expression, and item necessity. Experts evaluated the questionnaire's core measurement items (i.e., teachers' digital literacy, demand for digital teaching model activities, specific teaching activity requirements, and potential barriers) – totalling 27 items – scoring each on a 1–4 scale across the three dimensions. They provided revision or refinement suggestions, and I-CVI values were calculated accordingly. As the basic information section served solely for sample characteristic description, it was excluded from content validity analysis.

Following the completion of the review by the five experts, the researchers collated and statistically analysed the scoring results. In accordance with the scoring criteria, items receiving a score of 3 or 4 were deemed acceptable. Subsequently, based on the expert ratings, the researchers calculated the I-CVI values for each item across the three dimensions, as well as the overall I-CVI for each item. They further derived the overall S-CVI/Ave and S-CVI/UA. The results are presented in Table 3.1. For clarity, the table denotes I-CVI-1 for the content-relatedness dimension, I-CVI-2 for the clarity of expression dimension, I-CVI-3 for the necessity dimension, and I-CVI for the composite validity index of each item.

Table 3.1 Statistical Summary of CVI Values by Category

No	I-CVI-1	I-CVI-2	I-CVI-3	I-CVI
6	1	0.8	1	0.93
7	1	0.8	1	0.93
8	1	0.8	1	0.93
9	1	1	1	1
10	1	1	1	1
11	1	1	1	1
12	1	1	1	1
13	1	1	1	1
14	1	1	1	1
15	1	1	1	1
16	1	1	1	1
17	1	1	1	1
18	1	1	1	1
19	1	1	1	1
20	1	1	1	1
21	1	1	1	1
22	1	0.8	1	0.93
23	1	1	1	1
24	1	1	1	1
25	1	1	1	1
26	1	1	1	1
27	1	1	1	1
28	1	1	1	1
29	1	1	1	1
30	1	1	1	1
31	1	0.8	1	0.93
32	1	1	1	1
		S-CVI/Ave		0.98
		S-CVI/UA		0.81

Note: The above serial numbers correspond to the question numbers in the questionnaire.

Based on the expert review findings, the questionnaire demonstrated excellent overall content validity: the composite I-CVI for all items fell within the 0.93–1.00 range, indicating a high degree of consensus among experts across three dimensions—content relevance, clarity of expression, and necessity. Specifically, items Q9–Q21, Q23–Q30, and Q32 achieved a composite I-CVI of 1.00, signifying that all five experts unanimously affirmed these questions fully align with the research objective of ‘Mathematics Teachers' Digital Teaching Needs’. For items such as Q6, Q7, Q8, Q22, and Q31 with coefficients of 0.93, although some experts expressed reservations regarding clarity of expression, their scores remain well above the standard threshold of 0.80. These items are generally acceptable and require only minor adjustments prior to formal distribution.

Regarding the overall CVI, the S-CVI/Ave value of 0.98 exceeds the threshold of 0.9, indicating that the questionnaire has achieved consistent expert recognition and possesses high content validity. The S-CVI/UA value of 0.81 exceeds the threshold of 0.8, indicating that the majority of items received unanimous expert endorsement. In summary, this questionnaire demonstrates sound content validity, effectively reflecting the construct intended for measurement in this research.

3.2.2 Surface Validity

Researchers must consider surface validity, which refers to whether a questionnaire superficially appears capable of measuring its intended concepts. That is, whether the items seem reasonable, easily comprehensible, and align with common-sense judgement (Singh, 2017).

To address surface validity, the researcher incorporated a dimension for assessing clarity of expression within the expert feedback form. As demonstrated by the I-CVI values for clarity of expression in Table 3.1, all items achieved an I-CVI score greater than or equal to the threshold of 0.8. Consequently, the surface validity of each questionnaire item meets the required standard.

3.3 Reliability and Pilot Study

Reliability denotes the consistency and stability of a measurement instrument across different time points, contexts, or assessors, reflecting the dependability of its results. Reliability testing is crucial as it indicates the internal consistency of the measurement tool. Internal consistency is typically assessed using Cronbach's alpha (Huck, 2012).

Based on prior research, the researchers ultimately selected 25 subjects for the pilot study. Owing to geographical constraints and for operational convenience, questionnaires were distributed and collected online via Wenjuanxing. The reliability and quality of the questionnaire at this stage were assessed through the survey results.

Researchers categorised the four sections of the questionnaire (excluding basic information) into three dimensions: digital literacy, needs scale, and barriers scale. Cronbach's α was calculated for each section.

To determine Cronbach's α, the researchers utilised SPSS statistical software. After importing the questionnaire results for each section, they navigated to [Analyse]→ [Scale] →[Reliability Analysis]. All scale items were selected in the 'Items' box, and Cronbach's α was calculated for each section. The final results are presented in Table 3.2 below.

Table 3.2 Cronbach's α for the Pilot Study in the Requirements Analysis Phase

Part	Cronbach Alpha	N of Entries
Digital literacy	0.812	6
Needs	0.815	13
Barriers	0.748	3

According to Cronbach's Alpha evaluation criteria, the Cronbach's α values for both the digital literacy and needs sections fall within the [0.8, 0.9] range, indicating good internal consistency for these components. The barrier section, containing only three items, exhibits a slightly lower Cronbach's α value, yet remains within the [0.7, 0.8) range, suggesting its internal consistency is generally acceptable.

3.4 Formal Research and Findings

Following the completion of the questionnaire's reliability and validity assessment alongside the pilot study, researchers conducted a formal survey involving 165 mathematics teachers from four schools. Given the geographical dispersion of participants, an online questionnaire was administered via QWXian. Ultimately, 161 valid responses were retrieved, and the collected data underwent analysis.

Participant Background

Table 3.3 presents the demographic characteristics of participants, comprising ultimately 80 males and 81 females.

Table 3.3 Participants' Demographics

Variables		Frequency	Percentage（%）
Gender	Male	80	49.7
	Female	81	50.3
Age	21-30	39	22.36
	31-40	60	37.27
	41-50	43	26.71
	41-60	14	8.69
	over 60	5	4.97

Researchers employed SPSS to conduct t-tests on scores for the digital literacy, demand scale, and barrier scale based on the gender variable. After importing the results from each of the three questionnaire sections into SPSS, the mean scores for each item within the three sections were first calculated. Subsequently, the following analyses were performed: [Analysis]→ [Compare Means]→ [Independent Samples T-test]. The mean values for each section were selected as test variables, with gender as the grouping variable. The final test results are presented in Table 3.4.

Table 3.4 T-test Results for Digital Technology Needs Analysis

Variables	Gender	N	Mean	Std.	t	P-value
Digital literacy	Male	80	3.74	0.62	3.249	0.001
	Female	81	3.40	0.72		
Needs	Male	80	4.02	0.58	-0.274	0.785
	Female	81	4.04	0.62		
Barriers	Male	80	3.03	0.80	0.311	0.756
	Female	81	2.99	0.72		

As shown in Table 3.4 above, when gender differs, only the digital literacy component exhibits a significant difference (P-value < 0.05), while the other two components show no significant variation. This indicates that men possess higher digital literacy than women. However, both men and women demonstrate a high level of demand for digital technology (Men: Mean = 4.02; Women: Mean = 4.04).

The researcher subsequently employed SPSS to conduct variance analyses on scores for digital literacy, demand scales, and barrier scales according to age. The specific procedure involved opening [Analysis]→[Compare Means]→[One-Way ANOVA], selecting the mean values for the three components as dependent variables and age as the factor. The final test results are presented in Table 3.5 below.

Table 3.5 ANOVA results for digital technology needs analysis

Variables	Age	N	Mean	Std.	F	Sig.
Digital literacy	21-30	39	3.84	0.56	2.547	0.042
	31-40	60	3.40	0.74		
	41-50	43	3.56	0.71		
	41-60	14	3.59	0.61		
	Over 60	5	3.43	0.59		
Needs	21-30	39	4.26	0.41	6.743	0.000
	31-40	60	4.12	0.55		
	41-50	43	3.92	0.69		
	41-60	14	3.56	0.61		
	Over 60	5	3.27	0.88		
Barriers	21-30	39	2.96	0.87	0.827	0.510
	31-40	60	2.95	0.72		
	41-50	43	3.14	0.71		
	41-60	14	2.90	0.66		
	Over 60	5	3.40	1.01		

The table above demonstrates significant differences (P<0.05) in the digital literacy and demand scales across different age groups, indicating that teachers of varying ages possess differing levels of digital literacy and exhibit distinct demands for digital technologies. The data reveals that younger teachers express a higher degree of demand for digital technologies, which aligns with real-world observations. Conversely, no significant differences (P>0.05) were observed in the barriers scale.

However, It is noteworthy that despite significant age differences, the average scores across all age groups on the digital needs scale exceeded 3.5. This indicates that, overall, the teaching community holds high expectations for the pedagogical application of digital technologies. This suggests that university lecturers have widely recognised the significant value of digital teaching in enhancing classroom interactivity, visualising instruction, and stimulating student interest.

4. Findings and Discussion

This study conducted a formal questionnaire survey among 165 mathematics teachers across four higher education institutions, yielding 161 valid responses. It comprehensively analysed teachers' performance across three dimensions: digital literacy, digital teaching needs, and barriers to digital teaching. The findings reveal distinct characteristics in mathematics teachers' application of digital technologies from both gender and age perspectives, providing a basis for the subsequent design and promotion of digital teaching models.

Overall, the study found that university mathematics teachers generally hold positive attitudes towards the pedagogical application of digital technologies, with significant differences in digital literacy and demand levels observed across genders and age groups. These findings not only illuminate teacher characteristics during the current digital transformation of university mathematics teaching but also provide empirical evidence for subsequent digital teaching model design and development. Future research may further explore the relationship between teachers' digital literacy and teaching effectiveness. By incorporating qualitative research methods, it could delve deeper into teachers' authentic experiences and needs within digital teaching practices, thereby providing more targeted support pathways for the digital transformation of higher mathematics courses.

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