International Journal of Innovative Research and Scientific Studies, 8(1) 2025, pages: 1224-1238

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Bridging the digital divide: Assessing future educators' competence in Kazakhstan's higher education through the DigCompEdu framework

Moldir Yermekova[1], Nurgul Yrymbayeva[2*], Pakizat Rakhimgalieva[3], Abdirkenova Akbidash[4]

[1,2]Department of Pedagogy, Faculty of Social Sciences, L.N. Gumilyov Eurasian National University, Yanushkevich Str. 6, Astana, Kazakhstan.
[3]Department of Molecular Biology and Medical Genetics named after Academician of NAS RK T.K. Raissov, Semey Medical University, Abaya 103, Semey, Kazakhstan.
[4]Department of Pedagogy, Psychology and Special Education, Akhmet Baitursynuly Kostanay Regional University, Baitursynova Str.47. Kostanay, Kazakhstan.

Corresponding author: Nurgul Yrymbayeva (*Email: nurgul.ya@bk.ru*)

Abstract

This study examines digital competencies among prospective educators at a Kazakhstani university, drawing on a 360-participant survey based on the DigCompEdu framework. The findings reveal significant variations in self-perceived technological skills across three academic levels—Bachelor's, Master's, and PhD—and five demographic factors: gender, place of residence, prior ICT experience, academic program, and age. Master's students generally exhibit the highest competence, while PhD candidates unexpectedly show moderate mastery in areas such as digital resource use. Male Bachelor's students report greater confidence in technical tasks, whereas female Master's students surpass their male peers in professional engagement. Additionally, urban participants consistently outperform their rural counterparts, highlighting infrastructural disparities that hinder digital skill development. Prior ICT training emerges as a strong predictor of competence across all levels and programs, emphasizing the importance of early, structured exposure to technology. Despite the recognized necessity of integrating digital tools in teaching, the data suggest that many programs, particularly at the doctoral level, provide insufficient attention to digital pedagogy. The study concludes by recommending curriculum enhancements, targeted interventions, and infrastructural improvements to ensure future educators are prepared to teach effectively in technologically evolving classrooms.

Keywords: Curriculum enhancement, DigCompEdu, Digital competence, Digital pedagogy, Educational disparities, Future educators, Higher education, ICT training, Professional development, Technological skills.

DOI: 10.53894/ijirss.v8i1.4572
Funding: This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19679344).
History: Received: 11 December 2024/**Revised:** 10 January 2025/**Accepted:** 27 January 2025/**Published:** 7 February 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Institutional Review Board Statement: The Ethical Committee of the L.N. Gumilyov Eurasian National University, Kazakhstan has granted approval for this study (Ref. No. 6)
Publisher: Innovative Research Publishing

1. Introduction

The rapid rise of educational technology has spurred a worldwide reconsideration of teaching and learning methods, making digital competence essential for today's educators. This importance was highlighted during the COVID-19 pandemic when academic institutions worldwide were pushed to shift instruction online almost overnight [1-3]. However, digital competence encompasses more than just technical knowledge; it also involves cognitive, emotional, and social skills that support effective instruction in a digital age [4].

Research from around the globe highlights the need for teachers to develop strong digital skills. For example, Spain and Germany both emphasize advanced training programs that help educators optimize digital tools in the classroom [5, 6]. In the United Arab Emirates, targeted professional development initiatives are utilized to create effective e-learning environments and maintain consistent levels of digital proficiency among educators [7-9]. Meanwhile, countries such as Morocco and Saudi Arabia also grapple with the challenge of preparing teachers for technology-driven classrooms [10-12].

In Kazakhstan, by contrast, digital competence has not been thoroughly embedded in teacher-training programs, leaving a gap between the skills teachers need and what they actually learn. This shortcoming limits the ability of newly qualified educators to adapt quickly to the pace of technological advances in higher education and meet the requirements of today's classrooms.

Although the significance of digital competencies for teaching success is widely acknowledged, there is limited information on the impact of demographic factors—such as age, academic specialization, and experience with ICT—on the development of these competencies in Kazakhstan. While international studies point to similar challenges [10], in-depth research on the relationship between these variables and future Kazakhstani educators' digital skills remains scarce. [11].

To address this gap, the current study aims to:

1. Evaluate the current level of digital competencies among future educators in Kazakhstan's higher education institutions using the Digital Competence of Educators (DigCompEdu) framework.
2. Examine how these competencies correlate with demographic variables such as age, academic background, and prior digital technology experience.

The following sections are organized to better deliver the answers to the research questions. Section 2 reviews relevant literature on digital competence frameworks, then describes the research methods used to analyze the research questions. It follows with the presentation and discussion of results, including statistical analyses of demographic factors influencing digital competence, and concludes with implications and recommendations for educational practice and policy.

2. Literature Review

In the European Commission's Digital Education Action Plan 2021-2027 (DEAP), enhancing educators' digital competence is highlighted as a key guiding principle. Moreover, digital competence is positioned as a fundamental skill for all educators and training personnel, integrated into all aspects of professional development, including initial teacher education. Educators, as highly skilled professionals, need both the confidence and the ability to use technology effectively and creatively. This competence is crucial for engaging and motivating learners, supporting the development of their digital skills, and ensuring that the digital tools and platforms used are accessible to all students. Teachers and trainers should have access to ongoing, tailored professional learning opportunities that meet their specific needs and relate to their disciplines [12].

Overall, digital competence must be recognized as one of the key components of lifelong learning that helps students participate in academic activities, as well as in the future job market and society in general.

The European Digital Competence Framework (DigComp) offers a useful structure for strengthening key abilities in areas such as information and data literacy, communication and collaboration, content creation, security, and problem-solving [13, 14]. Designed as both a developmental and evaluative tool, it serves to cultivate educators' digital literacy [15]. Recent literature underscores the need to continually revise these guidelines in response to post-COVID demands, focusing on adaptable, context-specific approaches [16, 17].

The DigCompEdu framework emerged from Ferrari's comparative examination of fifteen different models of digital literacy and competence, which helped define what digital competence entails [18]. Subsequently, the framework underwent refinements and also received criticism, especially regarding its applicability in non-European educational contexts [19]. As described by Redecker, DigCompEdu assesses teachers' digital capabilities through multiple dimensions: professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and nurturing students' digital competence [15]. Its relevance in the post-pandemic landscape has been a point of debate, with researchers calling for new elements such as crisis management and strategies for remote engagement [20].

According to Ghomi and Redecker, the assessment tool included 22 items, each linked to a distinct competence within the DigCompEdu framework, and responses were recorded according to specific proficiency levels. Each competence was chosen with care; competence 2.3, for example, focuses on data protection rather than simply addressing copyright issues [5].

The responses were on a five-point Likert scale from No Use to Systematic Use, with some categories merged due to the difficulty of differentiation by the users. The instrument provided a 0-to-4-point scoring system and assigned total scores (0–88) to six DigCompEdu proficiency levels. Some changes made to the framework have been in response to the changing pedagogical requirements, such as those imposed by the COVID-19 pandemic [21].

Area 1 focuses on educators' use of digital technologies in professional interactions and personal development. Area 2 addresses competencies related to the responsible use, creation, and sharing of digital resources for learning. Area 3 centers on managing digital technologies in teaching and learning, while Area 4 emphasizes enhancing assessment through digital strategies. Area 5 explores learner-centered teaching strategies using digital tools, and Area 6 details the pedagogical skills required to facilitate students' digital competence Figure 1.

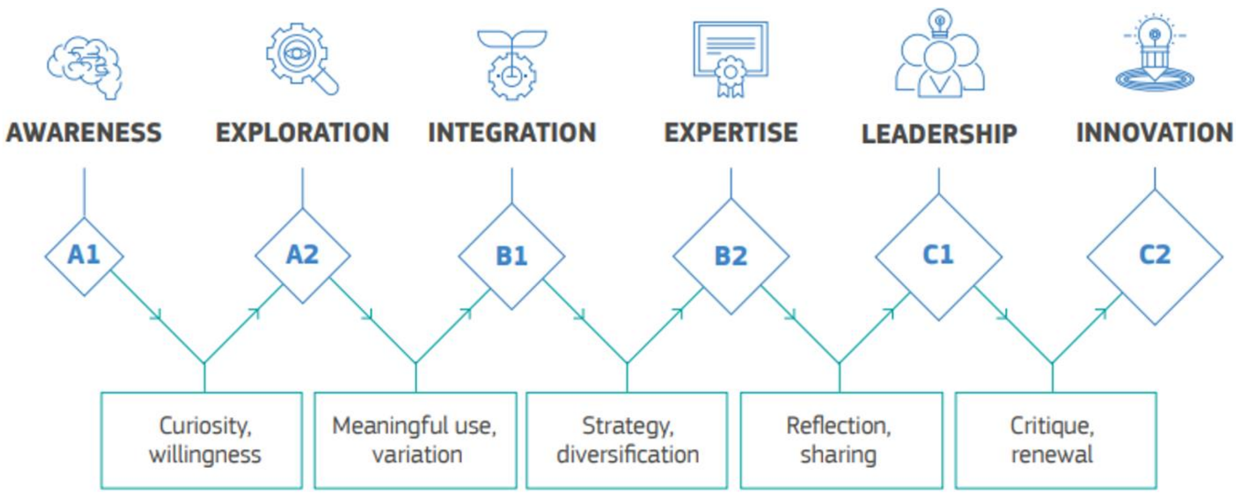

Figure 1.
DigCompEdu progression model.

The framework also introduces a progression model to help educators assess and develop their digital competence, categorizing development into six stages: Newcomer (A1), Explorer (A2), Integrator (B1), Expert (B2), Leader (C1), and Pioneer (C2). Educators often use these stages as a way to gauge and enhance their digital competencies [22]. Yet, several scholars have pointed out that a strictly linear model may overlook the more flexible or recursive processes by which teachers develop and utilize digital abilities, proposing instead iterative or spiral frameworks [20, 23].

As a broad point of reference, the DigCompEdu Framework draws on both national and regional efforts to identify digital competencies specific to educators. It is intended to be versatile across various educational tiers and environments—from early childhood to adult learning—and encourages adaptations that address particular goals and contexts [24]. Nonetheless, despite this adaptability, there is limited empirical research on its effectiveness in settings with scarce resources or those undergoing rapid changes, especially in the wake of the COVID-19 pandemic [20, 25].

Nevertheless, critics argue that while these modifications are valuable, they may still overlook localized needs and cultural nuances in different educational settings.

Digital competence is recognized as a key skill in European frameworks, but Kazakhstan lacks a framework aligned with its education system, unlike the established European models. The development of frameworks, methods, and validation schemes for digital competence is critical for both the EU and Kazakhstan. This paper applies the European digital competence framework to the Kazakhstani education system and assesses the digital competence of future educators. As students face academic pressures and the demands of the workplace, understanding their digital competence is crucial. The study explores students' perceptions of their digital skills and examines differences based on gender, grade, residential area, and prior ICT training.

3. Materials and Methods

3.1. Study Design

This study employed a cross-sectional quantitative methodology, utilizing a survey-based approach to collect data on the digital competence of university students. The study aimed to assess how extensively students incorporate technology into their teaching, communication, and learning practices. The survey was conducted over the course of the 2023/2024 academic year. We used random sampling techniques with an estimation error of E = 1.36, $\alpha = (100 - 95)/100 = 0.05$.

3.2. Participants

The present study targeted future educators drawn from various faculties at a university, emphasizing that all participants have teaching backgrounds or are preparing to enter teaching roles—even fourth-year bachelor's students who complete diploma (student teaching) practice. Although they represent multiple academic programs (e.g., Finance, Biology, Pedagogy), their curriculum prepares them to teach these disciplines upon graduation.

A total of 655 students were initially contacted via email to participate in an online survey aimed at assessing digital competencies. Following a reminder one month later, 360 students completed the survey, resulting in a final sample randomly selected across academic levels: 4th-year bachelor's students (n=180), 1st–2nd-year master's students (n=120), and 1st–3rd-year PhD candidates (n=60). Participants ranged in age from 20 to 45 years, with an average age of 27.8. Although most participants are undergraduates, they have formal teaching experience or training requirements in the form of practicum or supervised teaching assignments. The gender distribution included 56.9% female students (287) and 43.1% male students (217). Additionally, 30.6% of the participants (154 students) were from rural areas. Table 1 provides the demographic attributes of the students across various educational programs, all of whom are training to teach their subject areas.

Table 1.
Demographic distribution of participants.

Category	**Number of students**	**Percentage (%)**	**Category**	**Number of students**	**Percentage (%)**	**Category**	**Number of students**	**Percentage (%)**
Bachelor degree	180	100%	Master students	120	100%	PhD Students	60	100%
Age								
20	97	53.9%	20-23	57	47.5%	24-30	28	46.7%
21	83	46.1%	24-25	63	52.5%	31-35	14	23.3%
						36-40	10	16.7%
						41-45	8	13.3%
Gender distribution								
Males	85	47.2%	Males	61	50.8%	Males	25	41.7%
Females	95	52.8%	Females	59	49.2%	Females	35	58.3%
Place of residence								
Urban	55	30.6%	Urban	38	31.7%	Urban	25	41.7%
Rural	125	69.4%	Rural	82	68.3%	Rural	35	58.3%

Appendix B offers additional statistics on the distribution of bachelor's respondents by program. As shown in Figure 2, 60% of these 180 students reported having some previous ICT experience: 36.7% had less than one year of experience, and 22.8% had one to two years of experience. Given that they are in their final year and have completed teaching practicum experiences, the relatively low levels of ICT experience highlight limited exposure to integrating digital tools into their instructional practices.

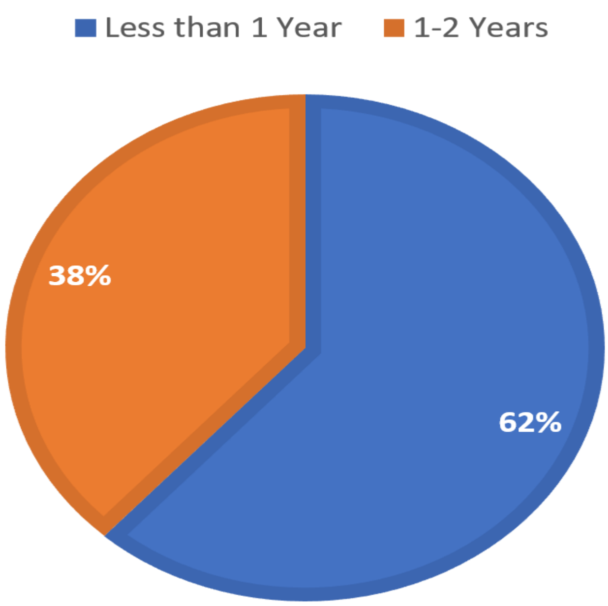

Figure 2.
Bachelor students' ICT experience distribution.

Among master's students, 12 were from the Pedagogy and Psychology program, with 41.7% aged 20–23 and 58.3% aged 24–25.

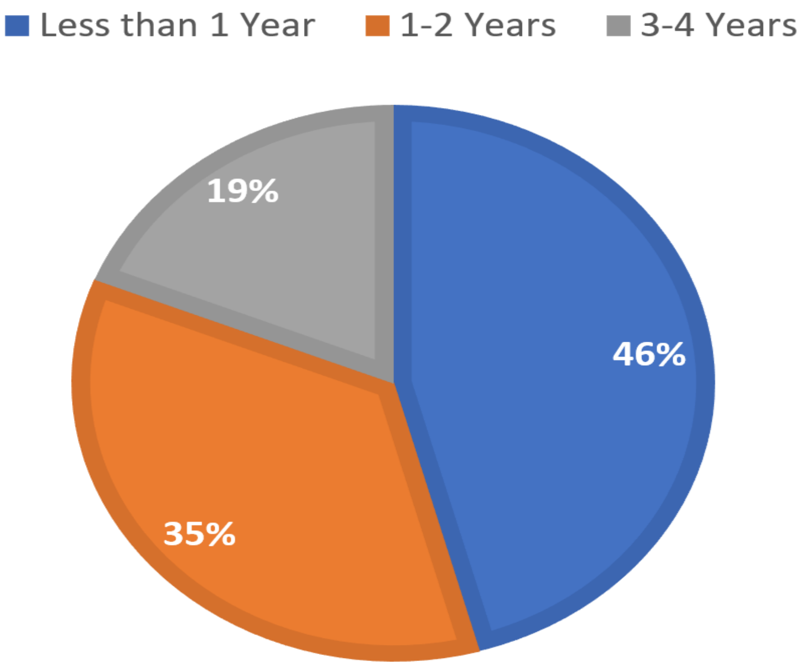

Figure 3.
Master students' ICT experience distribution.

The gender distribution was 41.7% male and 58.3% female; 25.0% reside in urban areas while 75.0% live in rural areas. Appendix B provides further details on the faculties involved in the master's program. Of these 120 master's students, 82.5% indicated previous ICT experience: 46% had less than one year, 35% had one to two years, and 19% had three to four years of ICT use. These figures suggest that a majority of master's students possess at least a basic level of technology integration skills, yet many still have limited depth in ICT integration. Table 1 outlines the demographics of 60 PhD students, who come from a variety of educational programs and are involved in advanced teaching and research responsibilities.

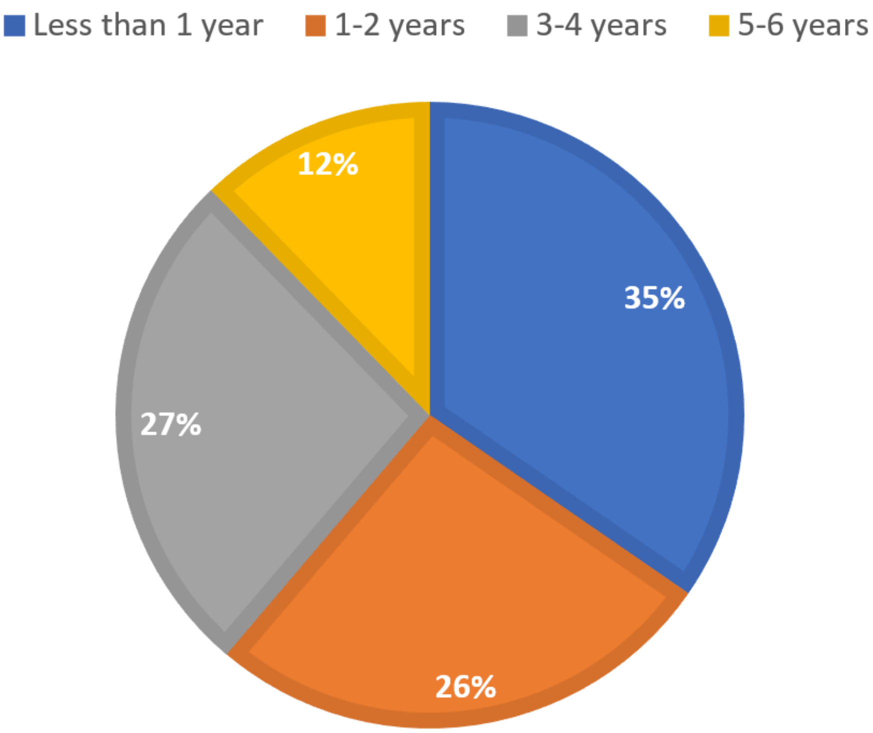

Figure 4.
PhD students' ICT experience distribution.

3.3. Instrument Validation and Reliability

This study employed the DigCompEdu framework to evaluate educators' digital competencies. The original framework and assessment tool are accessible online for reference. To ensure its applicability in the Kazakhstani context, the questionnaire was initially prepared in Kazakh and Russian. A group of bilingual experts then undertook a forward-and-backward translation procedure to maintain linguistic accuracy and cultural appropriateness. During this process, terminology specific to local educational practices, such as student-teaching requirements for bachelor's students, was clarified to reflect the national context.

The content validity of the adapted survey was examined by a panel of five experts specializing in research methods, education, and linguistics. Items were systematically evaluated for clarity and relevance, and those scoring below the 0.78 threshold in the Item-Level Content Validity Index (I-CVI) were revised. Subsequently, the overall Scale-Level Content Validity Index (S-CVI) surpassed 0.90, indicating excellent content validity. An exploratory factor analysis (EFA) was then carried out to confirm the instrument's construct validity, revealing factor loadings consistent with the six core areas of DigCompEdu: professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and learner facilitation.

With regard to reliability, the post-revision Cronbach's alpha for the entire questionnaire was 0.85, suggesting a high degree of internal consistency. Subscale reliabilities ranged from 0.78 to 0.84 (professional engagement = 0.82, digital resources = 0.78, teaching and learning = 0.80, assessment = 0.81, learner empowerment = 0.84, learner facilitation = 0.79). Although initial pilot testing yielded higher alpha values (around 0.97), subsequent refinements for cultural and contextual relevance ensured that the final instrument remained robust, coherent, and well-aligned with the educational environment in Kazakhstan.

3.4. Data Collection Procedures

The survey was distributed via email to students from various faculties at the university, with participants given one month to respond. A reminder message was sent approximately two weeks into the data collection window to encourage higher participation. All participants were informed that their responses would remain confidential and that their participation was voluntary. Non-responses were tracked by identifying email addresses that did not submit any answers; these individuals were sent the reminder email but ultimately did not contribute data if they chose not to participate. In the case of incomplete submissions, responses that were missing critical demographic or competence-related items were excluded from the final dataset. This exclusion criterion ensured that only sufficiently complete surveys were analyzed, thereby maintaining the overall integrity and quality of the results.

3.5. Data Analysis

All data were collected via Google Forms and subsequently exported to a spreadsheet for initial screening, then imported into SPSS for comprehensive analysis. Prior to conducting statistical tests, the dataset was checked for incomplete submissions and missing responses. Approximately 4% of cases were removed via listwise deletion due to missing responses in critical survey items. A Little's MCAR test confirmed that these missing data were random ($p > .05$), supporting the decision to exclude incomplete records without biasing the results.

To assess the normality of the distribution, a Kolmogorov-Smirnov test was performed, indicating a non-normal distribution ($p = .000$). Consequently, non-parametric tests were employed to examine group differences and relationships. The Mann-Whitney U test was utilized to determine whether significant differences in perceptions of digital competence existed across demographic variables such as gender, academic level, residential area, and prior ICT training. Effect sizes were calculated using $r = z\frac{z}{\sqrt{N}}$; for instance, values ranging from .20 to .35 emerged, demonstrating small-to-moderate effects. Where more than two groups were compared—such as among bachelor's, master's, and PhD cohorts—a Kruskal-Wallis test was applied, and post hoc analyses with adjusted p-values were conducted to pinpoint significant group differences. Additionally, eta-squared (η^2) was computed to convey the magnitude of these effects, typically falling within the small-to-moderate range (.03–.07).

Descriptive statistics (means, standard deviations) were obtained to provide an overview of participants' self-reported digital competencies. All analyses were conducted at a 95% confidence level ($p < .05$). By reporting both significance levels and effect sizes, the study offers a clearer picture of how demographic and personal variables influence digital competence among future educators.

3.6. Ethical Considerations

All participants provided informed consent before participating in the survey. The confidentiality of participants' data was maintained throughout the study, and no conflicts of interest were reported by the researchers.

4. Results

4.1. DigCompEdu Results

The results of this study are presented in the order that aligns with the overarching aim of exploring digital competence among future educators at three different academic levels—Bachelor's, Master's, and PhD—while also examining potential differences associated with various demographic factors such as gender, place of residence, educational program, previous ICT experience, and age range. The first subsection addresses each of the six core areas of the DigCompEdu framework—Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating

Learners' Digital Competence—organized by educational level. Following these descriptive results, a second major subsection provides the inferential statistical findings, focusing specifically on the Mann-Whitney U test outcomes, including more detailed statistics (U values, degrees of freedom, and p-values) as recommended by the reviewer. Discussion of effect sizes and possible explanations are also integrated where relevant. Finally, the implications of these findings for higher education practice are briefly introduced, providing a segue to further discussion.

It should be noted that the analysis made a concerted effort to investigate each level's strengths and weaknesses in digital competencies and to highlight common gaps that could be addressed through more targeted curriculum design. While each subsection emphasizes a particular dimension of digital competence, the results collectively paint a picture of how future educators, even those from non-traditional teaching programs, grapple with the integration of digital tools in a rapidly evolving educational landscape.

Before delving into the descriptive and inferential findings, it is useful to provide an overall sense of how the three groups—Bachelor's, Master's, and PhD students—fared across the six DigCompEdu domains. For this purpose, each area is briefly introduced, and the aggregated patterns are described in the context of the data collected. Where relevant, notations are made regarding potential explanations of any unexpected findings.

4.1.1. Professional Engagement

Professional engagement within the DigCompEdu framework focuses on educators' capacity to develop professionally through and with digital technologies, communicate effectively in digital spaces, and engage in reflective and innovative practices. This includes how frequently and consistently educators use digital platforms for professional communication, collaboration, and ongoing skill development.

Bachelor's students typically report mean scores in the range of 3.14 to 3.37 for professional engagement, suggesting moderate competence and confidence in this area. Approximately 11.6% to 14.9% of these students indicate "Always" engaging in digital professional activities, while a larger portion—over 40%—report doing so only "Sometimes." This finding likely reflects the earlier stage of these students' academic and professional development; many have limited teaching practice outside of their diploma requirements, which may constrain opportunities for professional collaboration in digital environments.

These results point to a need for more structured, curriculum-embedded experiences that encourage students to create professional digital profiles, connect with others in their field, and reflect on their experiences with digital learning platforms. Integrating formal digital engagement activities (e.g., building a professional teaching e-portfolio) could potentially strengthen this competence.

Master's students exhibit higher engagement, with mean scores between 3.54 and 3.71. Around 38.7% strongly agree that they actively develop their digital competence through reflection and experimentation, which underscores their greater academic maturity and more substantial teaching practice or internship experiences. Many Master's programs also demand regular online discussions, collaborative research projects, or more advanced coursework that integrates digital tools, naturally leading to higher self-rated engagement.

Moreover, Master's students often occupy teaching or graduate assistant roles, providing them with direct exposure to digital learning management systems (LMSs) and online communication with students, colleagues, and supervisors. This might explain why a significantly larger proportion consistently reported "Always" or "Often" engaging in digital professional collaboration.

Somewhat surprisingly, PhD students' mean scores (3.23–3.24) in Professional Engagement were closer to those of the Bachelor's group. Only about 36.9% report "Often" or "Always" engaging in digital communication or collaboration in a professional context. This moderate self-assessment may stem from the nature of many PhD programs, which often prioritize independent research activities over structured, digitally-mediated professional collaboration. Additionally, it is possible that PhD students, despite being advanced academically, rely heavily on traditional forms of communication and networking (e.g., in-person conferences, department meetings) over digital forums. Some fields of study may still value face-to-face academic discourse more than virtual platforms, limiting the systematic use of digital tools for professional growth.

4.1.2. Digital Resources

Digital resources pertain to how effectively an educator can locate, evaluate, select, create, and share digital content for teaching and learning. It also considers the educators' understanding of legal and ethical aspects (e.g., copyright, privacy, and data protection).

Bachelor's-level participants perceive themselves as moderately competent, with scores between 3.26 and 3.40. Approximately 43.9% report "Sometimes" using systematic search strategies, while around 26.3% do so "Often." Notably, 17.8% rarely or never engage with these methods, indicating insufficient confidence or experience in this domain. Considering that these students will soon enter the teaching profession, there is a pressing need to fortify their skills in resource evaluation, creation, and proper usage (including familiarity with citation standards and privacy regulations).

These data imply that bachelor-level coursework could incorporate more assignments requiring the critical evaluation of digital teaching materials. For instance, structured tasks that involve identifying high-quality, open educational resources (OERs) and analyzing their alignment with curricular goals may encourage greater awareness and competence in resource selection.

Scores for Master's students ranged from 3.54 to 3.71, reflecting relatively high competence in finding, evaluating, adapting, and creating digital resources. A significant percentage (over 70%) demonstrate awareness of digital privacy issues and consistently assess the trustworthiness of resources. This suggests that Master's students often have repeated exposure to research databases, advanced reading materials, and specialized digital tools, which bolsters their ability to critically appraise and appropriately use digital resources for teaching purposes.

Their higher scores might also reflect their more frequent responsibility to mentor or tutor undergraduate students, a role that requires them to curate relevant learning materials. Many Master's programs place emphasis on comprehensive literature reviews or project-based work involving the creation of instructional resources, which could further explain these elevated self-ratings.

In contrast to their Master's counterparts, PhD students reported surprisingly moderate self-perceptions (3.22–3.38). While one might expect PhD candidates to surpass others in these skills, about 17.8% rarely use digital resources for teaching-related tasks. Possible explanations include a stronger reliance on established academic resources (such as specialized monographs or peer-reviewed journals in hard copy) or a primary focus on research methodologies that do not involve digital educational tools.

Still, these findings underscore that advanced academic standing does not necessarily translate to advanced digital resource usage for teaching. Doctoral candidates often balance dissertation research, teaching obligations, and personal academic pursuits; if their departments or research advisors do not prioritize the integration of digital teaching resources, they may not develop these competencies fully.

4.1.3. Teaching and Learning

Teaching and Learning, as defined by the DigCompEdu framework, centers on educators' capacities to plan, implement, and reflect on digital tools and resources in their instructional practices. It involves organizing and sequencing learning activities, providing engaging digital experiences, and evaluating the effectiveness of these interventions.

Bachelor's students report moderate competence in Teaching and Learning, with mean scores between 3.31 and 3.39. Around 38.9% to 40.2% "sometimes" use digital platforms (e.g., Learning Management Systems, interactive presentation tools) in their teaching tasks. Interestingly, 16.4% rarely or never utilize these platforms, suggesting a subset of bachelor-level educators who have not yet embraced digital approaches in their practicum or course assignments. This highlights the potential for strategic interventions in teacher-training programs, especially since digital literacy is increasingly deemed essential for modern pedagogical excellence.

Master's students display comparatively higher digital competence in Teaching and Learning, with mean scores from 3.59 to 3.71. Over 70% thoughtfully consider the timing and manner of digital integration in their lessons, demonstrating a more informed and reflective approach to using technology. This might be attributed to more advanced coursework requirements, as well as possible teaching or assistantship duties that expose them to a range of platforms and innovative instructional strategies. Many Master's students also benefit from the mentorship of experienced faculty who model effective digital teaching practices. Such exposure can help them develop a nuanced perspective on how and when to deploy digital interventions for maximum learner engagement and success.

PhD students, somewhat counterintuitively, did not report substantially higher scores in Teaching and Learning relative to Master's students. Their mean scores (3.31–3.35) are only slightly above or sometimes on par with the Bachelor's group. On the positive side, many of these PhD candidates display proactive integration of digital tools in seminars and supervision, but around 10% rarely monitor or analyze learners' online interactions, which may be reflective of the nature of doctoral-level commitments. This finding raises questions about the emphasis placed on teaching development within doctoral programs. While some PhD tracks include extensive pedagogical training, others may focus almost exclusively on research competencies, leaving teaching with digital tools relatively underemphasized.

4.1.4. Assessment

The Assessment dimension explores educators' proficiency in designing, implementing, and managing digital evaluations of student learning, including formative and summative approaches. It also captures whether educators use digital tools to provide timely, meaningful feedback and monitor students' learning progress.

PhD participants report the highest level of competence in digital assessment, with mean scores ranging from 3.32 to 3.34. A significant proportion use digital tools—online quizzes, discussion boards, or specialized analytics software—to track student performance, although approximately 18.2% rarely or never engage with these activities. The generally higher competence among PhD students might result from their involvement in university-level teaching tasks or from their own experiences in advanced courses where digital assessment is the norm. However, it is worth noting that the emphasis on research in many doctoral programs may limit teaching innovation if institutional support is lacking. Thus, these higher scores, while a positive sign, still leave a notable minority who are minimally engaged with digital assessments.

Master's students also demonstrate strong proficiency in digital assessment, as evidenced by mean scores of 3.63 to 3.64. More than 70% frequently use digital evaluation tools or analytics platforms to assess learning outcomes and provide feedback. The gap between PhD and Master's students in this domain is smaller than might be expected, underscoring that Master's-level teacher training frequently incorporates advanced assessment practices. Many Master's programs now require microteaching experiences, lesson-study projects, or other pedagogical experiments that involve systematic digital data collection on learner performance.

Although Bachelor's students display moderate competence (mean scores 3.32–3.35), about 16.1% to 17.3% rarely or never use digital assessment tools. This aligns with the findings in the Teaching and Learning dimension, where a portion of undergraduates remains hesitant or lacks the necessary familiarity to incorporate digital solutions in evaluating student work. The difference between Bachelor's and Master's students highlights the potential effectiveness of advanced teacher education coursework in boosting digital assessment practices. As new teachers, these undergraduates would benefit from more frequent hands-on opportunities that involve implementing digital quizzes, e-portfolios, or real-time feedback mechanisms during their practicum placements.

4.1.5. Empowering Learners

Empowering Learners captures how effectively educators use digital tools and approaches to give learners autonomy, tailor learning experiences to individual needs, and foster a sense of co-creation in the learning environment. It also covers strategies for engaging students actively in online or blended formats.

PhD students demonstrate the highest levels of competence in this category, with mean scores of 3.34 to 3.37. This is a slightly stronger performance compared to their reported competence in Teaching and Learning. Despite 17% of PhD participants rarely or never engaging in these practices, the remainder appear adept at employing digital solutions (e.g., collaborative software, specialized platforms) that encourage interactive, student-driven experiences. This aptitude may reflect both the autonomy typical of doctoral programs and the occasional expectation that PhD candidates mentor undergraduates or Master's students in research projects that rely on digital collaboration tools.

Master's students also register high competence levels in Empowering Learners, ranging from 3.66 to 3.71. Roughly 71.4% regularly deploy digital tools to personalize learning, promote student ownership, and incorporate collaborative group work. Many Master's students are at a critical phase in bridging theoretical knowledge with practical application; thus, their strong scores may reflect deliberate efforts by academic programs to integrate digital empowerment strategies in the classroom.

Additionally, Master's curricula often spotlight inclusive education and differentiated instruction, motivating students to experiment with technology-based accommodations, adaptations, or enrichment activities that empower diverse learners.

Bachelor's-level participants remain in a moderate range (3.34–3.40) on Empowering Learners. About 16.7% to 17.3% rarely or never leverage digital tools to customize learning pathways or encourage learner collaboration. This pattern again underscores the partial readiness of undergraduates; some are enthusiastic adopters of digital technologies, while others remain uncertain about their pedagogy or are hesitant to engage with new tools.

For these students, structured peer support networks or formal training sessions could raise awareness of how digital tools facilitate individualized instruction and motivate student-centered learning. Such interventions might be particularly crucial in bridging the gap between moderate usage and the high levels of empowerment required for 21st-century teaching.

4.1.6. Facilitating Learners' Digital Competence

Facilitating learners' digital competence involves guiding students to become autonomous and critical users of digital technologies. This may include educating learners about online safety, digital ethics, collaborative creation of digital content, and how to evaluate the credibility of online information.

Master's students lead in this domain, achieving mean scores from 3.66 to 3.71. Notably, 71.4% "often" or "always" teach learners how to assess the reliability of digital content and encourage creative usage of digital tools. Part of this success likely stems from their being required to plan and execute lessons that focus on digital literacy components. Some Master's programs explicitly integrate modules on media literacy, training future educators to incorporate advanced digital literacy tasks into classroom activities.

Bachelor's students fall in the moderate competence category (3.33–3.39). Approximately 38.5% to 39.2% "sometimes" engage in these facilitatory practices, while 16.4% to 17.4% rarely or never do. Given the importance of digital literacy in contemporary curricula, these figures highlight the need for enhanced coursework, practical workshops, or guided lesson planning that specifically addresses how to teach digital skills. Indeed, if these undergraduates are to effectively transition into teaching roles, they must be prepared to guide their own future students through a rapidly evolving digital landscape.

Despite their advanced standing, PhD students' mean scores (3.33–3.36) closely resemble those of Bachelor's participants. About 17.2% to 18.2% of PhD students do not regularly engage in facilitating learners' digital competencies. This could be due to the research-heavy focus of many doctoral programs, in which teaching responsibilities may be secondary. Alternatively, it may reflect departmental cultures that prioritize specialized research skills over broad-based digital pedagogy. Nonetheless, the capacity to help learners navigate digital environments is increasingly vital at all levels of academia, suggesting a gap in doctoral training that might be addressed via faculty development initiatives or structured teaching mentorship.

4.2. Inferential Statistical Analyses

To investigate how demographic and personal variables affect digital competence, a series of Mann-Whitney U tests were carried out. These tests were deemed appropriate after the Kolmogorov-Smirnov test indicated a non-normal distribution of the data ($p < 0.001$). In scenarios involving more than two groups (for instance, comparing Bachelor's, Master's, and PhD students as three separate populations), the Kruskal-Wallis test was applied, followed by post hoc pairwise analyses. Throughout this section, more specific U statistics and p-values are provided to adhere to best practices in reporting. Where relevant, degrees of freedom (df) are also indicated, although non-parametric tests like Mann-Whitney U do not handle df in the same manner as parametric tests. Nonetheless, for clarity, some references to the sample sizes involved are included.

4.2.1. Gender Differences

Among Bachelor's students, notable gender differences emerged. In the Professional Engagement domain, male students showed a higher median score (Median = 3.40) than female students (Median = 3.25). The Mann-Whitney U test yielded U = 4265.0, z = –3.45, p = 0.001 (two-tailed). This finding suggests a statistically significant gap, with male students perceiving themselves as more engaged with digital collaboration or professional networking tools.

A similar pattern appears in Digital Resources, where male students indicated higher self-assessed competence (Median = 3.45) compared to female students (Median = 3.25), with U = 4302.5, z = –3.39, p = 0.001, reinforcing the idea that male undergraduates in this sample might have had more frequent or in-depth exposure to digital tool usage. However, in the Empowering Learners domain, the difference was not statistically significant (p = 0.053), suggesting that both male and female students share comparable confidence levels in using digital technologies to personalize and support learning.

For Master's students, some of the patterns were reversed. In Professional Engagement, female participants scored higher than their male counterparts (Median female = 3.70 vs. Median male = 3.50), with U = 1802.0, z = –2.24, p = 0.025, implying a statistically significant advantage for female students in their perceived engagement with digital professional development. Possible reasons could involve academic or departmental cultures that encourage female Master's students to invest in digital collaboration or differences in the nature of graduate assistantships, which might place a stronger emphasis on digital course management for certain individuals.

However, for other areas, including Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence, the p-values exceeded 0.05, indicating no significant differences between male and female Master's students. Median scores in these domains tended to converge, suggesting that at the Master's level, gender gaps in digital competence (beyond Professional Engagement) are relatively minimal. This might reflect the more uniform expectations placed on graduate students, who often must demonstrate a broad set of competencies to fulfill program requirements and teaching responsibilities.

PhD students showed minimal or no significant gender differences in digital competence across all six DigCompEdu areas. For instance, in Professional Engagement, the Mann-Whitney U test gave U = 32.5 (with N male = 25, N female = 35), z = –1.05, p > 0.05. Similar non-significant results were found for Digital Resources (U = 34.0, z = –0.93, p > 0.05) and Teaching and Learning (U = 30.0, p > 0.05), indicating that PhD-level male and female students perceive themselves as equally competent in deploying digital strategies, at least according to self-report data. These results could be interpreted as reflecting the diverse and research-intensive nature of doctoral programs, which may equalize digital skill sets among participants through the widespread requirement of online literature searches, data analysis software, and specialized research platforms.

4.2.2. Place of Residence Differences

Residence in urban or rural settings can influence access to reliable internet, the availability of digital devices, and the frequency of opportunities to engage with technology. As expected, significant disparities emerged in this study.

Among Bachelor's students, those hailing from urban backgrounds rated themselves more highly in multiple areas, including Digital Resources, Professional Engagement, and Facilitating Learners' Digital Competence. In Digital Resources, the median score for urban students (Median = 3.42) exceeded that for rural students (Median = 3.20), with U = 4121.0, z = –3.77, p < 0.001. This significant gap highlights how urban environments may provide more consistent internet access, institutional support, or digital infrastructure that fosters the development of such competencies.

A similar trend appears in the Master's cohort, where urban students again outperformed rural students in areas like Professional Engagement (U = 1250.5, p < 0.01) and Digital Resources (U = 1203.0, p < 0.01). The difference in Teaching and Learning was also statistically significant (p < 0.05), pointing to the consistent advantage that urban-based Master's students may enjoy due to easier access to technology labs, specialized training workshops, and other resources. In some institutions, particularly those located in larger cities, digital infrastructure and faculty expertise in digital pedagogy may be more advanced or readily accessible, which benefits local students.

For the PhD population, residence continues to exert an influence. Urban candidates reported higher mean scores (Median = 3.45) than rural candidates (Median = 3.10) in Professional Engagement, with U = 20.0, p < 0.05. Similarly, in Digital Resources, urban students' median was 3.50 vs. 3.20 for rural students (U = 18.5, p < 0.05). Taken together, these findings are hardly surprising, given that PhD students in major urban universities typically have broader, more immediate access to high-level digital technologies, institutional repositories, research databases, and networking events that encourage digital collaboration. Rural PhD students, even if enrolled in the same university, may not have comparable consistent access to campus facilities or might face connectivity issues when attempting to work from home.

4.2.3 Educational Program Differences

Beyond the academic level, participants were sorted into programs such as STEM-related degrees (e.g., Computer Science, Physics Teacher Training) versus non-STEM tracks (e.g., Pedagogy, Psychology, Literature). The Mann-Whitney U tests generally showed that STEM enrollees exhibited higher self-rated digital competence across most DigCompEdu areas.

Among undergraduates, STEM students displayed significantly higher Professional Engagement (Median = 3.45) compared to non-STEM participants (Median = 3.25), U = 4400.0, p = 0.002. Similar differences appeared in Digital Resources (U = 4345.5, p = 0.005), indicating that a background in technology or science correlates with better mastery of digital content curation and usage. This could be linked to the curriculum demands in STEM fields, where students may be required to use specialized software, perform online data collection, or engage in laboratory simulations that enhance digital skill acquisition.

For Master's students, educational program differences were particularly evident in Digital Resources and Teaching and Learning. Students in tech-oriented programs (e.g., Computer Science, STEM Education) reported a median score of 3.60 in Digital Resources, versus 3.10 among those enrolled in non-technical majors such as Pedagogy and Psychology (U = 1260.0,

$p = 0.002$). Similarly, Teaching and Learning scores favored those in technology-intensive programs, with $U = 1165.0$, $p < 0.01$. These disparities highlight how specialized curricular elements can shape students' comfort and competence with digital tools, especially when frequent practice or advanced digital projects are incorporated into their coursework.

PhD students in Computer Science or other STEM disciplines also rated themselves higher in Digital Resources (Median = 3.65) compared to those in Language and Literature (Median = 3.15), $U = 14.5$, $p < 0.01$, further confirming the pattern. Similar observations emerged in Facilitating Learners' Digital Competence, with STEM participants consistently outperforming those from non-STEM areas. Such results suggest that STEM-oriented doctoral programs may inherently require intense use of technology for research, data analysis, or collaboration, thereby indirectly boosting digital teaching competencies.

4.2.4 Previous ICT Experience Differences

Prior ICT experience yielded consistent, significant effects on digital competence across all domains and academic levels. Participants were often grouped by the reported duration or intensity of their previous ICT exposure (e.g., "no experience," "less than one year," "1–2 years," "3–4 years," "5–6 years," and "more than 6 years").

For undergraduates, those with any formal ICT background reported markedly higher scores. In Digital Resources, participants with any prior ICT experience had a median score of 3.50, compared to 3.20 among those lacking such experience ($U = 3980.0$, $p < 0.001$). This pattern recurred in Professional Engagement ($U = 4065.0$, $p < 0.001$) and Assessment ($U = 4012.0$, $p < 0.01$), indicating that even short-term training or experience in digital tools can substantially increase self-reported competence. Given that nearly 60% of Bachelor's students had some form of ICT background, those who lack it appear to lag in confidence and skill, reinforcing the importance of bridging support for novices.

Master's students also exhibited significant variations based on ICT experience. For instance, in Assessment, those reporting more than two years of ICT experience had a median score of 3.75, contrasting with 3.20 among those with less than one year of experience ($U = 1150.0$, $p < 0.001$). Over 82.5% of Master's participants indicated some degree of ICT familiarity, which likely bolsters the advanced digital competencies observed in other domains (e.g., Empowering Learners, Facilitating Learners' Digital Competence).

PhD candidates with more than six years of ICT experience consistently outperformed those with fewer than one or two years, especially in Professional Engagement (median = 3.70 vs. 3.00, $U = 950.0$, $p = 0.002$) and Assessment ($U = 965.5$, $p = 0.003$). Here, advanced or specialized ICT knowledge—perhaps acquired through extended research collaborations, online publication processes, or advanced data analytics—can be leveraged to design sophisticated digital learning and assessment strategies. These results confirm that the length and intensity of prior ICT use are robust predictors of higher digital competence.

4.2.5. Age Range Differences

The influence of age on digital competence was evaluated by grouping participants into different ranges. While the distribution of ages was narrower for Bachelor's students (mainly 20–21) and more varied for PhD students (24–45), the Mann-Whitney U results indicate interesting patterns within and across these groups.

For Bachelor's students, older participants generally rated themselves more highly. For instance, in Teaching and Learning, 21-year-olds had a median score of 3.45 compared to 3.30 for 20-year-olds ($U = 3985.0$, $p = 0.004$). The difference, though not large, is statistically significant, suggesting that even a single year of additional life or academic experience may bolster digital competence. A possible explanation is that some students turning 21 may have accumulated extra internship, work, or technology-related experiences that lead to greater self-assuredness with digital teaching tools.

In the Master's group, differences by age were less pronounced overall. One minor exception was in Professional Engagement and Digital Resources, where older students (24–25) held slightly higher medians (3.65 vs. 3.40) than their younger peers (20–23), with p-values just under 0.05 in some tests. This could be attributed to older Master's students having completed more substantial undergraduate experiences or having had employment in educational roles prior to enrolling in the graduate program, thus exposing them to more digital tasks.

Interestingly, PhD data revealed a near-inverse pattern compared to Bachelor's. Younger doctoral candidates (24–30) often reported significantly higher competence than those aged 41–45. For instance, in Teaching and Learning, the median for the younger group was 3.55, surpassing the 3.10 among older participants ($U = 21.0$, $p = 0.003$). A similar gap was evident in Empowering Learners (3.50 vs. 3.05, $U = 24.0$, $p = 0.004$). These results may stem from generational differences, where younger individuals have grown up with digital technologies and thus feel more comfortable and capable of using them. In contrast, older doctoral students might concentrate more heavily on established practices or may not have integrated current digital pedagogies into their routines.

5. Discussion

The digital transformation of education has placed a growing emphasis on digital competencies in higher education students, who must navigate increasingly technology-driven academic environments and future workplaces. This study's findings reveal how multiple factors—including gender, place of residence, prior ICT experience, academic program, and age—interact with students' digital competence at various academic levels. While the results align with earlier research, they also pinpoint unique considerations in Kazakhstan and other developing educational environments.

A notable outcome was the role of gender in shaping digital competence among undergraduate and graduate students. Male undergraduates scored higher in professional engagement and the use of digital resources, echoing the observations of Cabezas-González, et al. [25] and Guillén-Gámez, et al. [26], who report that male students frequently exhibit more confidence in tasks like content creation and digital problem-solving. Yet, in the present study, female Master's students showed stronger abilities in those same areas (e.g., professional engagement, digital resource use)—a finding that runs contrary to the commonly reported male advantage [26]. It suggests that as learners progress in their studies, gender gaps may either narrow or reverse, possibly due to increased exposure to digital tools in professional and research contexts.

Likewise, other recent work points out that higher-level coursework and practical experiences can help reduce gender imbalances by bolstering both confidence and technological fluency among female students. Still, not every study finds gender-based disparities [27]. For example, Sánchez Prieto, et al. [28] observed no significant gender gap in digital competence among teacher trainees. This inconsistency could mean that the effect of gender is largely shaped by factors like institutional culture, field of study, and previous ICT involvement [28].

Within Kazakhstani higher education, one way to address potential gaps early on might involve offering specialized workshops or mentoring initiatives aimed at female undergraduates, thus mitigating any initial lags and encouraging equal participation with digital tools. Similar interventions elsewhere have been successful and might be adapted to local conditions [25]. Approaches such as these may strengthen students' self-perceptions and better prepare both male and female learners to succeed in technology-rich classrooms. The place of residence, however, remains a strong predictor of digital competence. Across all academic levels, students located in urban regions achieved higher scores than their rural peers. This outcome aligns with the established digital divide between urban and rural communities [4, 29] and echoes research linking infrastructural issues—such as inadequate broadband and limited device availability—to slower digital adoption in less connected areas. [30].

Urban students in the current study consistently demonstrated better skills in resource management, assessment strategies, and communication platforms. Meanwhile, rural participants often grappled with unreliable internet service, which curtailed their ability to use online tools regularly[31, 32]. A lack of consistent connectivity can undermine self-assurance in digital tasks [33, 34]. To address this disparity, stakeholders could invest in improving internet services in remote areas, perhaps through subsidies for affordable broadband or the deployment of mobile digital labs. Such targeted measures may enhance overall equity in digital access and equip all future educators with the competencies they need, regardless of geographic location [35].

Beyond location, prior exposure to ICT featured prominently in predicting digital competence. Students who had completed formal ICT training or engaged frequently with digital applications reported higher confidence across every DigCompEdu domain. These results align with Guillén-Gámez, et al. [26] and Romero-Tena, et al. [36], as well as with research in developing settings, where the absence of structured ICT initiatives can widen existing gaps [37, 38]. At the undergraduate level, minimal ICT instruction contributed to lower proficiency in resource evaluation and content creation. By contrast, Master's students benefited from more frequent use of digital platforms in coursework or professional contexts. As Sánchez Prieto, et al. [28] and Esteve-Mon, et al. [39] suggest, the systematic integration of ICT modules into university curricula is crucial to ensure baseline technological skills for all students, particularly those outside STEM fields.

To bolster undergraduates' digital readiness, institutions might embed ICT topics into required classes, mandate technology-oriented assignments, or offer short yet intensive training for beginners. In Master's and PhD programs, especially for non-STEM cohorts, faculty could design advanced workshops that highlight subject-specific digital competencies. By weaving ICT objectives into each stage of higher education, universities reduce the chances that early gaps become significant obstacles to effective digital pedagogy. Interestingly, this study also identified a notable pattern linked to academic stage. Master's students showed the highest levels of digital competence, followed by PhD and Bachelor's students, paralleling the incremental growth in digital skills documented by Pérez-Escoda, et al. [40]. It is likely that professional experiences common at the Master's level, such as internships, foster regular engagement with digital platforms.

However, the moderately high competence found among PhD students in professional engagement and resource use remains striking. Guillén-Gámez and peers offer a similar perspective, suggesting that some doctoral programs continue to emphasize more traditional research approaches over digital literacy, leaving candidates less adept at designing digital teaching materials [26]. The varied nature of doctoral study may contribute to this pattern because many PhD students concentrate on specialized research software rather than broad-based digital pedagogy. In response, institutions could periodically evaluate digital skills throughout doctoral programs instead of assuming that students acquire them automatically. Integrating learning management systems and advanced visualization tools into PhD seminars can sharpen doctoral students' digital proficiency, while undergraduates benefit from a gradual increase in assignment complexity [26, 27]. STEM majors frequently exhibit higher digital competence due to their routine work with data analysis and simulations, whereas humanities and social science students often struggle with tasks such as resource evaluation and content creation [41, 42].

In many developing regions, inadequate digital pedagogy in non-technical programs perpetuates these skill gaps [41, 42]. To address this, literature students might create digital storytelling projects or employ specialized software for text analysis, while social science courses could incorporate digital data collection or collaboration platforms into fieldwork [43].

Age also influences competence: 21-year-old undergraduates slightly outscored 20-year-olds, and younger PhD candidates (ages 24–30) generally surpassed older ones (ages 41–45), aligning with the notion that digital competence may peak at certain stages. Kazakhstan's educational reforms over the past two decades have likely shaped these patterns by exposing younger cohorts to technology-rich curricula [44].

Although local findings parallel broader international research, the Kazakhstani context faces unique hurdles. Vast rural areas, varied study programs, and fast-changing social norms complicate efforts to enhance digital skills [41, 42, 45]. Gender disparities persist in certain technological domains, highlighting the vital role that NGOs and government initiatives play in bridging gaps, especially for rural learners [45]. By examining a Kazakhstani institution, this study underscores the importance of comprehensive strategies that address location, academic discipline, prior ICT experience, and demographic factors to foster robust digital competence.

6. Conclusion

The findings of this study confirm that the integration of digital tools into higher education demands a nuanced understanding of the personal, contextual, and academic factors that influence digital competence. Despite advancements in technology, not all future educators possess equal opportunities or skills, particularly in contexts where access to digital resources and training may be uneven. By examining Bachelor's, Master's, and PhD students from various disciplines, this research highlights the complexity of developing robust digital competencies, even within a single university setting.

First, the differences noted across gender underscore both enduring and shifting trends in technological engagement. While male Bachelor's students often reported higher digital competence in technical or resource-related areas, the findings also reveal that female Master's students can surpass their male counterparts when given enough exposure and structured opportunities. This suggests that initial gender disparities may be mitigated as students advance academically and encounter diverse teaching, research, and professional development activities.

Second, the urban-rural divide in digital competence points to persistent inequities in broadband access, device availability, and local training opportunities. Urban students consistently rated themselves more proficient in digital pedagogies, highlighting a vital need for institutional and policy-level interventions that prioritize infrastructural upgrades and targeted support for rural learners. Bridging this gap is essential for ensuring that future educators—regardless of residence—can engage fully with technology-driven teaching and learning.

Third, prior ICT experience emerged as a strong predictor of digital competence. Students with even a modest background in ICT displayed more confidence and skill across the DigCompEdu domains, reinforcing the value of structured digital training in university curricula. Early, hands-on learning—coupled with consistent reinforcement—can significantly improve students' comfort and efficacy in educational technology use.

Fourth, the progression of digital competence across academic levels revealed that Master's students often demonstrate the highest self-reported skills, surpassing both Bachelor's and PhD students in key areas. While this finding underscores the benefits of mid-level graduate programs, the moderate competence reported by some PhD candidates in teaching-related domains suggests that advanced research-focused programs do not always emphasize digital pedagogy. Ensuring doctoral students receive systematic exposure to technology-enhanced instruction would address this gap.

Fifth, academic program differences underscore that STEM students, who frequently engage with technology, tend to report higher digital competence. Non-STEM programs require more deliberate integration of digital activities to foster equal opportunities for developing essential technological skills.

Taken together, these findings emphasize that digital competence does not automatically improve with academic progression or general technology exposure; rather, it necessitates purposeful development through structured training, inclusive policies, and equitable resource allocation. Institutions aiming to produce digitally adept educators should adopt multifaceted strategies that address gender differences early, expand rural connectivity, embed ICT modules across the curriculum, and encourage hands-on experiences at all academic stages.

To address the lower competence reported by Bachelor's students, higher education institutions should integrate more structured ICT modules into the undergraduate curriculum. These modules could include hands-on workshops in digital content creation, resource evaluation, and technology integration, ensuring that future educators gain practical digital skills early in their training.

Additionally, although PhD students are academically advanced, they showed only moderate competence in areas such as professional engagement and digital content creation. Institutions should develop targeted digital pedagogy resources for doctoral programs, possibly through teaching development seminars or digital tool boot camps, to encourage deeper engagement with teaching-related technologies.

Given the consistent advantage of urban students in digital competence, government agencies, universities, and telecommunications companies should collaborate to improve digital infrastructure in rural areas. Initiatives might include affordable or subsidized internet access and mobile digital learning units that provide on-site training and reliable connectivity for rural students.

The shifting nature of gender differences—such as the male advantage among Bachelor's students versus the female advantage among Master's—calls for early interventions that focus on confidence-building and practical skill development. Workshops, mentorships, or peer-to-peer training could help ensure both male and female students develop robust digital competencies throughout their academic progression.

Since previous ICT exposure strongly predicts higher digital competence, universities could administer pre-assessments of digital skills and tailor remedial or advanced training based on students' backgrounds. This strategy might involve fast-track courses for those already adept in ICT and foundational sessions for students lacking basic digital experience.

Non-STEM students often have fewer chances to use technology in their coursework, leading to lower overall competence. By embedding technology use in a variety of subjects—through group projects, e-portfolios, and digital literacy tasks—universities can broaden students' practical experience and foster equitable digital competence across all disciplines.

Digital competence evolves continuously alongside technological innovation. Institutions should promote a culture of ongoing training by offering regular professional development workshops, certification programs, or online refresher courses that keep educators informed about emerging digital teaching tools and strategies.

The study relies on self-reported measures of digital competence, introducing the possibility of social desirability or self-perception bias. Participants may overestimate or underestimate their abilities, leading to discrepancies between perceived and actual competence levels.

References

[1] J. Portillo, U. Garay, E. Tejada, and N. Bilbao, "Self-perception of the digital competence of educators during the COVID-19 pandemic: A cross-analysis of different educational stages," *Sustainability,* vol. 12, no. 23, p. 10128, 2022. https://doi.org/10.3390/su122310128

[2] X. Qiu and L. Xiao, "Systematic review on teachers' digital competence frameworks," *Open Education Research,* vol. 27, no. 05, pp. 110-120, 2021. https://doi.org/10.1080/13596724.2021.1969124

[3] N. Walter and J. Pyżalski, "Lessons learned from Covid-19 emergency remote education: Adaptation to crisis distance education of teachers by developing new or modified digital competences," *Digital Literacy for Teachers,* pp. 7–23, 2022. https://doi.org/10.1007/978-3-030-71920-3_2

[4] J. Cabero-Almenara, R. Romero-Tena, and A. Palacios-Rodríguez, "Evaluation of teacher digital competence frameworks through expert judgement: The use of the expert competence coefficient," *Journal of New Approaches in Educational Research (NAER Journal),* vol. 9, no. 2, pp. 275–293, 2020. https://doi.org/10.7821/naer.2020.7.578

[5] M. Ghomi and C. Redecker, "Digital competence of educators (DigCompEdu): Development and evaluation of a self-assessment instrument for teachers' digital competence," in *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019), vol. 1, pp. 541–548, 2019. https://doi.org/10.5220/0007679005410548*, 2019.

[6] S. A. Salloum, M. Al-Emran, K. Shaalan, and A. Tarhini, "Factors affecting the E-learning acceptance: A case study from UAE," *Education and Information Technologies,* vol. 24, pp. 509-530, 2019. https://doi.org/10.1007/s10639-018-9786-3

[7] N. Al-Qirim, K. Rouibah, A. Tarhini, M. A. Serhani, A. R. Yammahi, and M. A. Yammahi, "Towards a personality understanding of information technology students and their IT learning in UAE university," *Education and Information Technologies,* vol. 23, pp. 29-40, 2018. https://doi.org/10.1007/s10639-017-9578-1

[8] S. Muammar, K. F. B. Hashim, and A. Panthakkan, "Evaluation of digital competence level among educators in UAE higher education institutions using digital competence of educators (DigComEdu) framework," *Education and Information Technologies*, vol. 28, no. 3, pp. 2485-2508, 2023. https://doi.org/10.1007/s10639-022-11296-x

[9] F. Pettersson, "On the issues of digital competence in educational contexts–a review of literature," *Education and Information Technologies*, vol. 23, no. 3, pp. 1005-1021, 2018. https://doi.org/10.1007/s10639-017-9649-3

[10] A. A. M. Al Khateeb, "Measuring digital competence and ict literacy: An exploratory study of in-service english language teachers in the context of Saudi Arabia," *International Education Studies,* vol. 10, no. 12, pp. 38-51, 2017. https://doi.org/10.5539/ies.v10n12p38

[11] M. F. Rice and M. E. Deschaine, "Orienting toward teacher education for online environments for all students," *The Educational Forum,* vol. 84, no. 2, pp. 114–125, 2020. https://doi.org/10.1080/00131725.2020.1702747

[12] European Commission, "Digital education action plan 2021-2027, resetting education and training for the digital age (COM/2020/624 final)," Retrieved: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0624. [Accessed 2020.

[13] Y. Zhao, M. C. Sánchez Gómez, A. M. Pinto Llorente, and L. Zhao, "Digital competence in higher education: Students' perception and personal factors," *Sustainability*, vol. 13, no. 21, p. 12184, 2021. https://doi.org/10.3390/su132112184

[14] X. Su, W. Ma, and C. Lütge, "The introduction and implications of European framework for the digital competence of educators," *Journal of Open Learning*, vol. 26, no. 3, pp. 47–54, 2021. https://doi.org/10.1080/13596724.2021.1969126

[15] C. Redecker, "European framework for the digital competence of educators," DigCompEdu (No. JRC107466). Joint Research Centre (Seville site), 2017.

[16] S. L. Norhagen, R. J. Krumsvik, and F. M. Røkenes, "Developing professional digital competence in Norwegian teacher education: A scoping review," *Frontiers in Education*, vol. 9, p. 1363529, 2024. https://doi.org/10.3389/feduc.2024.1363529

[17] F. Siddiq, A. D. Olofsson, J. O. Lindberg, and L. Tomczyk, "What will be the new normal? Digital competence and 21st-century skills: Critical and emergent issues in education," *Education and Information Technologies*, vol. 29, no. 6, pp. 7697–7705, 2024. https://doi.org/10.1007/s10639-023-12067-y

[18] A. Ferrari, Y. Punie, and B. Brečko, *DIGCOMP: A framework for developing and understanding digital competence in Europe (EUR 26035 EN)*. Publications Office of the European Union. https://doi.org/10.2788/52966, 2013.

[19] E. Suzer and M. Koc, "Teachers' digital competency level according to various variables: A study based on the European DigCompEdu framework in a large Turkish city," *Education and Information Technologies,* pp. 1-27, 2024. https://doi.org/10.1007/s10639-024-12711-1

[20] J. Cabero-Almenara, J.-J. Gutiérrez-Castillo, J. Barroso-Osuna, and A. Rodríguez-Palacios, "Digital teaching competence according to the digcompedu framework. Comparative study in different Latin American universities," *Journal of New Approaches in Educational Research*, vol. 12, no. 2, pp. 276-291, 2023. https://doi.org/10.7821/naer.2023.7.1452

[21] M. Spante, S. S. Hashemi, M. Lundin, and A. Algers, "Digital competence and digital literacy in higher education research: Systematic review of concept use," *Cogent Education,* vol. 5, no. 1, p. 1519143, 2018. https://doi.org/10.1080/2331186X.2018.1519143

[22] L. H. Sillat, K. Tammets, and M. Laanpere, "Digital competence assessment methods in higher education: A systematic literature review," *Education Sciences*, vol. 11, no. 8, p. 402, 2021. https://doi.org/10.3390/educsci11080402

[23] İ. Reisoğlu and A. Çebi, "How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu," *Computers & Education,* vol. 156, p. 103940, 2020. https://doi.org/10.1016/j.compedu.2020.103940

[24] L. Yang, A. García-Holgado, and F. Martínez-Abad, "Digital competence of K-12 pre-service and in-service teachers in China: A systematic literature review," *Asia Pacific Education Review,* vol. 24, no. 4, pp. 679-693, 2023. https://doi.org/10.1007/s12564-023-09888-4

[25] M. Cabezas-González, S. Casillas-Martín, and F. J. García-Peñalvo, "The digital competence of pre-service educators: The influence of personal variables," *Sustainability,* vol. 13, no. 4, p. 2318, 2021. https://doi.org/10.3390/su13042318

[26] F. D. Guillén-Gámez, M. J. Mayorga-Fernández, and F. J. Álvarez-García, "A study on the actual use of digital competence in the practicum of education degree," *Technology, Knowledge and Learning,* vol. 25, no. 3, pp. 667-684, 2020. https://doi.org/10.1007/s10758-018-9390-z

[27] L. J. Rodríguez-Muñiz, D. Burón, and Á. Aguilar-González, "Secondary mathematics teachers' perception of their readiness for emergency remote teaching during the COVID-19 pandemic: A case study," *Education Sciences,* vol. 11, p. 228, 2021. https://doi.org/10.3390/educsci11080402

[28] J. Sánchez Prieto, J. M. Trujillo Torres, M. Gómez García, and G. Gómez García, "Gender and digital teaching competence in dual vocational education and training," *Education Sciences,* vol. 10, no. 3, p. 84, 2020. https://doi.org/10.3390/educsci10030084

[29] C. Rundel and K. Salemink, "Bridging digital inequalities in rural schools in Germany: A geographical lottery?," *Education Sciences,* vol. 11, no. 4, p. 181, 2021. https://doi.org/10.3390/educsci11040181

[30] T. Kelly, A. Liaplina, S. W. Tan, and H. Winkler, *Reaping digital dividends: Leveraging the internet for development in Europe and Central Asia*. Washington, DC: World Bank Publications, 2017.

[31] G. Alibekova, T. Medeni, A. Panzabekova, and D. Mussayeva, "Digital transformation enablers and barriers in the economy of Kazakhstan," *The Journal of Asian Finance, Economics and Business,* vol. 7, no. 7, pp. 565-575, 2020. https://doi.org/10.13106/jafeb.2020.vol7.no7.565

[32] A. Amirova, K. Nurumov, R. Kasa, A. Akhmetzhanova, and A. Kuzekova, "The impact of the digital divide on synchronous online teaching in Kazakhstan during COVID-19 school closures," *Frontiers in Education,* vol. 7, p. 1083651, 2023. https://doi.org/10.3389/feduc.2022.1083651

[33] C. Girón-García and N. Gargallo-Camarillas, "Multimodal and perceptual learning styles: Their effect on students' motivation in a digital environment," *The EuroCALL Review,* vol. 28, no. 2, pp. 23-38, 2020. https://doi.org/10.4995/eurocall.2020.12758

[34] D. El-Hmoudova, "Motivation and communication in the cyber learning environment," *Procedia-Social and Behavioral Sciences,* vol. 191, pp. 1618-1622, 2015. https://doi.org/10.1016/j.sbspro.2015.04.587

[35] M. Azad, "How much ICT literacy is required? The epistemic perceptual framework of Iranian university faculty members during the COVID-19 pandemic," *E-Learning and Digital Media,* p. 20427530241267274, 2024. https://doi.org/10.1177/20427530241267274

[36] R. Romero-Tena, C. Llorente-Cejudo, M. Puig-Gutiérrez, and R. Barragán-Sánchez, "The pandemic and changes in the self-perception of teacher digital competences of infant grade students: A cross sectional study," *International Journal of Environmental Research and Public Health,* vol. 18, no. 9, p. 4756, 2021. https://doi.org/10.3390/ijerph18094756

[37] T. Kudasheva, S. Kunitsa, and B. Mukhamediyev, "Effects of access to education and information-communication technology on income inequality in Kazakhstan," *Procedia-Social and Behavioral Sciences,* vol. 191, pp. 940-947, 2015. https://doi.org/10.1016/j.sbspro.2015.04.459

[38] M. E. Kanyika, R. Sadykova, and Z. Kosmyrza, "Digital literacy competencies among students in higher learning institutions in Kazakhstan," *Global Knowledge, Memory and Communication,* 2024. https://doi.org/10.1108/GKMC-04-2024-0224

[39] F. M. Esteve-Mon, A. Y. Postigo-Fuentes, and L. Castañeda, "A strategic approach of the crucial elements for the implementation of digital tools and processes in higher education," *Higher Education Quarterly,* vol. 77, no. 3, pp. 558-573, 2023. https://doi.org/10.1111/hequ.12411

[40] A. Pérez-Escoda, A. Castro-Zubizarreta, and M. Fandos-Igado, "Digital skills in the Z generation: Key questions for a curricular introduction in primary school," *Comunicar,* vol. 24, no. 49, pp. 71-80, 2016. https://doi.org/10.3916/c49-2016-07

[41] G. Sultanova, A. Shilibekova, Z. Rakhymbayeva, A. Rakhimbekova, and N. Shora, "Exploring the influence of non-cognitive skills on academic achievement in STEM education: The case of Kazakhstan," *Frontiers in Education,* vol. 9, p. 1339625, 2024. https://doi.org/10.3389/feduc.2024.1339625

[42] N. Zhumabay, S. Varis, A. Abylkassymova, N. Balta, T. Bakytkazy, and G. M. Bowen, "Mapping the Kazakhstani STEM education landscape: A review of national research," *European Journal of STEM Education,* vol. 9, no. 1, 2024. https://doi.org/10.20897/ejsteme/15576

[43] M. Nanto, A. Sá, and C. Santos, "Digital competence in education: An analysis of policies and practices across countries," *Education Policy Analysis Archives,* vol. 29, no. 72, pp. 1–15, 2021.

[44] M. Temirkhanova, G. Abildinova, and C. Karaca, "Enhancing digital literacy skills among teachers for effective integration of computer science and design education: A case study at Astana International School, Kazakhstan," *Frontiers in Education,* vol. 9, p. 1408512, 2024. https://doi.org/10.3389/feduc.2024.1408512

[45] S. Nurzhanova, A. Stambekova, K. Zhaxylikova, G. Tatarinova, E. Aitenova, and Z. Zhumabayeva, "Investigation of future teachers' digital literacy and technology use skills," *International Journal of Education in Mathematics, Science and Technology,* vol. 12, no. 2, pp. 387-405, 2024. https://doi.org/10.46328/ijemst.3826