Contemporary Educational Technology, 2026, **18**(2), ep654
ISSN: 1309-517X (Online)

OPEN ACCESS

Research Article

Navigating the digital divide: An in-depth exploration of ICT devices, knowledge, belief, usage, and attitude in educational settings

Zhansaya Bakytbekova [1*]
0009-0008-0634-0491

Mary F. Rice [2]
0000-0002-8138-512X

Esad Esgin [3]
0009-0005-0132-9857

Guldina Kamalova [1]
0000-0001-6406-8897

Shirinkyz Shekerbekova [1]
0000-0003-4778-4132

[1] Abai Kazakh National Pedagogical University, Almaty, KAZAKHSTAN
[2] University of New Mexico, Albuquerque, NM, USA
[3] Independent Researcher, Athens, GREECE
[*] Corresponding author: sungirlkz1@gmail.com

Citation: Bakytbekova, Z., Rice, M. F., Esgin, E., Kamalova, G., & Shekerbekova, G. (2026). Navigating the digital divide: An in-depth exploration of ICT devices, knowledge, belief, usage, and attitude in educational settings. *Contemporary Educational Technology, 18*(2), Article ep654. https://doi.org/10.30935/cedtech/18530

ARTICLE INFO

Received: 10 Nov 2025
Accepted: 12 Apr 2026

ABSTRACT

Information and communication technologies (ICT) play an increasingly important role in modern education, shaping how teachers access information, design instruction, and support student learning. Understanding the factors that influence ICT engagement among teachers is therefore critical for effective technology integration. This study explored the relationships between demographic factors, technology ownership, and teachers' knowledge, beliefs, usage, and attitudes toward ICT in educational settings. The study involved 160 university students from Almaty, Kazakhstan, who completed a comprehensive survey assessing their ICT device ownership, knowledge, usage frequency, and attitudes toward ICT. Mediation analysis was conducted to investigate the role of beliefs in the relationship between attitudes and ICT usage. The findings revealed significant correlations between ICT knowledge, attitudes, and usage. Although beliefs about ICT partially mediated the relationship between attitudes and usage, attitudes had a substantial direct effect on ICT usage. Gender and grade level did not show significant differences in ICT engagement. The findings suggest that fostering positive attitudes towards ICT among teachers is crucial for enhancing its integration in educational settings. These findings provide practical views about teacher education and policy by highlighting the importance of increasing positive attitudes toward ICT to support more effective and meaningful integration of technology in educational settings

Keywords: ICT in education, digital divide, ICT knowledge, technology integration, belief mediation

INTRODUCTION

In educational settings, information and communication technologies (ICT) systematically organizes a set of data transmission tools, information resources, interaction protocols, hardware-software, and

organizational and methodological support. Four key parts can be considered when defining ICT in education: an instrument that relates to learning about ICT, a supporting tool, a medium for educational objectives, and a tool for school organization and management. Using ICT in educational settings used to be more skills-based, such as uploading a document, or maneuvering a mouse—but modern ICT use has been reconceptualized toward an arrangement of complex digital literacies that involve complex decision making about what tool to use, how to critically evaluate information, and where to share products and artifacts made with programs and applications on devices (Rice & Bailon, 2023).

Because of the shifting definition and the increased demands for pedagogical complexity, ICT availability in schools does not automatically result in shifts in teaching practices. Teachers must use the ICT they have (Reddy & Babu, 2024). While researchers agree that ICT can improve access to information, the promises made by ICT advocates usually do not live up to the expectations (Garcia & Lee, 2020). To date, there is not enough evidence to support the claim that ICT presence and higher-quality learning are directly correlated, implying that ICT is an insufficient necessity in the transformation of education (Castañeda & Selwyn, 2018; Fischer et al., 2020).

Despite the mixed results, there is evidence that effective usage of ICT in education has the potential to support inclusive education and equitable access to quality learning opportunities by enhancing access to information and accommodating each student's specific needs and challenges (Abendan et al., 2023; Mim & Chowdhury, 2018). Besides, ICT developments combined with the challenges brought on by the COVID-19 pandemic have forced educators to reconsider established teaching approaches (Reddy & Babu, 2024). International studies consistently report that teachers were unable to use the ICT they had to teach online (Ata et al., 2021; Luo et al., 2021; Maksimović & Dimić, 2016). Understanding more about what makes teachers want to adopt available ICT is a useful pursuit (Luo et al., 2021; Shoraevna et al., 2021). These global challenges show the importance of understanding how teachers engage with ICT, including their access to devices, knowledge, attitudes, beliefs, and patterns of usage.

Understanding the differences in digital opportunities is imperative for educators, policymakers, and researchers. The primary aim of this research is to highlight connections between demographic factors, the ownership of ICT devices, and teachers' perceptions regarding the integration of ICT in the teaching-learning process. Grounded in key theoretical framework of the Technological Pedagogical Content Knowledge framework (Mishra & Koehler, 2006), this research seeks to provide visions into the dynamics shaping ICT engagement among teachers. This study holds significance in identifying potential differences in technology access, knowledge, and attitudes among teachers. The findings will contribute to the development of targeted strategies to bridge gaps and enhance the equitable integration of ICT in educational practices.

Although the participants in this study are pre-service teachers, examining their ICT knowledge, beliefs, attitudes, and usage is important because these future educators will soon be responsible for integrating technology into their own teaching practices. Although previous studies have examined teachers' attitudes, knowledge, or ICT usage separately, fewer studies have investigated the relationships among ICT ownership, knowledge, beliefs, attitudes, and usage simultaneously. Moreover, limited empirical evidence exists regarding these relationships among pre-service teachers in Kazakhstan. Therefore, this study aims to explore these interrelated dimensions of ICT engagement.

Research Questions

1. What ICT devices do pre-service teachers own, and how frequently do they use ICT devices, tools, and services?
2. How do pre-service teachers evaluate their knowledge of ICT?
3. What are the relationships among pre-service teachers' attitudes toward ICT, their beliefs about ICT, and their actual ICT usage?
4. Do pre-service teachers' attitudes, beliefs, and ICT usage differ according to demographic characteristics such as gender and grade level?

In this study, we distinguish between attitudes and beliefs regarding educational technology. Attitudes refer to participants' evaluative tendencies toward using digital tools (e.g., whether they feel technology is useful, enjoyable, or burdensome). Beliefs, in contrast, are understood as deeper, more stable conceptions

about the role and purpose of technology in learning, including assumptions about how digital tools should support pedagogy, student engagement, and knowledge construction.

In the context of teacher education, the concept of the digital divide extends beyond mere access to technological devices and includes differences in digital competencies, attitudes, beliefs, and patterns of technology use (Korsah et al., 2025; Wekullo, 2026). Pre-service teachers may have access to ICT devices but still differ in their knowledge of digital tools, their confidence in using them, and their beliefs about their pedagogical value. These differences reflect broader dimensions of the digital divide related to skills, motivation, and meaningful engagement with technology. Therefore, examining ICT ownership, knowledge, attitudes, beliefs, and usage among pre-service teachers provides an important perspective for understanding how future educators may experience and potentially reproduce or reduce digital inequalities in educational settings.

Digital Divide and Its Effects on the Integration of ICT in Education

The so-called *digital divide* refers to the societal disparity between people who have access to the basic ICT required for digital learning, such as computers, smartphones, and the Internet, and those who do not (Cullen, 2001; Garcia & Lee, 2020). Since ICT have become so pervasive in our lives, those who lack or have insufficient access to it are unable to fully participate in society due to the digital divide. The digital divide does not focus only on physical access but also on motivation, competencies, and practical use of ICT. In developing countries, the disparity is often substantially larger (Soomro et al., 2020).

Scholars identified the digital divide as a key issue for social justice in the modern day, given its detrimental consequences on disadvantaged groups. The problem exists all around the world and remains a source of concern for society (Ben Youssef et al., 2022; Rogers, 2016; Soomro et al., 2020). Many related research studies (Dolan, 2016; Moldavan et al., 2022) have highlighted the negative effects that the digital divide has on society and further research on digital equity is necessary, considering all the dimensions (motivational, physical, skills, and usage) of access to ICT (Moldavan et al., 2022; Soomro et al., 2020).

Teachers need to be well-prepared to facilitate students' learning using ICT as schools aim to prepare them to live in a digital-dependent society and work at digital-first businesses (Bordios et al., 2026). However, many today's teachers grew up during a period of transition and possess differing levels of competency and familiarity with the wide range of ICT available to them. Their ability to use ICT to improve student learning and digital competencies is somewhat dependent on how comfortable they are with and utilizing ICT in their daily lives (Hatlevik & Hatlevik, 2018). Beyond that, students' belief in their competency to properly integrate ICT into education influences their decision to do so rather than sticking with established teaching methods (Hatlevik & Hatlevik, 2018).

Relevant literature also emphasizes the difficulties associated with the digital divide and its impact on equitable access to ICT, and the need for coordinated efforts to provide equitable access to ICT and promote an inclusive learning environment (Abendan et al., 2023; Jardin, 2023). These cover a wide range of significant barriers impeding the integration of ICT in education but are not limited to the lack of ICT infrastructures and equipment (e.g., computers, the Internet facilities, projectors), inadequate support for teachers, lack of experience in teaching with ICT, and insufficient ICT training (Reddy & Babu, 2024). Additionally, age as a factor of the digital divide appears to be another significant barrier since it can make older people less able to make sense of large amounts of Internet information, which can lead to feelings of insecurity, fear, and anxiety (McMurtrey et al., 2011). The wider and deeper the effect, the more concerning this trend has grown (Acilar, 2021; Cheng et al., 2022).

Accordingly, the issue of the digital divide among teachers in various contexts must be addressed. Such examinations support implementing appropriate strategies to eliminate or significantly reduce the issue among teachers. These would also aid in advancing the United Nations (2017) sustainable development goals for 2030, which aim to address inequalities in global access to and involvement in education (Soomro et al., 2020).

Teacher-Level Factors Affecting ICT Use

The rapid growth of ICT has transformed students into digital learners, necessitating the integration of ICT into instructional methods by teachers (Akram et al., 2022). A thorough literature review to investigate the complexities of the ICT integration process revealed that discussions on the various elements impacting the integration process have persisted (Lai & Bower, 2019). Over the course of decades, research has revealed that the success of this integration is dependent on several interrelated variables pertaining to teacher characteristics, schools, and educational systems such as the attitudes, ICT knowledge, and abilities of the teachers (Akram et al., 2022; Bingimlas, 2009; Casillas Martín et al., 2020; Ifinedo et al., 2020; Inan & Lowther, 2010; Joo et al., 2016; Petko et al., 2018; Reddy & Babu, 2024). It is critical to comprehend how knowledge, beliefs, attitudes, usage, and the environment interact with one another in terms of the use of ICT in education (Bower, 2019; Casillas Martín et al., 2020; Ifinedo et al., 2020; Reddy & Babu, 2024). In the rest of this section, accordingly, we reviewed the literature thoroughly to identify the interrelation among factors affecting the integration of ICT in education.

Attitude

Attitudes toward ICT can be viewed as a complex construct made up of various components, such as the comfort or anxiety teachers experience when using ICT; the motivation teachers exhibit for using ICT with their students (Admiraal et al., 2020); and the beliefs they have developed over the course of their life regarding the usefulness of ICT.

According to some literature, teachers' attitudes toward ICT effects ICT use for teaching (Cavas et al., 2009; Jardin, 2023). Some researchers have also claimed that teachers are more likely to incorporate ICT into the teaching process if they have more positive affective, cognitive, and behavioral attitudes toward it (Abdullah et al., 2006; Cavas et al., 2009; Guillén-Gámez & Mayorga-Fernández, 2020). In short, the prevailing theory from research has been to place most responsibility for effective ICT use on teacher attitude. There have been some dissenting opinions from this. For example, Rice (2021) used data from rural teachers to demonstrate how teachers who were positive toward technologies and *wanted* to use it were entangled within social, cultural, and political complexities that they were constantly navigating. Thus, while attitude might not be the only factor in ICT use in classrooms, it is one that has been regarded as being capable of peeling off to study and there have been many attempts to isolated it over the years. Findings from these attempts are highlighted below.

Attitude, usage

There is a preoccupation with positive attitudes in ICT usage, as this has been one of the most frequently mentioned factors correlated to ICT use (Cavas et al., 2009; Jardin, 2023; Smith et al., 2000). For example, Ropp (1999) discovered a significant correlation between ICT attitudes and computer access as well as weekly computer usage hours among pre-service teachers. According to the results of Drossel et al. (2017), the antecedents regarding teachers' attitudes have the most significant impact on the frequency of computer use.

Attitude, knowledge

Studies reveal that teachers' attitudes and digital competence are two crucial factors impacting teachers' ICT usage in education (Kucirkova et al., 2019). Moreover, pre-service teachers' attitudes toward ICT are significantly and positively correlated with their ICT knowledge, suggesting a causal relationship between the two (Luo et al., 2021; Tondeur et al., 2020). It was also demonstrated that the attitudes of the pre-service teachers and their ability to use such technology and ICT knowledge and skills are crucial to the success of the integration of ICT in education (Aljuzayri, 2021; Mahdum et al., 2019). Akkoyunlu (1996) discovered that there is a relationship between teachers' knowledge of ICT and their attitude toward it. According to this study, the more knowledge about ICT, the more positive attitude toward the use of it in teaching education. The dominant theme of most studies of attitude and technology is that if teachers would just accept ICT without complaint, then ICT use to teach would be so much easier. It is debatable whether that is an appropriate stance to take toward teachers' professional knowledge.

Attitude, knowledge, usage

Casillas Martín et al. (2020) found that pre-service teachers self-evaluate their attitude toward ICT as favorable, their use of it as moderate, and their knowledge of it as scarce. It became evident that they lacked the necessary digital proficiency to be referred to as "digital natives" and that they would not be able to use ICT effectively for their future academic or professional endeavors.

Knowledge, usage, belief

According to a study by Ocak and Akdemir (2008), science teachers' ICT usage and ICT literacies have relationships. Additionally, teachers who have more experiences with ICT use more ICT in their lessons (Cavas et al., 2009). Several studies (Abbasi et al., 2022; Akram et al., 2022; Casillas Martín et al., 2020) found a strong correlation between teachers' ICT knowledge their use of it in education.

Also, some teachers might avoid using technologies *because* they have knowledge about ICT and their belief that using it in certain instances would be detrimental to students. For example, Rice and Cun (2021) pointed out that young children's access to and use of ICT in educational settings could be a carefully choreographed matter based on knowledge of child development, communication with parents, and the teacher's goals sociality and other matters. The goal is not to have teachers use ICT indiscriminately, but thoughtfully, and in the children's best interest.

ICT ownership

Access to ICT devices is foundational for the digital age and key instruments for supporting students in using knowledge competently for work (Pelgrum, 2001). According to the UNESCO framework of media and information literacy curriculum for teachers, educating students successfully in the digital age requires teachers to have a deeper understanding of ICT (Guvercin, 2025; Wilson et al., 2011). Furthermore, education in the digital era has evolved beyond just integrating ICT for educational objectives. To alter their practices using technological advancements, teachers must acquire new skill sets as designers, mentors, facilitators, and evaluators (Mishra & Koehler et al., 2016).

Numerous studies have investigated the impact of ICT ownership on teachers' attitudes toward ICT, their belief in their computer skills, and their focus on enhancing the quality of their existing practice, and there is a constant correlation between ICT ownership and attitudes toward ICT as well as favorable outcomes when creating instructional materials (Cavas et al., 2009; Roussos, 2007). The findings of Cavas et al. (2009) showed that computer ownership at home had a significant effect on teachers' attitudes toward ICT.

Gender

One of the most studied factors in attitudes toward ICT is gender. According to the literature, there are inconsistent findings when it comes to gender (Cavas et al., 2009). While some research implies that male teachers exhibited more positive attitudes toward ICT than female teachers (Guillén-Gámez & Mayorga-Fernández, 2020), other studies find little to no variations in the attitudes of teachers based on their gender (Badia et al., 2017; Cavas et al., 2009; Kpolovie & Awusaku, 2016). It is not understood how the design of the studies, or the genders of the researchers affected the outcomes of these studies.

One example of such a study came from Esgin et al. (2016). These researchers examined gender differences in computer-related achievement, anxiety, and attitude with a meta-analysis in Turkey sample. While they found that the effect of gender on computer achievement, computer anxiety, and computer-related attitude is in favor of male students, this effect is negligible or small. Another paper (Guillén-Gámez & Mayorga-Fernández, 2020) investigated the predictor variables of ICT attitudes and showed that gender is one of them.

According to Reddy and Babu (2024), male teachers frequently viewed online teaching as more enjoyable, whereas female teachers typically indicated that they faced greater pressure. The impact of occupational stress on teachers' beliefs is also examined in the study, and it is discovered that gender has no discernible effect on how teachers view the interaction between occupational stress and the experience of teaching online. Again, it is difficult to separate the stress of using ICT from other potential stresses placed on women in a professional context.

METHODOLOGY

This study employed a quantitative survey research design to examine pre-service teachers' ICT ownership, knowledge, beliefs, attitudes, and usage. Given that the research questions focus on identifying patterns of ICT access, self-reported knowledge, usage behaviors, and relationships among attitudes and beliefs, a survey-based strategy provides an efficient and suitable method for addressing these research objectives.

Participants

This study was carried out with 160 university students from Almaty, Kazakhstan. There were 78 female and 37 male students. They were students of informatics from 1 to 4th grade (1st grade 32, 2nd grade 22, 3rd grade 30, and 4th grade 19 students) at the physics-mathematic-informatics institute. This group once graduated will have diploma in teaching informatics at both middle and secondary schools. The population of the students in the institute is about 3,323 students. Among them: 2,861 undergraduate students, 462 graduate students and 36 doctoral students. The share of foreign students is 3% (80 people). At the same time, 92% of students are holders of state educational grants.

This university was established in 1928 during the Soviet Union. In the university there are about 16,000 students in seven different institutes. Some of the general courses in the informatics department are as follows: theory and methodology of teaching computer science, digitization of education, robotics and mechatronics, STEM approaches in education, information systems, and high technologies in education.

Instrument

The instrument used in this study was a research-developed questionnaire designed to assess university students' engagement with ICT. The questionnaire consisted of seven sections covering demographics, ICT device ownership, self-rated knowledge, frequency of use of ICT devices, tools and services, and perceptions of ICT including attitudes, benefits, and beliefs.

The perception section of the instrument consisted of three dimensions: attitude, perceived benefits, and beliefs about ICT in education. The attitude dimension measured participants' general views about the role of ICT in the teaching-learning process (e.g., *"The use of ICTs in the teaching-learning process is important"* and *"The use of ICTs makes the teaching-learning process more interesting"*). The benefit dimension focused on the perceived instructional advantages of ICT integration (e.g., *"The use of ICTs helps me organize the teaching-learning process better"* and *"The use of ICTs helps me integrate the curriculum and teaching-learning process"*). The belief dimension assessed participants' beliefs about the pedagogical value of ICT for student learning (e.g., *"I believe that ICTs enhance students' learning in the teaching-learning process"* and *"ICTs help students understand abstract content more effectively"*).

Items measuring perceptions were rated on a 5-point Likert scale, while knowledge and usage items were scored on a 10-point scale. The initial version was created through collaborative discussions among the authors and then translated into Kazakh by the first author. To ensure translation accuracy and clarity, two English language instructors reviewed the Kazakh version, and three students read it aloud to identify and revise any unclear wording.

To confirm the construct validity of the perception items, confirmatory factor analysis was conducted using three latent variables: attitude, benefit, and belief. All factor loadings were statistically significant ($p < .001$), ranging from 0.70 to 1.03, indicating strong item-factor relationships. Model fit indices supported the adequacy of the three-factor model: CFI = 0.92, TLI = 0.91, and RMSEA = 0.09 (90% CI: 0.08, 0.10). Factor covariances were also significant, confirming the interrelated nature of these constructs. Internal consistency was high across all subscales ($\alpha = 0.96$ for attitude, $\alpha = 0.97$ for usage, and $\alpha = 0.94$ for belief).

Data Collection

There are 322 students in the informatics department and we invited students to participate in this study during the department meeting with students. We explained the aim of the study and asked them to help us by filling in the questionnaire. We prepared a Google Form to collect data. We sent a related link to students WhatsApp groups. In Kazakhstan, teachers generally prefer to communicate with students through

WhatsApp. We sent reminders two times to increase the participation. Students generally filled out the questionnaire at their appropriate time. Of the 322 students 160 students provide responses (response rate of 49.7%). However, after data cleaning the responses of 115 students were used for data analyses. Of the 45 students who were removed many of them scored the same value such as all 5 or all 4, etc.

Data Analyses

The frequency of ownership for devices and self-assessments were depicted through radar charts to illustrate the distribution of ICT knowledge among the participants. Due to the non-normal distribution of the data, the Mann-Whitney U test was employed to compare the attitudes, beliefs, and ICT usage between male and female students. Similarly, the Kruskal-Wallis test was used to compare the attitudes, beliefs, and ICT usage across different grade levels (1st to 4th grade students). Moreover, we conducted mediation analysis, employing bootstrapping techniques. Mediation analysis is a statistical technique used to examine the indirect effect of an independent variable on a dependent variable through one or more intervening variables, known as mediators. In this study, we investigated whether students' beliefs about ICT mediated the relationship between their attitudes toward ICT and their actual usage of ICT. Bootstrapping is a resampling method used to estimate the sampling distribution of a statistic by repeatedly resampling from the observed data. The significance of the indirect effect was assessed through bootstrapping techniques, which included 5,000 samples and a 95% confidence interval (CI) (Preacher & Hayes, 2008).

Ethical Statement

Ethical approval for this study was obtained from the Ethics Committee at Abai Kazakh National Pedagogical University dated June 25, 2024. Participation in the study was entirely voluntary, and informed consent was obtained from all participants prior to data collection. The purpose of the research was clearly explained, and participants were assured that their responses would remain anonymous and confidential. Data were collected and reported in accordance with institutional ethical guidelines, ensuring the protection of participants' rights and privacy throughout the research process.

RESULTS

Our questionnaire consisted of several parts. The first five parts included the number of devices that students own, their knowledge of ICT, frequency of using ICT devices, tolls, and services. The last part included items about their attitude, engagement, and beliefs about ICT. For the first five parts, we carried out descriptive statistics through radar charts, and for the last part, we did mediation analyses to establish a link between student attitudes and engagement through their beliefs about ICT. Moreover, for the last part, we carried out inferential statistics to see how students' attitudes, usage, and beliefs differ based on demographic characteristics.

Q1. Which of the Following ICT Devices Do You Own?

Students were asked if they own ICT devices: desktop computer, laptop, digital camera, digital camcorder, smartphone, tablet, e-reader, GPS, a type of wearable, and others. Out of the 115 students surveyed, 11 (10%) possessed just one of these devices, with five owning smartphones. Similarly, 31 (27%) had two of these devices, with 29 having smartphones. Additionally, 18 (17%) owned three of these devices, while 12 (10%) had four, eight (7%) had five, nine (8%) had six, 11 (10%) had seven, and one had eight. Moreover, nine (8%) possessed all these devices, and six (5%) had all these devices along with an additional one not specified. The amount of each device possessed by students is visualized in **Figure 1**.

As seen in **Figure 1**, almost all students have both laptops and smartphones (94% and 90%, respectively). Digital cameras and digital camcorders are two least possessed devices by the students (17% and 18%, respectively).

Q2. Your Knowledge About ICT

Students rated their knowledge of ICT between 1 and 10. They scored their knowledge on following areas; ICT, Learning and knowledge technologies, Empowerment and participation technologies, Web 2.0, Web 3.0,

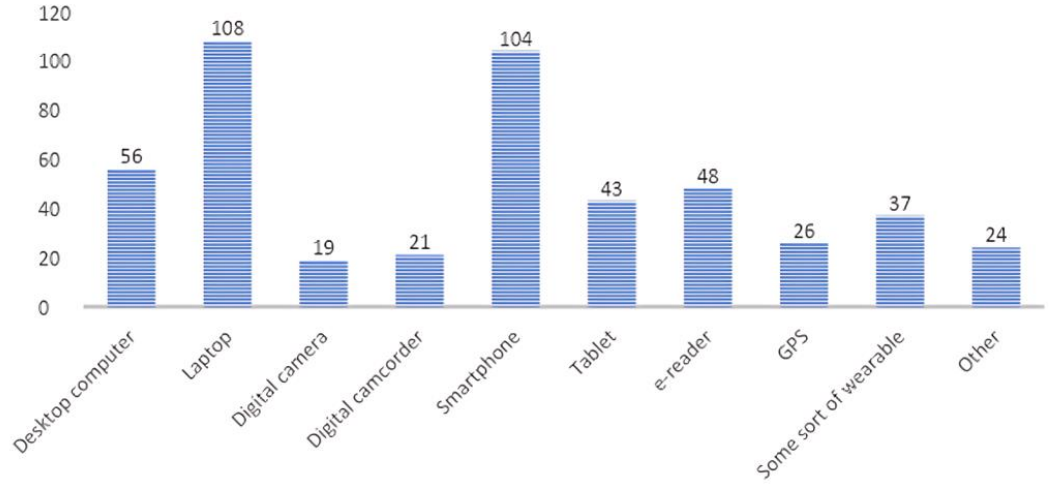

Figure 1. ICT device ownership among students (Source: The authors' own production)

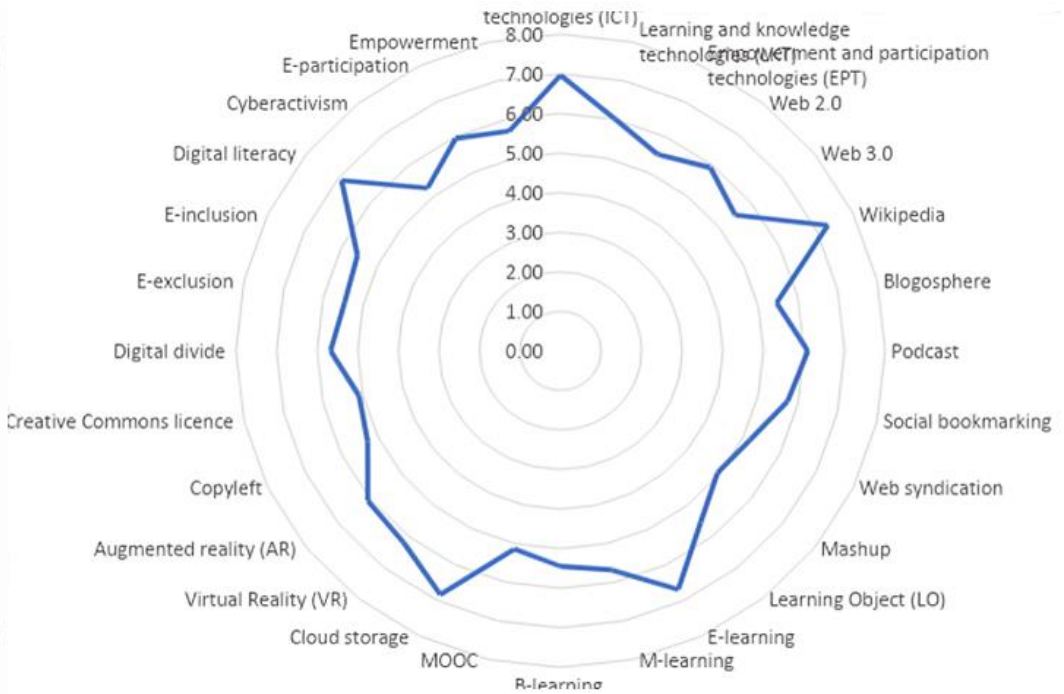

Figure 2. Students' knowledge about ICT (Source: The authors' own production)

Wikipedia, Blogosphere, Podcast, Social bookmarking, Web syndication, Mashup, Learning Object, E-learning, M-learning, B-learning, MOOC, Cloud storage, Virtual Reality, Augmented reality, Copyleft, Creative Commons license, Digital divide, E-exclusion, E-inclusion, Digital literacy, Cyberactivism, E-participation, and Empowerment. Students' responses are depicted in **Figure 2** via a radar chart.

The radar chart in **Figure 2** indicates that students' knowledge about Wikipedia is the highest (M = 7.31) and that of Mashup (mean [M] = 4.95) is the least. However, the average students' knowledge of ICT is moderate (M = 5.83).

Q3. How Frequently You Use ICT Devices?

Students rated their frequency of using ICT devices between 1 and 10. They scored their frequency of the usage on the following devices: computers, digital camera, digital camcorder, smartphone, tablet, e-reader, GPS, wearable, and Other. A radar chart (**Figure 3**) was generated to demonstrate the average usage of each device.

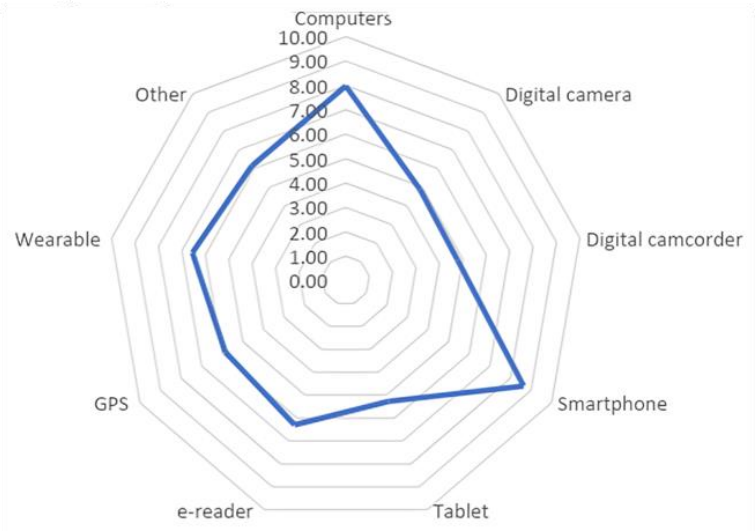

Figure 3. Frequency of use of ICT devices (Source: The authors' own production)

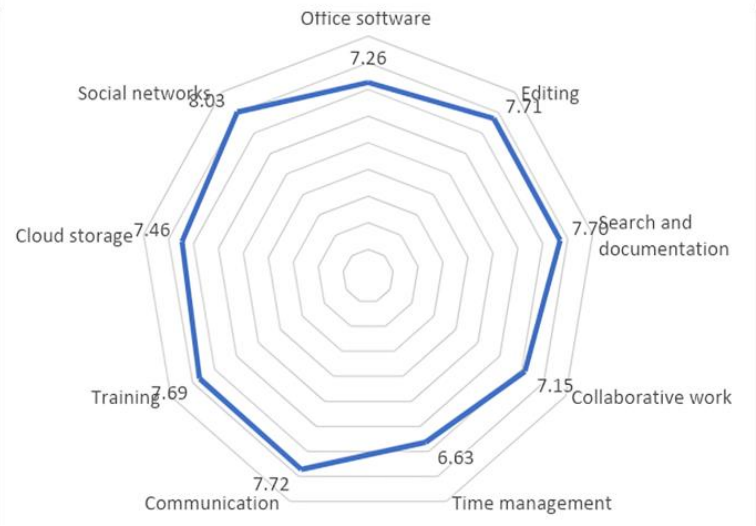

Figure 4. Frequency of use of ICT tools (Source: The authors' own production)

As seen in the radar chart depicted in **Figure 3** smartphones (M = 8.63) and computers (M = 7.97) are the two mostly used devices. Digital camcorders (M = 4.77) and digital cameras (M = 4.86) were the two least used devices.

Q4. How Frequently You Use ICT Tools?

Students rated their frequency of using ICT tools between 1 and 10. They scored their frequency of the usage on the following tools: office software, editing, search and documentation, collaborative work, time management, communication, training, cloud storage, social networks. A radar chart (**Figure 4**) was generated to demonstrate the average usage of each tool.

As seen in the radar chart depicted in **Figure 4**, ICT tools are mostly used for social networks (M = 8.03) and communication (M = 7.72) while it is used least for time management (M = 6.63) and collaborative work (M = 7.15). The circular shape of the chart indicates that students are using all these tools almost equally.

Q5. How Frequently You Use ICT Services?

Students rated their frequency of using ICT services between 1 and 10. They scored their frequency of the usage on the following services; Twitter, Facebook, WhatsApp; Internet to upload and share pictures; Internet to upload and share videos; Internet to upload and share presentations; Internet to upload and share audio; communication; I have my own blog; I have my own website; I search wikis; I publish on wikis; Internet to

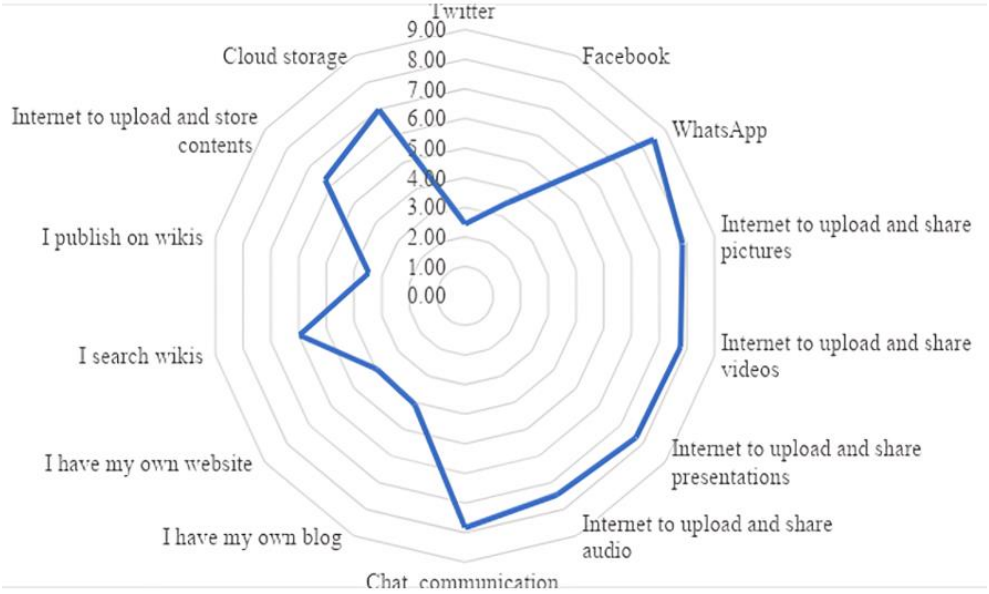

Figure 5. Frequency of use of ICT services (Source: The authors' own production)

Table 1. Mediation estimates

Effect	Estimate	SE	95% CI		Z	p	Percentage of mediation (%)
			Lower	Upper			
Indirect	0.09	0.08	-0.07	0.25	1.18	0.238	23.95
Direct	0.30	0.14	0.05	0.59	2.21	0.027	76.05
Total	0.40	0.12	0.15	0.63	3.31	< .001	100

upload and store contents; cloud storage. A radar chart was generated to demonstrate the average usage of each service (**Figure 5**). As seen in **Figure 5**, students' usage of WhatsApp (M = 8.49) is the highest, while Twitter (X) (M = 2.43) is the least.

Mediation Analyses

We investigated the study hypotheses by testing:

(a) students' attitudes toward ICT positively influence their actual usage of ICT and

(b) beliefs about ICT mediate the relationship between students' attitudes toward ICT and their actual usage of ICT.

Based on the results in **Table 1** provided for mediation estimates, the findings can be summarized as follows:

The indirect effect of students' beliefs about ICT on their actual usage of ICT is estimated to be 0.09 (standard error [SE] = 0.08), 95% CI [-0.07; 0.25]. This effect is not statistically significant at the conventional alpha level (p = 0.238). The percentage of mediation, representing the proportion of the total effect of attitude on ICT usage explained by beliefs, is calculated to be approximately 23.95%.

The direct effect of students' attitudes toward ICT on their usage of ICT is estimated to be 0.30 (SE = 0.14), 95% CI [0.05; 0.59]. This effect is statistically significant (p = 0.027). The percentage of direct effect indicates that approximately 76.05% of the total effect of attitude on ICT usage is not mediated by beliefs.

The total effect of students' attitudes toward ICT on their usage of ICT is estimated to be 0.40 95% CI [0.15; 0.63]. This effect is statistically significant (p < 0.001). The total effect represents the combined influence of both direct and indirect pathways from attitude to ICT usage. The mediation model is detailed in **Figure 6**.

In summary, while beliefs about ICT partially mediate the relationship between attitude and ICT usage, the direct effect of attitude remains significant, indicating that attitudes play a substantial role in influencing students' actual usage of ICT.

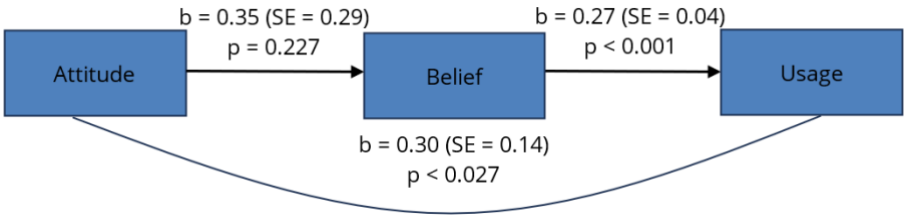

Figure 6. The mediation model (Source: The authors' own production)

Table 2. Gender effects

Descriptives	Gender (F = 1 & M = 2)	N	M	Median	SD	Shapiro-Wilk	
						W	p
Attitude	1	78	40.46	42.00	10.08	0.79	< .001
	2	37	39.49	39.00	7.71	0.93	0.024
Usage	1	78	38.10	40.00	9.73	0.90	< .001
	2	37	35.59	37.00	9.62	0.94	0.042
Belief	1	78	20.05	20.00	4.42	0.88	< .001
	2	37	19.62	20.00	3.80	0.92	0.009

Table 3. The effect of grades on teaching

Descriptives	Grade	N	M	Median	SD	Shapiro-Wilk	
						W	p
Attitude	1	32	39.56	40.00	9.82	0.82	< .001
	2	30	40.77	40.50	7.38	0.88	0.003
	3	30	39.23	40.00	11.33	0.83	< .001
	4	23	41.35	43.00	8.55	0.85	0.003
Usage	1	32	35.00	36.50	9.83	0.94	0.071
	2	30	37.17	39.50	7.93	0.93	0.044
	3	30	40.47	42.50	9.58	0.87	0.001
	4	23	36.52	40.00	11.31	0.85	0.003
Belief	1	32	19.56	20.00	4.60	0.87	0.001
	2	30	19.47	20.00	2.81	0.90	0.008
	3	30	20.23	21.00	4.90	0.86	< .001
	4	23	20.57	21.00	4.40	0.86	0.004

The Effect of Gender and Grade

The effect of gender on students' attitudes, beliefs, and usage of ICT was confirmed with Mann Whitney U test because the data were not normally distributed. The descriptive statistics are presented in **Table 2**. The differences between the medians (see **Table 2**) of the male and female students' attitudes, beliefs, and usage of ICT were not significant ($p > 0.05$). The effect of grades teaching on students' attitudes, beliefs, and usage of ICT was verified with Kruskal Wallis test because the data was not normally distributed. The descriptive statistics are presented in **Table 3**. The differences between the medians (see **Table 3**) of the first, second, third, and fourth grade students' attitudes, beliefs, and usage of ICT were not significant ($p > 0.05$).

DISCUSSION

This study examined pre-service teachers' ICT ownership, knowledge, attitudes, beliefs, and usage within the broader framework of the digital divide and technology adoption theories. From a digital divide perspective, inequalities in technology use are not limited to access to devices but also include differences in digital skills, attitudes, and meaningful engagement with ICT. Therefore, examining these dimensions among pre-service teachers provides views about how future educators may integrate technology in their professional practice.

The findings of this study reveal some important ideas about the nature of youth's social media use in the context of Kazakhstan. The study's findings revealed that students do have access to devices, often two devices, in the form of a smart phone and a laptop computer (94% with a smart phone and 90% with a laptop

computer). These devices are regarded as being the Internet ready, although no question was directly asked about access to the Internet. The high level of smartphone and laptop ownership among participants shows that the first-level digital divide (access to technology) may be relatively small in this group. However, differences in ICT knowledge and usage patterns indicate that second-level digital divide factors, such as digital skills and meaningful engagement with ICT, remain relevant (Cullen, 2001; Soomro et al., 2020).

The respondents also rated themselves high on ICT knowledge, and high with the uses of their devices, which aligns with previous research (Casillas Martín et al., 2020). Specifically high uses included social media and communication (e.g., WhatsApp). However, most uses that were tracked were high. Respondents also indicated generally high use for Internet usages such as maintaining websites, blogging, searching, and similar, although, what respondents are reporting using ICT less for uses such as time management. These uses represented evidence of strong positive attitudes toward ICT (Ropp, 1999). The significant role of attitudes in predicting ICT usage aligns with technology adoption models such as the UTAUT framework, which emphasizes the importance of users' perceptions and motivations in technology use (Venkatesh et al., 2003). Positive attitudes toward ICT may therefore encourage pre-service teachers to integrate digital tools more frequently in their future teaching practices.

Also important were the study's findings that the beliefs about ICT were not significant in predicting ICT use, although attitude did have some significance. What this shows is that respondents might be purposeful and agentive in their use of ICT. Instead of considering this a limitation to be overcome by more pressure to use ICT more often for more tasks, what might be a better idea is to help users understand how to leverage their agencies as users to determine when, where, and how to use ICT on terms that are appropriate for the tasks they want to do and the life goals that they have (Rice, 2021). There might be bias on the part of researcher(s) that assumes that more ICT use is always better or always an indicator of a more sophisticated user, but this might be a logical fallacy of the field. Moreover, it might be indicative of global pressure to make policies and practices that encourage very high use of ICT (Skare & Soriano, 2021). The aim of any policy should be to improve the experiences of children and their teachers and not merely to enlarge the market for educational technologies vendors (Rice & Bailon, 2023; Rice & Cun, 2021).

For gender, it is also increasingly difficult to generalize about gender because it is difficult to separate gender from other social identities, such as race and ethnicity, in terms of social expectations. Studies about ICT that favor men and boys should be interpreted with caution to consider what other factors might be contributing to women and girls' access to and use of ICT (e.g., Esgin et al., 2016).

IMPLICATIONS

The findings of this study suggest several implications for practice and research. The high levels of personal ICT use among participants indicate a baseline level of digital familiarity that teacher education programs can build upon. However, because this study did not examine teaching-related ICT use, we cannot assume that personal familiarity translates into confidence or willingness to integrate digital tools into instructional practice. Therefore, teacher education programs may consider providing structured opportunities for pre-service teachers to apply familiar digital tools in lesson planning and pedagogical decision-making, making explicit the distinction between personal use and purposeful instructional use.

For research, future work should directly investigate how pre-service teachers make decisions about using (or not using) digital tools for instructional purposes. This includes examining how personal digital habits, contextual factors, and pedagogical beliefs influence the uptake of ICT in teaching. Such studies would provide a clearer understanding of how familiarity becomes (or does not become) meaningful pedagogical integration.

Limitations

First, the sample comprised student teachers enrolled in a Diploma in Teaching Informatics program. This group is likely to possess more positive dispositions toward technology integration than pre-service teachers in other subject areas. Therefore, the findings should not be generalized to the broader pre-service teacher population. Second, participants were predominantly in a limited age range, typical of full-time pre-service teacher cohorts. As a result, the data do not reflect generational differences or the perspectives of mature-age candidates who may have varied professional or technological experiences. Third, we did not ask about

Internet availability/quality. This constrains interpretation of usage patterns and our ability to separate motivational/skills factors from first-mile access issues. Fourth, social-media usage items included Facebook and Twitter/X, but not Instagram (and related platforms such as TikTok). Given Instagram's prominence among university students in Central Asia, its omission may underestimate social-network activity or bias platform-specific inferences. Another limitation of this study relates to the relatively small sample size used in the final analyses. Although 322 students were invited to participate, only 160 completed the questionnaire, and after data cleaning 115 responses were received for analysis. While this sample size was sufficient to address the research questions and conduct the statistical analyses employed in the study, a larger sample could provide more robust estimates and allow for more advanced analyses or subgroup comparisons. Future studies with larger and more diverse samples may provide deeper views about the relationships among ICT ownership, knowledge, attitudes, beliefs, and usage among pre-service teachers.

CONCLUSION

This study provides a comprehensive exploration of the relationships between demographic factors, technology ownership, and teachers' knowledge, beliefs, usage, and attitudes toward ICT in educational settings. The findings highlight significant correlations between ICT knowledge, attitudes, and usage, with attitudes playing a substantial direct role in influencing ICT engagement. Despite the presence of ICT devices and moderate self-reported knowledge among students, beliefs about ICT were found to partially mediate the relationship between attitudes and actual usage.

The analysis revealed that demographic factors such as gender and grade level did not significantly affect ICT engagement, suggesting that attitudes toward ICT are more critical determinants of usage than demographic characteristics. This indicates the importance of developing strategies to enhance teachers' attitudes towards ICT, as positive attitudes are likely to result in more effective and frequent use of technology in teaching and learning processes.

Author contributions: ZB: conceptualization, methodology, data curation, formal analysis, investigation, writing – original draft. **MFR:** literature review, methodology review, writing – review & editing, writing – discussion section (lead). **EE:** methodology, validation, formal analysis, writing – review & editing. **GK:** data curation, investigation, resources, writing – review & editing. **SS:** investigation, data curation, project administration, writing – review & editing. All authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: This study was approved by the Ethics Committee at Abai Kazakh National Pedagogical University on 25 June 2024.

AI statement: The authors used AI tools solely for language editing and proofreading purposes. All intellectual content, analysis, and conclusions are the original work of the authors.

Declaration of interest: The authors declared no competing interests.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Abbasi, W. T., Ibrahim, A. H., & Ali, F. B. (2022). Perceptions about English as second language teachers' technology based English language teaching in Pakistan: Attitudes, uses of technology and challenges. In *Proceedings of International Conference on Emerging Technologies and Intelligent Systems* (pp. 314-325). Springer. https://doi.org/10.1007/978-3-030-82616-1_28

Abdullah, N. A., Abidin, M. J. Z., Luan, W. S., Majid, O., & Atan, H. (2006). The attitude and motivation of English language teachers towards the use of computers. *Malaysian Online Journal of Instructional Technology, 3*(1), 57-67. https://www.researchgate.net/publication/228409647_The_attitude_and_motivation_of_English_language_teachers_towards_the_use_of_computers

Abendan, C. F., Kilag, O. K., Uy, F., & Vestal, P. (2023). Transforming learning in the digital age: The confluence of innovation and education. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521) 1*(5), 1-13. https://www.researchgate.net/publication/376645961_Transforming_Learning_in_the_Digital_Age_The_Confluence_of_Innovation_and_Education

Acilar, A. (2021). Age and digital divide: The case of a developing country, Turkey. *International Journal of Innovation in the Digital Economy, 12*(3), 17-29. https://doi.org/10.4018/IJIDE.2021070102

Admiraal, W., Post, L., Lockhorst, D., Louws, M., & Kester, L. (2020). Personalizing learning with mobile technology in a secondary school in the Netherlands: Effects on students' autonomy support, learning motivation and achievement. *The European Educational Researcher, 3*(3), 119-137. https://doi.org/10.31757/euer.333

Akkoyunlu, B. (1996). Öğrencilerin bilgisayara karşı tutumları [Students' attitudes towards computers]. *Eğitim ve Bilim, 20*(100), 15-29.

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in Psychology, 13,* Article 920317. https://doi.org/10.3389/fpsyg.2022.920317

Aljuzayri, Z. (2021). The relationship between US high school science teacher's self-efficacy, professional development, and use of technology in classrooms. *Journal of Research in Science, Mathematics and Technology Education, 4*(1), 45-62. https://doi.org/10.31756/jrsmte.414

Ata, R., Yildirim, K., İpek, P., & Atas, U. C. (2021). Technology integration of Turkish elementary school: Teaching literacy skills in the post-COVID-19 era. *The European Educational Researcher, 4*(2), 193-207. https://doi.org/10.31757/euer.424

Badia, A., Garcia, C., & Meneses, J. (2017). Approaches to teaching online: Exploring factors influencing teachers in a fully online university. *British Journal of Educational Technology, 48*(6), 1193-1207. https://doi.org/10.1111/bjet.12475

Ben Youssef, A., Dahmani, M., & Ragni, L. (2022). ICT use, digital skills and students' academic performance: Exploring the digital divide. *Information, 13*(3), Article 129. https://doi.org/10.3390/info13030129

Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(3), 235-245. https://doi.org/10.12973/ejmste/75275

Bordios, A., Auxtero, A. M., Aniga, C., & Mula, R. (2026). From access to impact: Rethinking digital integration in Philippine math education. *Journal of Research in Didactical Sciences, 5*(1), 1-11. https://doi.org/10.51853/jorids/17785

Bower, M. (2019). Technology-mediated learning theory. *British Journal of Educational Technology, 50*(3), 1035-1048. https://doi.org/10.1111/bjet.12771

Casillas Martín, S., Cabezas González, M., & Garcia Peñalvo, F. J. (2020). Digital competence of early childhood education teachers: Attitude, knowledge and use of ICT. *European Journal of Teacher Education, 43*(2), 210-223. https://doi.org/10.1080/02619768.2019.1681393

Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education, 15*(1), Article 22. https://doi.org/10.1186/s41239-018-0109-y

Cavas, B., Cavas, P., Karaoglan, B., & Kisla, T. (2009). A study on science teachers' attitudes toward information and communications technologies in education. *The Turkish Online Journal of Educational Technology, 8*(2), Article 2. https://eric.ed.gov/?id=ED505935

Cheng, H., Lyu, K., Li, J., & Shiu, H. (2022). Bridging the digital divide for rural older adults by Family intergenerational learning: A classroom case in a rural primary school in China. *International Journal of Environmental Research and Public Health, 19*(1), Article 371. https://doi.org/10.3390/ijerph19010371

Cullen, R. (2001). Addressing the digital divide. *Online Information Review, 25*(5), 311-320. https://doi.org/10.1108/14684520110410517

Dolan, J. (2016). Splicing the divide: A review of research on the evolving digital divide among K-12 students. *Journal of Research on Technology in Education, 48*(1), 16-37. https://doi.org/10.1080/15391523.2015.1103147

Drossel, K., Eickelmann, B., & Gerick, J. (2017). Predictors of teachers' use of ICT in school–The relevance of school characteristics, teachers' attitudes and teacher collaboration. *Education and Information Technologies, 22*, 551-573. https://doi.org/10.1007/s10639-016-9476-y

Esgin, E., Elibol, M., & Dağlı, M. (2016). Gender differences in computer-related achievement, anxiety and attitude: A meta-analysis in Turkey sample. *Global Journal of Computer Sciences: Theory and Research, 6*(1), 2-9. https://doi.org/10.18844/gjcs.v6i1.1208

Fischer, G., Lundin, J., & Lindberg, J. O. J. (2020). Rethinking and reinventing learning, education and collaboration in the digital age—From creating technologies to transforming cultures. *The International Journal of Information and Learning Technology, 37*(5), 241-252. https://doi.org/10.1108/IJILT-04-2020-0051

Garcia, A., & Lee, C. H. (2020). Equity-centered approaches to educational technology. In M. J. Bishop, E. Boling, J. Elen, & V. Svihla (Eds.), *Handbook of research in educational communications and technology* (pp. 247-261). Springer. https://doi.org/10.1007/978-3-030-36119-8_10

Guillén-Gámez, F. D., & Mayorga-Fernández, M. J. (2020). Identification of variables that predict teachers' attitudes toward ICT in higher education for teaching and research: A study with regression. *Sustainability, 12*(4), Article 1312. https://doi.org/10.3390/su12041312

Guvercin, S. (2025). The urgent case for AI literacy in the 21st century. *International Educational Review, 3*(1), 41-44. https://int-er.com/article/the-urgent-case-for-ai-literacy-in-the-21st-century-16377

Hatlevik, I. K., & Hatlevik, O. E. (2018). Examining the relationship between teachers' ICT self-efficacy for educational purposes, collegial collaboration, lack of facilitation and the use of ICT in teaching practice. *Frontiers in Psychology, 9*, Article 935. https://doi.org/10.3389/fpsyg.2018.00935

Ifinedo, E., Rikala, J., & Hämäläinen, T. (2020). Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices and beliefs. *Computers & Education, 146*, Article 103760. https://doi.org/10.1016/j.compedu.2019.103760

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research and Development, 58*(2), 137-154. https://doi.org/10.1007/s11423-009-9132-y

Jardin, E. J. (2023). Exploring the use of technology in environmental education: Teachers' and students' perspectives. *Excellencia: International Multi-Disciplinary Journal of Education, 1*(1), 118-126. https://multijournals.org/index.php/excellencia-imje/article/view/12

Joo, Y. J., Lim, K. Y., Kim, N. H. (2016). The effects of secondary teachers' technostress on the intention to use technology in South Korea. *Computers & Education, 95*, 114-122. https://doi.org/10.1016/j.compedu.2015.12.004

Korsah, D. P., Abdulai, I. B., Duaquaye E., Korsah H. C. (2025). Technology accessibility and confidence: A comparative study of public and private basic schools. *Journal of Research in Didactical Sciences, 4*(1), 23-69. https://doi.org/10.51853/jorids/16341

Kpolovie, P. J., & Awusaku, O. K. (2016). ICT adoption attitude of lecturers. *European Journal of Computer Science and Information Technology, 4*(5), 9-57. https://eajournals.org/ejcsit/vol-4-issue-5-september-2015/ict-adoption-attitude-lecturers/

Kucirkova, N., Rowsell, J., & Falloon, G. (Eds.). (2019). *The Routledge international handbook of learning with technology in early childhood*. Routledge. https://doi.org/10.4324/9781315143040

Lai, J. W., & Bower, M. (2019). How is the use of technology in education evaluated? A systematic review. *Computers & Education, 133*, 27-42. https://doi.org/10.1016/j.compedu.2019.01.010

Luo, W., Berson, I. R., Berson, M. J., & Li, H. (2021). Are early childhood teachers ready for digital transformation of instruction in Mainland China? A systematic literature review. *Children and Youth Services Review, 120*, Article 105718. https://doi.org/10.1016/j.childyouth.2020.105718

Mahdum, M., Hadriana, H., & Safriyanti, M. (2019). Exploring teacher perceptions and motivations to ICT use in learning activities in Indonesia. *Journal of Information Technology Education: Research, 18*, 293-317. https://doi.org/10.28945/4366

Maksimovic, J., & Dimic, N. (2016). Digital technology and teachers' competence for its application in the classroom. *Research in Pedagogy, 6*(2), 59-71. https://doi.org/10.17810/2015.35

McMurtrey, M. E., Zeltmann, S. M., Downey, J. P., & McGaughey, R. E. (2011). Seniors and technology: Results from a field study. *Journal of Computer Information Systems, 51*(4), 22-30. https://doi.org/10.1080/08874417.2011.11645498

Mim, S. A., & Chowdhury, M. A. (2018). Mobile communication as a platform for learning science from peers: Possibilities in Bangladesh. *Journal of Research in Science, Mathematics and Technology Education, 1*(3), 267-282. https://doi.org/10.31756/jrsmte.132

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record: The Voice of Scholarship in Education, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mishra, P., & Koehler, M. J., & (Eds.). (2016). *Handbook of technological pedagogical content knowledge (TPACK) for educators*. Routledge. https://doi.org/10.4324/9781315771328

Moldavan, A. M., Capraro, R. M., & Capraro, M. M. (2022). Navigating (and disrupting) the digital divide: Urban teachers' perspectives on secondary mathematics instruction during COVID-19. *The Urban Review, 54*(2), 277-302. https://doi.org/10.1007/s11256-021-00611-4

Ocak, M. A., & Akdemir, O. (2008). An investigation of primary school science teachers' use of computer applications. *Turkish Online Journal of Educational Technology, 7*(4), 54-60. https://files.eric.ed.gov/fulltext/EJ1102938.pdf

Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: Results from a worldwide educational assessment. *Computers & Education, 37*(2), 163-178. https://doi.org/10.1016/S0360-1315(01)00045-8

Petko, D., Prasse, D., & Cantieni, A. (2018). The interplay of school readiness and teacher readiness for educational technology integration: A structural equation model. *Computers in the Schools, 35*(1), 1-18. https://doi.org/10.1080/07380569.2018.1428007

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879-891. https://doi.org/10.3758/BRM.40.3.879

Reddy, K. S., & Babu, N. S. (2024). Navigating the digital divide: Assessing faculty ICT skills and challenges in shaping the future of higher education in India. *Brazilian Journal of Development, 10*(1), 355-378. https://doi.org/10.34117/bjdv10n1-023

Rice, M. (2021). Reconceptualizing teacher professional learning about technology integration as intra-active entanglements. *Professional Development in Education, 47*(3), 524-537. https://doi.org/10.1080/19415257.2021.1891953

Rice, M., & Bailon, M. (2023). A qualitative analysis of publicly available standards and guidance about digital literacies in U.S. states. *Education and Information Systems, 28*, 6927-6948. https://doi.org/10.1007/s10639-022-11482-x

Rice, M., & Cun, A., (2021). Personalising digital learning for young children: Leveraging psychosocial identities and Techne for literacy development. *British Journal of Educational Technology, 52*(5), 1823-1838. https://doi.org/10.1111/bjet.13076

Rogers, S. E. (2016). Bridging the 21st century digital divide. *TechTrends, 60*(3), 197-199. https://doi.org/10.1007/s11528-016-0057-0

Ropp, M. M. (1999). Exploring individual characteristics associated with learning to use computers in preservice teacher preparation. *Journal of Research on Computing in Education, 31*(4), 402-424. https://doi.org/10.1080/08886504.1999.10782262

Roussos, P. (2007). The Greek computer attitudes scale: Construction and assessment of psychometric properties. *Computers in Human Behavior, 23*(1), 578-590. https://doi.org/10.1016/j.chb.2004.10.027

Shoraevna, Z., Eleupanovna, Z., Tashkenbaevna, S., Zulkarnayeva, Z., Anatolevna, L., & Nurlanbekovna, U. (2021). Teachers' views on the use of information and communication technologies (ICT) in education environments. *International Journal of Emerging Technologies in Learning, 16*(3), 261-273. https://doi.org/10.3991/ijet.v16i03.18801

Skare, M., & Soriano, D. R. (2021). How globalization is changing digital technology adoption: An international perspective. *Journal of Innovation & Knowledge, 6*(4), 222-233. https://doi.org/10.1016/j.jik.2021.04.001

Smith, B., Caputi, P., & Rawstorne, P. (2000). Differentiating computer experience and attitudes toward computers: An empirical investigation. *Computers in Human Behavior, 16*(1), 59-81. https://doi.org/10.1016/S0747-5632(99)00052-7

Soomro, K. A., Kale, U., Curtis, R., Akcaoglu, M., & Bernstein, M. (2020). Digital divide among higher education faculty. *International Journal of Educational Technology in Higher Education, 17*(1), Article 21. https://doi.org/10.1186/s41239-020-00191-5

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): A mixed-method study. *Educational Technology Research and Development, 68*(1), 319-343. https://doi.org/10.1007/s11423-019-09692-1

United Nations. (2017). Global indicator framework for the sustainable development goals and targets of the 2030 agenda for sustainable development. *United Nations*. https://unstats.un.org/sdgs/indicators/Global-Indicator-Framework-after-2024-refinement-English.pdf

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478. https://doi.org/10.2307/30036540

Wekullo, B. J., (2026). Professional development for K-12 mathematics teachers: A Systematic literature review of technology, pedagogy, and equity. *International Educational Review, 4*(1), 5-23. https://doi.org/10.58693/ier.412

Wilson, C., Grizzle, A., Tuazon, R., Akyempong, K., & Cheung, C. K. (2011). *Media and information literacy curriculum for teachers*. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000192971