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Digitalization in mathematics education: how distance and online learning shape pre-service teachers' career perceptions

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This study examines the perceptions of pre-service mathematics teachers with prior experience in distance education and engagement with digital tools regarding online and distance education, their professional perspectives, and their tendencies toward digital content creation. The findings indicate that while distance education enhances pedagogical flexibility, it also positions digital content creation as an essential professional skill. Participants recognize the effectiveness of digital tools in conveying mathematical concepts' abstract and visual aspects but acknowledge gaps in their competencies. The most striking finding reveals that shifting employment conditions push pre-service teachers to explore alternative career paths through digital platforms, with online teaching increasingly seen as a sustainable option rather than a temporary solution. This transformation fosters awareness of the necessity to develop digital pedagogical skills while urging teacher education programs to integrate digitalization strategies. Providing evidence of how digitalization reshapes teaching, this study underscores that digital competencies are no longer optional but a necessity.

KEYWORDS

pre-service mathematics teacher, distance education, online education, digital pedagogy, career flexibility, alternative employment

1 Introduction

Digital transformation has led to profound changes in educational processes, re-shaping both the professional development of teacher candidates and their instructional approaches. Today, teacher candidates do not solely rely on traditional teaching methods but rather enhance their learning processes and develop their professional skills through online platforms and digital tools (Selwyn, 2021; Bond et al., 2021). In particular, teacher candidates with online and distance education experience critically assess how they can integrate the digital literacy skills they have acquired into their teaching processes, shaping their professional orientations accordingly (Greenhow et al., 2021).

This transformation in education affects not only teacher candidates' face-to-face learning experiences but also their approaches to digital learning environments and flexible learning models. Especially during periods when remote education has become a necessity, teacher candidates have increased their interactions with digital platforms, gaining direct experience in integrating these tools into their instructional processes (Hodges et al., 2020). In this context, online educational environments and digital learning materials are no longer just alternatives but have become fundamental components supporting instructional processes. Teacher candidates are faced with the necessity of adapting traditional pedagogical approaches

to digitalized teaching environments, emphasizing the growing importance of digital pedagogy in professional development (Bozkurt and Sharma, 2022).

In disciplines such as mathematics education, which involve abstract concepts, the contributions of online educational tools and digital content to teaching and learning processes are particularly noteworthy. Research indicates that teacher candidates critically evaluate how they can utilize the skills and learning experiences gained in online education in their professional careers, leading them to increasingly turn to digital resources (Wang and Woo, 2010). Moreover, the effective use of digital tools and online resources in educational environments plays a significant role in shaping teacher candidates' professional identities and instructional strategies (Kimmmons and Veletsianos, 2014). Digitalized teaching processes are not only transforming teacher candidates' access to course materials but also their professional learning practices. This transformation has heightened interest in alternative learning and professional development environments that accelerate knowledge sharing in education and foster pedagogical perspectives through interaction.

In this regard, teacher candidates are not solely dependent on formal education platforms but develop learning practices within a broader digital ecosystem to support their professional growth and enhance their pedagogical skills. Social media, in particular, offers a dynamic and accessible environment for information retrieval, peer interaction, and the sharing of instructional materials (Greenhow and Askari, 2017). As teacher candidates increasingly turn to online resources, social media platforms gain prominence as spaces for pedagogical discussions, the exchange of teaching strategies, and the construction of professional identities.

The interactive, content-producing, and feedback mechanisms offered by social media-based learning environments add a complementary dimension to traditional teacher education processes, facilitating teacher candidates' adaptation to the requirements of the digital age (Trust et al., 2016). Therefore, when considering instructional processes supported by digital tools alongside the interaction opportunities provided by social media platforms, it becomes evident that they contribute to teacher candidates' professional development in multifaceted ways.

Recent studies in teacher education have underscored the transformative role of digital technology in shaping not only instructional strategies but also the professional identity development of pre-service teachers. The Technological Pedagogical Content Knowledge (TPACK) framework by Mishra and Koehler (2006) foregrounds the need to integrate technological tools with pedagogical and content knowledge to improve instructional effectiveness. Expanding on this, Schrum and Levin (2009) examined how digital platforms facilitate the formation of professional learning communities, enabling pre-service teachers to collaborate, reflect, and construct shared understandings of teaching practice. Trust (2012) and Carpenter et al. (2020) further advanced this discourse by highlighting the emergence of professional learning networks (PLNs), which allow teacher candidates to connect with global communities, access diverse resources, and engage in continuous professional dialogue. Ferdig et al. (2020) contributed additional insights by exploring the motivational and instructional benefits of game-based learning and interactive simulations, particularly in fostering experiential engagement within virtual environments. While these studies provide significant contributions, much of the literature

remains focused on isolated tools or frameworks. There is still a need for broader analyses that consider how teacher candidates interact with the wider digital ecosystem—encompassing formal platforms, social media, and informal learning spaces—and how these interactions inform their evolving beliefs and professional orientations. Drawing on Lave and Wenger's (1991) theory of *communities of practice*, this study considers how digital participation supports identity development through social engagement and collaborative meaning-making. Additionally, Bandura's (1986) *social cognitive theory* offers a complementary lens to understand how observational learning, perceived self-efficacy, and environmental factors shape professional growth in digitally mediated settings. Positioned at the intersection of these theoretical perspectives, the present work responds to a critical need in the field: to more holistically examine how sustained digital engagement contributes to teacher candidates' professional learning and identity formation in contemporary education.

This study aims to examine how pre-service teachers' online and distance education experiences shape their perceptions of the teaching profession and their professional orientations. In today's context, pre-service teachers access information and support their learning processes not only through formal educational platforms but also within a broader digital ecosystem. In this regard, the integration of social media and online educational tools has been considered not as a preference but as a necessity driven by the orientations of pre-service teachers.

Specifically, the diversification of ways in which pre-service teachers acquire information about teaching processes, engage in professional interactions, and access alternative learning resources has necessitated the consideration of social media-based platforms. Pre-service teachers contribute to their professional development not only through formal education processes but also by actively utilizing online communities, digital content creators, and interactive learning environments (Trust et al., 2016). Therefore, the data collection instrument used in this study has been structured to comprehensively analyze how pre-service teachers experience online education processes and how they utilize various digital resources throughout this process. This approach aims to present a broader framework that explores how pre-service teachers pursue professional development not only within formal education processes but also in the digital environments they voluntarily engage with.

In this context, both the impact of online education processes on pre-service teachers' perceptions of the teaching profession and their tendency to independently engage with digital resources have been examined together to provide a more comprehensive analysis. This approach seeks to highlight that teacher education processes in the digital age are not limited to in-class applications but also involve understanding how pre-service teachers navigate their development within the digital learning ecosystem.

The study examines the impact of online and distance education on pre-service mathematics teachers' professional identity development, pedagogical competencies, and career choices. As traditional teacher education models evolve with technological transformation, concerns about employment and the increasing difficulty of teacher appointments have led candidates to explore alternative career paths and develop digital pedagogical skills. However, the existing literature lacks sufficient empirical studies on how online education influences pre-service mathematics teachers'

career preferences, employment expectations, and inclination toward digital education platforms. In this context, the research aims to understand how pre-service mathematics teachers perceive online learning environments as opportunities, to what extent they integrate digital education tools into their professional development, and their orientation toward alternative mathematics teaching models.

The research question guiding this study is: “How do online and distance learning processes shape pre-service mathematics teachers’ professional identity development, employment expectations, and inclination toward alternative career paths?”

2 Method

2.1 Research design

In this study, a qualitative research design was adopted to explore the lived experiences and meaning-making processes of pre-service teachers regarding their online and distance education experiences. Qualitative research is particularly suitable for investigating complex, context-bound phenomena through the lens of participants’ subjective perspectives (Creswell and Poth, 2016). The study is grounded in an interpretivist paradigm, which assumes that reality is socially constructed and that knowledge emerges through individuals’ interactions with their environment (Lincoln and Guba, 1985). From this epistemological standpoint, the research design was developed to gain an in-depth understanding of how pre-service teachers construct their perceptions of instructional processes and professional identity within digital learning environments. The choice of qualitative methods was informed by the need to access participants’ written reflections and open-ended responses, which allow for rich and nuanced insights that cannot be captured through standardized quantitative measures. Learning is conceptualized in this study as a socially situated process, shaped by interaction, reflection, and engagement within digital contexts. This view aligns with sociocultural learning theories, particularly those emphasizing the socially situated nature of participation and identity development. Accordingly, the methodological framework was designed to reflect not only the research questions but also an effort to understand how experience and context shape teacher identity in contemporary educational settings.

2.2 Participants

The study group of this research consists of 58 pre-service mathematics teachers enrolled at two different universities. Participants were selected using a purposive sampling method, with the primary criterion being their direct participation in online and distance education. The selection process focused on individuals who had completed at least one academic term in a digital learning environment and had actively used digital platforms and tools in their learning processes. Announcements were shared in relevant course groups and institutional communication channels by instructors to invite potential participants. Participation was voluntary, and all participants were informed in advance about the purpose of the study, their right to withdraw at any time, and the confidentiality of their

responses. Informed consent was obtained from all participants prior to data collection.

Participants had attended online and distance courses for at least one academic term, gaining direct experience with various digital learning platforms and interactive educational tools. Through exposure to different technological infrastructures, instructional approaches, and digital learning environments, they had the opportunity to experience educational processes not only in traditional classroom settings but also in digital and remote learning spaces. These courses were part of their regular teacher education curriculum, and the researcher had no instructional role or influence in their delivery. The study did not involve any intervention or manipulation of coursework content or delivery; instead, it focused on participants’ natural learning experiences within their institutional contexts. Therefore, the data reflects participants’ genuine experiences without researcher involvement.

The selection of participants from two different universities was intended to enhance the diversity of research findings and provide a broader perspective. Pre-service mathematics teachers’ experiences with online education may vary depending on their individual learning styles, the digital tools they used, and their level of engagement in instructional processes. Relying on data from a single university might have resulted in a limited perspective on digital learning processes, whereas selecting participants from two institutions enhances the comprehensiveness and reliability of the research. However, the primary aim of the study is not to compare differences between universities but rather to provide a general understanding of pre-service mathematics teachers’ experiences with online education and their professional perceptions. Therefore, the inclusion of two universities serves solely to ensure data diversity and to reach more comprehensive conclusions.

The data collected through an open-ended written questionnaire, completed individually by all 58 participants. Responses were processed anonymously and analyzed in accordance with ethical principles to ensure confidentiality and research integrity.

2.3 Data collection

2.3.1 Identifying participants’ online and distance engagement

Before initiating the main research, a preliminary evaluation survey was conducted to identify the digital platforms and social media tools used by participants during their online and distance education experience. In this initial phase, participants were asked the question: “Which digital platforms or applications have you used in your online or distance education experience?” They were expected to specify the tools they had used, including university-based learning management systems (such as Moodle or ALMS), educational social media platforms, mobile applications, and interactive learning environments. This initial evaluation provided insights into participants’ digital engagement patterns and helped contextualize their familiarity with digital environments. These insights also informed the development of the open-ended questions used in the main phase of the study, which focused on professional development and career-related perspectives.

The data obtained from this preliminary phase were analyzed using frequency and percentage values to contextualize participants’

TABLE 1 Online platforms used by participants.

Platform type	Usage rate (%)	Number of users (n)	Example platforms
Educational social media	75.9%	44	YouTube, Instagram (Educational Pages)
Digital course materials	65.5%	38	Khan Academy, EBA, Coursera
Academic forums and blogs	34.5%	20	Research Gate, Medium, Academic Blogs
Teacher communities (social networks)	19.0%	11	Facebook Groups, Telegram Channels
Interactive learning tools	17.2%	10	Kahoot, Mentimeter, Quizlet

backgrounds and levels of digital familiarity, thereby helping to frame their responses in the main phase of the study. Table 1 presents the distribution of platform usage as reported by the participants.

As presented in Table 1, all participants reported having used at least one digital tool or platform as part of their online and distance education experiences. A substantial proportion (75.9%, $n = 44$) engaged with educational social media platforms such as YouTube and Instagram educational pages. Digital course materials were also widely accessed (65.5%, $n = 38$), followed by academic blogs and forums (34.5%, $n = 20$). In contrast, participation in teacher communities (19.0%, $n = 11$) and the use of interactive learning tools (17.2%, $n = 10$) were relatively limited. These findings indicate that while participants were exposed to a range of digital tools, the frequency and depth of their engagement varied considerably depending on the platform type.

2.3.2 Main data collection tool: open-ended questions

In the second phase of the study, a questionnaire consisting of open-ended questions was administered to explore pre-service mathematics teachers' experiences with online and distance education, their professional preferences, and their use of digital platforms. This followed the initial phase, which identified participants' prior engagement with digital tools. The questions were designed to examine how digital learning environments influenced their career perceptions and professional development, considering changes in employment conditions, the shift toward online teaching, and alternative career pathways.

The following open-ended questions were posed to pre-service teachers:

1. How have the courses you took during the distance education process influenced your perception of the teaching profession?
2. Do you create educational content on digital platforms? Why?
3. How have the educational resources accessed through digital platforms shaped your professional development?
4. How do digital platforms contribute to students in mathematics education?
5. Do you consider teaching through distance education as a future career option? Why?

6. What are the advantages of distance education in mathematics education?
7. What are the disadvantages of distance education in mathematics education?

2.4 Validity and reliability assessment

The formulation of the research questions was guided by existing literature, expert consultation, and a pilot study to ensure their alignment with the study's objectives. Studies on digital learning environments, professional identity development, and technology integration in teacher education (Koehler and Mishra, 2009; Sang et al., 2010) provided a theoretical foundation, highlighting the impact of online and distance education on pre-service teachers' professional growth, career decisions, and engagement with digital learning tools. These studies emphasized how teachers' perceptions of the profession evolve through their experiences with digital platforms, which informed the initial development of the research questions.

To further refine the questions, expert evaluations and a pilot study were conducted. Two educational science experts and one assessment and evaluation specialist reviewed the questions to assess their clarity, relevance, and alignment with the research objectives. Additionally, a pilot study with five pre-service mathematics teachers was conducted to evaluate the comprehensibility and neutrality of the open-ended questions. The feedback from both experts and participants led to several refinements, ensuring that the final questions effectively captured pre-service teachers' experiences with digital and distance education.

Following the pilot study, some questions were found to be too broad or lacking specificity, necessitating revisions to ensure a more structured and focused inquiry. For example, the original question "What do you think about online education?" was considered too vague and was divided into two distinct questions: "What are the advantages of distance education in mathematics education?" and "What are the disadvantages of distance education in mathematics education?" This modification ensured that participants provided more detailed and balanced reflections rather than general opinions. Similarly, some questions were adjusted to eliminate potential bias or overly narrow phrasing. The initial question "Do you think online education affects professional development?" was revised to "How have the educational resources accessed through digital platforms shaped your professional development?" to encourage participants to discuss specific tools and experiences rather than simply confirming an effect. Additionally, "Do you use social media for educational purposes?" was modified to "How do digital platforms contribute to students in mathematics education?" to broaden the scope beyond social media and allow for discussions on various digital learning environments. Through these refinements, the final set of questions became more precise, neutral, and reflective of pre-service mathematics teachers' experiences in digital and distance learning settings.

2.5 Implementation process

The data collection process was carried out in two stages. In the first stage, a preliminary assessment was conducted to gain a general

understanding of pre-service teachers' online and distance education experiences and their interactions with digital platforms. This pre-test aimed to refine the scope of the open-ended questions and ensure that the main data collection phase gathered more in-depth information. By identifying key themes and potential challenges in advance, this initial assessment helped structure the research instrument more effectively. In the second stage, the main data collection process was carried out using open-ended questions to explore pre-service teachers' experiences with online and distance education, their use of digital teaching materials, and their perspectives on professional development. All data were collected online via Google Forms, allowing for a detailed examination of the relationship between distance learning experiences and career planning.

2.6 Data analysis

The collected data were analyzed using the content analysis method. Participants' responses were grouped into specific themes, and a systematic analysis of the dataset revealed patterns related to their online and distance learning experiences. Following [Miles and Huberman's \(1994\)](#) content analysis framework, participant responses were repeatedly reviewed, an open coding process was applied to generate initial codes, and similar codes were merged into main themes and sub-themes. This approach allowed for a structured representation of pre-service teachers' experiences with online and distance learning and social media usage. To ensure coding reliability, responses were independently coded by two different researchers, and their coding findings were compared. The inter-coder agreement was calculated at 92%, indicating high reliability in the coding process.

Through thematic analysis, the advantages, challenges, and contributions of online and distance learning to professional development were examined in detail. Descriptive analysis was also applied, and findings were supported by direct quotations from participants to strengthen the interpretations.

2.7 Role of the researcher

In this study, the researcher played an active role in every stage of the data collection process. At the initial stage of the study, existing literature on online and distance education, teacher training, and digital platform usage was reviewed to develop the research questions. This review informed the scope and direction of the open-ended questions used in data collection. Factors such as changes in employment conditions, the shift toward digital platforms, and alternative career paths were considered based on relevant literature ([Bozkurt and Sharma, 2022](#); [Greenhow and Askari, 2017](#)).

The researcher managed the revision of the questions based on expert feedback, conducted the pilot study, conducted the pre-test to improve the validity of the data collection tool, and ensured that the final survey effectively captured the intended research objectives. During the main data collection phase, the researcher facilitated communication with participants, ensuring accurate, comprehensive, and unbiased data collection. In the analysis phase, the researcher contributed to coding reliability by collaborating with independent researchers, supporting content analysis, and assisting in the interpretation of findings.

3 Findings

Findings for each question will be presented by categorizing responses into themes along with their frequency and percentage values (see [Table 2](#)).

Question 1: How have the courses you took during the distance education process influenced your perception of the teaching profession?

This question was designed to assess the impact of pre-service teachers' experiences during the distance education process on their professional perceptions. The table below presents the obtained data.

The table illustrates the impact of distance education experiences on pre-service teachers' professional perceptions. A significant portion of the participants (43.1%) found the flexibility offered by distance education to be beneficial, while 29.3% stated that it enhanced their teaching skills, and 15.5% reported gaining competencies in technology use. On the other hand, 6.9% of respondents considered face-to-face education to be more effective, whereas 5.2% believed that distance education was not suitable for the nature of teaching. Overall, the majority of pre-service teachers acknowledged the contribution of distance education to their professional development. Participants who appreciated flexibility often mentioned the comfort of accessing lessons anytime and anywhere. Those who felt their teaching skills improved shared experiences about preparing online content and using educational tools. While only a few participants expressed negative views, their responses show that limited interaction in online settings can influence how they perceive effective teaching. Overall, the frequencies help identify which ideas were more common, while the example responses reflect the variety in how distance education shaped their thinking (see [Table 2](#)).

Question 2: Do you create educational content in digital platforms? Why?

This question aimed to explore pre-service teachers' engagement in producing educational content on social media and their experiences throughout this process. The table below presents the obtained data.

Based on the data presented in the table, the majority of responses come from pre-service teachers who do not currently produce content but intend to explore this process after graduation. Additionally, a notable group consists of those who have started creating content but have not yet published it. These responses suggest a growing awareness of the importance of content creation, though many feel unprepared or hesitant to share publicly at this stage. Some pre-service teachers contribute to the educational process by sharing high-quality existing content rather than producing their own. This indicates a preference for curating rather than creating, possibly due to concerns about confidence, expertise, or audience. The proportion of pre-service teachers actively sharing educational content is relatively low (see [Table 3](#)).

Question 3: How have the educational resources accessed through digital platforms shaped your professional development?

TABLE 2 The impact of distance education on pre-service teachers’ professional perceptions.

Theme	<i>f</i>	%	Example response
I appreciated the flexibility of distance education	25	43.1%	“Being able to attend classes regardless of time and place showed me that teaching can be practiced in different ways.”
Distance education improved my teaching skills	17	29.3%	“I realized the importance of using digital tools in teaching and improved myself in preparing online materials.”
It enhanced my technology-related skills	9	15.5%	“I learned educational software that I had never used before and discovered how to integrate them into teaching.”
I found face-to-face education more effective	4	6.9%	“I noticed that interacting with students is more challenging in an online environment; face-to-face education feels more efficient.”
It had a negative impact; it is not suitable for the nature of teaching	3	5.2%	“The lack of direct interaction with students weakens one of the most essential aspects of the teaching profession—engagement.”
Total	58	100%	

TABLE 3 Pre-service teachers’ tendencies toward producing educational content on digital platforms.

Theme	<i>f</i>	%	Example response
I do not create content, but I plan to after graduation	28	48.3%	“I am currently just observing; I will start creating content after graduation.”
I do not create content, but I follow educational content	15	25.9%	“I follow educational content on digital platforms, but I have not considered producing it yet.”
I create educational content but have not published it yet	6	10.3%	“I develop my own content, but for now, I am only keeping it in my archive.”
I do not create content, but I share existing materials	5	8.6%	“I do not create my own content, but I share high-quality videos and materials with my followers.”
I do not intend to use digital platforms for teaching	3	5.2%	“I do not think using digital platforms is necessary for teaching.”
I create and publish educational content	1	1.7%	“I share short videos related to mathematics lessons.”
Total	58	100%	

TABLE 4 The impact of education received through digital resources on teaching perceptions.

Theme	<i>f</i>	%	Example response
I believe it will enhance my teaching skills	19	32.8%	“Through videos, I have learned better instructional techniques.”
I have become more open to technological opportunities	15	25.9%	“I plan to integrate digital tools into my teaching practices.”
I have realized the need to improve myself technologically	14	24.1%	“I have realized that I need to develop my digital skills for effective teaching.”
I have gained awareness of student motivation	7	12.1%	“I have discovered social media-based learning strategies to engage students.”
I think it has had a negative impact / I did not feel its effect	3	5.2%	“Digital platforms sometimes provide overly superficial content, and they have not had a significant impact on my perception of teaching.”
Total	58	100%	

This question was designed to assess the impact of education received through digital resources on pre-service teachers’ perceptions of the teaching profession. The table below presents the obtained data.

This table highlights the impact of digital resources on pre-service teachers’ perceptions of teaching. Many participants noted that digital education has enhanced their teaching skills and made them more open to using technological tools in their practices. Responses like “I plan to integrate digital tools into my teaching practices” suggest that pre-service teachers are actively considering how to apply what they have encountered into real classroom contexts. They also emphasized the need to improve their digital competencies for effective teaching. Additionally, some teachers became more aware of student motivation and discovered new ways

to engage students using social media-based learning strategies. These insights indicate that digital platforms serve not only as a content source but also as inspiration for student-centered approaches. However, a few participants expressed concerns about the superficial content on digital platforms, stating that it has not significantly impacted their teaching perceptions (see Table 4).

Question 4: How do digital platforms contribute to students in mathematics education?

This question aimed to evaluate pre-service teachers’ perspectives on how the use of digital platforms contributes to students’ learning processes. The table below presents the obtained data.

This table illustrates how pre-service teachers evaluate the impact of digital platforms on students in mathematics education. The majority of respondents believe that digital environments provide a more visual and interactive learning process and support individualized learning. These responses reflect a recognition of the role of multimedia tools in making abstract mathematical concepts more accessible and adaptable to different learning styles. Some pre-service teachers also noted that digital resources increase students' engagement in lessons and grant access to diverse educational materials. The emphasis on student motivation, especially through social media-based content, suggests that pre-service teachers are aware of the potential of digital tools to reshape students' attitudes toward mathematics. However, a small number of participants expressed uncertainty about the necessity of digital environments in mathematics teaching (see [Table 5](#)).

Question 5: Do you consider teaching through distance education as a future career option? Why?

This question was designed to understand pre-service teachers' perspectives on the possibility of pursuing a teaching career through digital and online platforms. Responses were analyzed and categorized into themes, with frequency and percentage values calculated. The table below presents the obtained data.

This table evaluates pre-service teachers' perceptions of teaching through digital and online platforms as a potential future career path. A significant proportion of pre-service teachers highlighted the potential of digital environments to reach a broader student base, provide additional income, and offer flexible working conditions. These responses suggest that participants see distance education not only as a temporary solution, but as a viable professional model with expanding opportunities. Additionally, some pre-service teachers emphasized the alternative employment opportunities that digital platforms provide, particularly in response to decreasing job opportunities in the public education sector. This reflects a realistic and strategic approach to adapting their professional goals to evolving job markets. On the other hand, some participants expressed concerns about the long-term sustainability of digital teaching, while a small group firmly believed that teaching should be conducted in a face-to-face classroom setting, arguing that digital platforms lack the same level of student-teacher interaction. These views underscore the importance participants place on relational aspects of teaching, which they believe are difficult to replicate online (see [Table 6](#)).

Question 6: What are the advantages of distance education in mathematics education?

This question aimed to assess how pre-service teachers perceive the positive aspects of distance education in mathematics education. The table below presents the obtained data.

This table provides an overview of how pre-service teachers assess the benefits of distance education in mathematics education. Most respondents highlighted its ability to provide more flexible learning opportunities and reach a broader audience. Some pre-service teachers also emphasized that visual and interactive content enhances students' comprehension of mathematical concepts. Additionally, advantages such as individualized feedback and lower costs were also mentioned (see [Table 7](#)).

Question 7: What Are the Disadvantages of Distance Education in Mathematics Education?

This question aimed to assess how pre-service teachers perceive the negative aspects of distance education in mathematics education. The table below presents the obtained data.

This table summarizes pre-service teachers' perceptions of the drawbacks of distance education in mathematics education. The most frequently mentioned issue is the lack of face-to-face interaction, which participants identified as a challenge in engaging directly with students. Another commonly cited concern is challenges in adapting to digital innovations, as some respondents found it overwhelming to keep up with new digital tools and instructional technologies. Additionally, distraction during learning and difficulties in providing feedback were reported, indicating that maintaining student focus and offering individualized guidance can be difficult in a digital environment. Internet connectivity problems and limited technical access were also noted as obstacles to participation. Lastly, concerns about information reliability and content accuracy were mentioned, as some pre-service teachers found it difficult to verify the accuracy of mathematical content shared on digital platforms (see [Table 8](#)).

4 Discussions

This study examines the impact of distance education experiences on pre-service elementary mathematics teachers' professional perceptions, their tendencies toward digital content creation, and their perspectives on social media-based teaching processes. The findings

TABLE 5 Benefits of using digital platforms in mathematics education for students.

Theme	<i>f</i>	%	Example response
Facilitates more visual and interactive learning	39	39.7%	"Videos and visuals make concepts more comprehensible."
Provides students with individualized learning opportunities	24	20.7%	"Students can learn at their own pace."
Enhances student engagement in lessons	19	19.0%	"Especially through mathematics content on social media, students develop a more positive attitude toward the subject."
Provides access to diverse educational resources	12	17.2%	"They can listen to lessons from different teachers and sources."
I am uncertain about this	4	3.4%	"I am not sure whether digital environments are necessary for mathematics teaching."
Total	58	100%	

TABLE 6 Perception of teaching through distance education as a future career option.

Theme	<i>f</i>	%	Example response
Yes, it allows reaching a larger number of students	29	32.8%	"I can provide education to a broad audience without students needing private lessons."
Yes, it provides additional income and flexibility	27	32.8%	"By teaching through social media, I can generate financial income."
It offers alternative employment opportunities	22	15.5%	"Since opportunities for public sector employment are decreasing, I can sustain my profession through digital platforms."
It has advantages, but I am unsure about its sustainability	13	13.8%	"Teaching through social media seems appealing, but I am uncertain about its long-term effectiveness."
No, I believe teaching should be conducted face-to-face	5	5.2%	"I do not think teaching without a real classroom environment can be effective."
Total	58	100%	

TABLE 7 Advantages of distance education in mathematics education.

Theme	<i>f</i>	%	Example response
Provides students with flexible learning opportunities	31	53.4%	"Students can learn mathematical concepts at their own pace."
Enables reaching a broader audience	11	19.0%	"I can teach mathematics to more students without physical constraints."
Offers visualized and interactive content	9	15.5%	"Videos and interactive simulations make mathematical concepts more comprehensible."
Allows for individualized feedback	4	6.9%	"I can provide step-by-step feedback on students' problem-solving approaches."
Cost-effective compared to traditional education	3	5.2%	"It can be a more affordable alternative to private tutoring in mathematics."
Total	58	100%	

TABLE 8 Disadvantages of distance education in mathematics education.

Theme	<i>f</i>	%	Example response
Lack of face-to-face interaction	18	31.0%	"Engaging directly with students becomes more challenging."
Challenges in adapting to digital innovations	16	27.6%	"Adapting to new digital tools and instructional technologies is overwhelming at times."
May cause distraction	9	15.5%	"Students can easily lose focus while learning through digital platforms."
Feedback process can be challenging	7	12.1%	"Providing individualized feedback takes more time."
Internet access or technical issues may arise	5	8.6%	"Some students cannot attend lessons due to connectivity problems."
Concerns about information reliability and content accuracy	3	5.2%	"It is difficult to verify the accuracy of some content shared on digital platforms."
Total	58	100%	

indicate that most pre-service teachers have adapted to distance education and believe that digital teaching materials and technology-based instructional methods contribute to their professional development. While a few pre-service teachers expressed concerns about limited interaction and adapting to digital tools, the overall responses suggest a recognition of the need to enhance digital competencies. While they are aware of the evolving job opportunities in the private sector and digital platforms, they also understand the necessity of further development in these areas to stay competitive and meet the demands of the changing educational landscape. This study contributes to the field by highlighting how distance education experiences shape pre-service mathematics teachers' professional perceptions and digital engagement practices, offering insight into evolving pedagogical needs in mathematics education.

Since mathematics education inherently requires the understanding of abstract concepts, the integration of digital tools

as a supportive element in teaching processes emerges as a key finding of this research. The abstract nature of mathematics, coupled with the need for visual and interactive tools to support learning, highlights the importance of incorporating digital platforms to enhance the learning experience. Participants in this study indicated that the effective use of digital platforms can help overcome the challenges of teaching abstract mathematical concepts by making them more visual and interactive. They further emphasized that digital tools can provide dynamic ways to illustrate concepts, making them more accessible to students. Similarly, Koehler and Mishra's (2009) Technological Pedagogical Content Knowledge (TPACK) Model stresses that teachers should be equipped not only with pedagogical and subject-matter knowledge but also with technological proficiency. In this context, the findings of this study suggest that pre-service elementary mathematics teachers are becoming increasingly aware of the active use of digital tools in their

profession and are inclined to develop these competencies further. Moreover, participants recognized that when distance education is utilized, this technological proficiency enables more effective mathematics instruction, aligning with the nature of the subject. Although there may be some social interaction limitations compared to face-to-face teaching, digital platforms present opportunities for rich, interactive learning experiences that are well-suited to the demands of teaching mathematics.

When evaluating pre-service teachers' tendencies toward digital content creation, the findings reveal that while most have not yet actively produced educational content, they are interested in the field and plan to do so in the future. Notably, pre-service teachers tend to use social media and online platforms primarily for information consumption rather than active content creation. This aligns with the findings of [Greenhow and Lewin \(2019\)](#), who argue that teachers do not fully understand how to utilize social media and digital platforms pedagogically but would benefit from targeted support and structured opportunities that foster pedagogical use of these tools. Additionally, [Ranieri et al. \(2012\)](#) highlight that teachers' active participation as content creators in digital platforms enhances their professional competence and increases student engagement. However, the findings of this study suggest that pre-service elementary mathematics teachers are in the early stages of building confidence for digital content creation, despite having plans to engage in content creation in the future. Recent studies reinforce these observations. [Marais \(2023\)](#) reported that although many pre-service teachers developed strong digital competencies through coursework and portfolios, they still struggled with producing pedagogical content independently and desired more scaffolded support. [Labor and Escandallo \(2024\)](#) similarly found that teachers need structured curricular frameworks to effectively transform literacy into digital resource production. Furthermore, [Chen et al. \(2025\)](#), in their systematic review, emphasize that while pre-service teachers exhibit solid general digital literacy, they lack institutional backing and formal opportunities to transition into active content creators.

In recent years, the reduction in government hiring quotas for elementary mathematics teachers has increased competition among teacher candidates seeking employment in this field. The shrinking job opportunities in the public sector have led pre-service teachers to explore alternative career pathways. In this regard, proficiency in digital and technology-supported teaching methods creates new opportunities for pre-service teachers in the private sector and distance education platforms. Particularly in private schools, online courses, and independent educational platforms, teachers who can produce digital content and effectively manage distance education processes are increasingly preferred. Moreover, pre-service teachers have begun to shape their professional careers by establishing their own brands through social media, YouTube, online learning platforms, and private tutoring systems. Given that mathematics education involves abstract concepts, digital tools can facilitate more effective learning experiences for both teachers and students. Therefore, developing digital competencies enables pre-service teachers to gain a competitive advantage in the private sector, reinforcing their future employment prospects.

Additionally, the global digitalization of education systems and the increasing necessity for teachers to possess technology-integrated instructional skills have led to significant changes in teacher training programs ([Selwyn, 2021](#)). In countries such as the United States, Canada, and Finland, teacher preparation programs are now assessed

not only based on traditional classroom teaching skills but also on digital pedagogical competencies ([Kimmons and Veletsianos, 2014](#)). For example, in Estonia and Sweden, knowing how to use technology-supported teaching and effectively manage distance education processes has become a key determinant of teachers' professional success ([Christine, 2017](#)). A similar transformation is expected globally making it crucial for pre-service elementary mathematics teachers to adapt to this process for both their individual professional development and the future of the education system. In this context, pre-service mathematics teachers should engage more in digital content creation, and teacher education programs should incorporate more hands-on training to develop these skills. While this study provides significant insights into how pre-service teachers' distance education experiences shape their professional perceptions, the findings also show that pre-service math teachers, recognizing the importance of having strong digital competencies for effective teaching, are becoming increasingly aware of the necessity of being equipped with these skills. This is consistent with previous research highlighting the critical role of technological pedagogical content knowledge and digital proficiency in teacher preparation ([Koehler and Mishra, 2009](#); [Tondeur et al., 2012](#); [Kay, 2006](#); [Redecker and Punie, 2017](#)). Moreover, the participants in this study expressed a tendency to consider distance education as a future career pathway, particularly in response to the growing uncertainty in securing public sector employment. In recent years, global education systems have undergone substantial transformations. The COVID-19 pandemic, along with large-scale natural disasters in different parts of the world, particularly the devastating earthquakes in early 2023, has made distance education an inevitable necessity in instructional processes. While the pandemic compelled teachers and students to adopt online learning tools, post-earthquake distance education implementations in affected regions have reinforced the perception of online learning as a viable long-term alternative. Consequently, the demand for digital teaching methodologies has increased, making it more critical for pre-service teachers to learn and implement technology-supported teaching strategies.

The findings of this study suggest that pre-service elementary mathematics teachers recognize the impact of distance education on their professional perceptions and have developed a growing interest in digital competencies. Since mathematics education involves abstract concepts, technology-supported teaching methods have the potential to enhance students' learning experiences. However, most pre-service teachers indicated that they require further guidance in digital content creation and the management of technology-based instructional processes. These findings align with these findings align with previous research. [Bozkurt and Sharma \(2022\)](#), in their study on the effects on pre-service teachers, emphasized that the ability to adapt to distance education has become increasingly important for shaping teachers' professional identities. Similarly, [Hodges et al. \(2020\)](#) argue that while distance education transforms pre-service teachers' pedagogical skills, it also presents challenges in terms of interaction and hands-on learning. The findings of this study similarly indicate that pre-service elementary mathematics teachers recognize the impact of distance education on their profession but require additional support to manage the process more effectively.

Furthermore, pre-service teachers' growing interest in digital competencies may also be linked to changes in Türkiye's educational policies and teacher recruitment processes. In recent years, the

reduction of elementary mathematics teaching positions in government hiring has led pre-service teachers to seek alternative career paths in the private sector and digital platforms. Skills in digital content production and online instruction provide significant advantages for pre-service teachers seeking to sustain their professional careers through private schools, online courses, and one-on-one tutoring systems. [Christine \(2017\)](#), in the analysis of digital education policies in Europe, emphasizes that teachers' ability to deliver technology-supported instruction has become a key factor in employment processes. Similarly, [Kimmons and Veletsianos \(2014\)](#) argue that teachers' active engagement in social media and digital platforms strengthens their professional identities and enhances alternative career opportunities.

In this study, the distance and online education experiences of pre-service math teachers are examined, with a focus not only on the positive aspects but also on the challenges they face. Pre-service math teachers have demonstrated an awareness of both the advantages and disadvantages of distance education. Particularly within the context of mathematics education, they highlighted several challenges associated with digital education. They noted that adapting to certain digital applications can be time-consuming and that digital environments may cause distractions among students. Additionally, they acknowledged the technical difficulties involved, recognizing that learning new technologies and staying updated with technological advancements is both challenging and time-intensive. Despite these challenges, pre-service math teachers emphasized the advantages of digital education, particularly in terms of visualization. They found digital tools effective in making abstract mathematical concepts more accessible. Furthermore, they appreciated the flexibility that digital platforms offer, noting the opportunity to reach a wider audience and enhance teaching practices.

These findings indicate that pre-service elementary mathematics teachers must be equipped not only with traditional instructional skills but also with digital pedagogical competencies. The shift in global education policies and the increasing integration of technology into education system necessitate the development of digital skills among pre-service teachers. To help future teachers assess their profession from a broader perspective, teacher training programs should allocate more emphasis on digital content creation and technology-supported instructional processes.

This study reveals the impact of distance education experiences on pre-service elementary mathematics teachers' professional perceptions and their tendencies toward digitalization. The findings suggest that pre-service teachers are becoming increasingly aware of the effective use of digital tools; however, they still require guidance on fully integrating these skills into their instructional practices. In the process of digital transformation in education, it is essential to develop policies that not only train pre-service teachers as content consumers but also enable them to become active digital content creators.

5 Limitations

This study is limited to the experiences and perceptions of 58 pre-service elementary mathematics teachers from two universities. The findings are based on self-reported data collected through

online forms, which may reflect subjective interpretations. Additionally, the study does not include in-depth observations or longitudinal tracking of participants' professional development over time. Therefore, the findings should be interpreted within the context of these limitations.

6 Suggestions

Based on the findings of this study, it is crucial to enhance the digital pedagogical competencies of pre-service elementary mathematics teachers by integrating technology-supported instructional methods more effectively into teacher training programs. Studies such as [Koehler and Mishra \(2009\)](#) emphasize the importance of Technological Pedagogical Content Knowledge (TPACK), suggesting that structured opportunities for practice and mentorship are essential in developing content creation and digital teaching competencies. Therefore, increasing the number of practicum-based courses and offering sustained mentoring experiences may enhance teachers' readiness for digital instruction. Additionally, organizing workshops and seminars on digital teaching methods can foster active participation in digital content development, which has been linked to improved student engagement and teacher self-efficacy ([Ranieri et al., 2012](#); [Greenhow and Lewin, 2019](#)). Given the current employment conditions, pre-service teachers should be encouraged to explore alternative career pathways in the private sector, including private schools, online education platforms, and independent tutoring systems, where distance education proficiency provides a strategic advantage. Future research should focus on developing structured training programs that equip pre-service teachers with digital skills and assess the long-term effectiveness of digital teaching in mathematics education. In line with findings from [Bozkurt and Sharma \(2022\)](#), such research should also investigate the pedagogical quality of digital environments and their implications for equity and access in mathematics learning. Additionally, exploring ways to optimize digital learning environments for conceptual understanding and student engagement will provide valuable insights. Conducting longitudinal studies on how pre-service teachers transition into distance education-based careers and evaluating their adaptability in digital teaching environments can offer critical guidance for designing adaptive and future-ready teacher education policies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The requirement of ethical approval was waived by Izmir Demokrasi University Ethics Committee – Educational Research Unit. The committee confirmed that this study was exempt from full ethical review as it involved voluntary and anonymous participation of adult pre-service teachers without any intervention for the studies.

involving humans because the study involved voluntary participation of adult pre-service teachers, with no intervention, medical procedures, or collection of sensitive personal data. Therefore, according to the institutional policy, ethical approval was not required. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because the study involved minimal risk and participants were informed about the purpose and voluntary nature of the research through an introductory statement in the online questionnaire. Since no identifiable personal data were collected, written informed consent was not required according to institutional guidelines.

Author contributions

BD: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

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