

Enhancement Pathways of Pre-Service Teachers' Digital Literacy in the Context of Educational Digital Transformation

Yini Yao*, Lili Zhou

Yunnan Technology and Business University, Yunnan 651701, Kunming, China

*Author to whom correspondence should be addressed.

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Abstract: In the context of the educational digital transformation, digital literacy has become a key competency for teacher professional development. As the future teaching workforce, enhancing the digital literacy of pre-service teachers is not only a practical necessity to adapt to the development of digital education but also a crucial foundation for reforming the teaching workforce and achieving personalized teaching. Currently, the cultivation of pre-service teachers' digital literacy faces multiple challenges, including constraints posed by their academic backgrounds, a fragmented curriculum system, and a lack of collaborative mechanisms. Therefore, this paper proposes that effective enhancement of pre-service teachers' digital literacy can be achieved through pathways such as forming specialized digital literacy teaching teams, constructing a systematic digital literacy curriculum system, and establishing multi-stakeholder collaboration mechanisms for digital literacy education. This will lay a solid foundation for high-quality development in future education.

Keywords: Digital transformation in education; Digital literacy; Pre-service teachers

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1. Introduction

Amid the global wave of societal digital transformation, the educational digital transformation has become a consensus in national education development strategies and signifies a redefinition and reshaping of educational development pathways in the era of intelligence. As early as 2020, UNESCO, ITU, and other organizations jointly released the report *Educational Digital Transformation: Connecting Schools, Empowering Students*, elaborating on the importance of this transformation^[1]. In 2021, UNESCO again published the report *Reimagining Our Futures Together: A New Social Contract for Education*, encouraging the embrace of digitalization to promote educational change. The *Unlimited Potential: Report on the Digital Development of World Higher Education*, compiled by the Secretariat of the Global MOOC and Online Education Alliance and released at the end of 2022, clearly outlined the trends, stages, and directions of change for the digital

development of world higher education. In the process of educational digital transformation, enhancing the digital literacy of both teachers and students is a crucial link. In recent years, attention to teacher digital literacy has continuously increased. China's Ministry of Education issued the *Teacher Digital Literacy* document in 2022, aiming to further promote its enhancement. However, the cultivation of digital literacy for pre-service teachers, who are the reserve force of the teaching workforce, has not yet received sufficient attention. The literacy level of pre-service teachers is directly related to the overall quality of the future teaching workforce and is a vital guarantee for the sustainable development of education.

2. The connotation of digital literacy and pre-service teachers' digital literacy

The concept of "digital literacy" was first formally introduced by American scholar Paul Gilster in 1997, who defined it as the comprehensive ability to access, understand, evaluate, integrate, and use information resources^[2]. The concept subsequently gained traction, leading to diverse interpretations across different fields. The 2017 NMC Strategic Brief defined digital literacy as "the ability to understand, express, and use digital resources when retrieving and creating digital content"^[3]. In China, the concept was initially introduced by Xiao Junhong in 2006, who argued that it should encompass not only pure technical skills but also cognitive, emotional, and social skills^[4]. With the deepening development of the digital era, numerous experts, drawing from their professional fields and employing different theoretical frameworks, have endowed the concept with richer connotations. This includes definitions of teacher digital literacy. The *Teacher Digital Literacy* standard released by China's Ministry of Education in 2022 defines it as the awareness, ability, and responsibility of teachers to appropriately utilize digital technologies to acquire, process, use, manage, and evaluate digital information and resources; to discover, analyze, and solve educational and teaching problems; and to optimize, innovate, and transform educational and teaching activities. However, directly applying the definition designed for in-service teachers to pre-service teachers is not entirely appropriate. This is because pre-service teachers and in-service teachers have different emphases in their digital literacy needs. The digital literacy standards for in-service teachers focus more on application within specific professional environments, emphasizing the practical operation of digital technologies. In contrast, the digital literacy of pre-service teachers should pay more attention to application skills as learners and future professional adaptability, covering critical and innovative thinking, self-directed learning ability, and problem-solving skills supported by digital technologies.

3. The value and significance of enhancing pre-service teachers' digital literacy

3.1. Adapting to the practical needs of educational digital development

With the rapid development of information technology, the field of education is undergoing profound changes. In 2021, the Ministry of Education and five other departments issued the *Guiding Opinions on Promoting New Educational Infrastructure Construction to Build a High-Quality Education Support System*, clearly stating the goal of achieving digital transformation, intelligent enhancement, and innovative integration in education by accelerating the development of new educational infrastructure, such as digital resources and smart campuses. In 2022, the *Key Work Points of the Department of Higher Education of the Ministry of Education* were released, proposing the comprehensive promotion of the digitalization process in higher education teaching and accelerating the construction of a sound digital system for higher education teaching^[5]. The report of the 20th National Congress of the Communist Party of China included "advancing the digitalization of education" for the first time, marking the official entry of China's education cause into a new period of digital development^[6].

The 2023 National Education Work Conference held in Beijing emphasized the need to deepen the promotion of the digital education strategy. As the main force of future education, pre-service teachers must possess the ability to adapt to the digital educational environment, and digital literacy is the core embodiment of this ability^[7]. Therefore, enhancing the digital literacy of pre-service teachers is a practical need to adapt to the development of digital education. Only when pre-service teachers possess corresponding digital literacy can they, in turn, promote the in-depth development of educational digitalization.

3.2. A key element in reforming teacher education for the digital age

To effectively advance the implementation of China's digital education strategy, further improve the standard system for educational informatization, and enhance teachers' awareness, ability, and responsibility in using digital technologies to optimize, innovate, and transform educational and teaching activities, the Ministry of Education promulgated the *Teacher Digital Literacy* standard in 2022. This shows that enhancing teacher digital literacy is an important part of teacher reform in the digital era. As future teachers, enhancing the digital literacy of pre-service teachers is even more crucial for teacher reform in the digital era. The advent of the digital age has brought about transformative changes in educational methods and resources. Traditional teaching tools such as blackboards, chalk, and textbooks are gradually being replaced by digital devices, online platforms, and multimedia resources. This requires pre-service teachers to master corresponding digital skills to effectively use these new teaching tools and improve teaching effectiveness. In the digital era, students' learning styles are also changing. They increasingly prefer to acquire information and solve problems through the internet and tend to engage in online communication and interaction with teachers and classmates. Therefore, pre-service teachers need to possess a certain level of digital literacy to better meet the basic requirements for teachers in the digital era.

3.3. An inevitable choice for realizing personalized student learning

Enhancing the digital literacy of pre-service teachers is an inevitable choice for achieving personalized student learning because digital technology provides diverse resources and tools for education, better meeting the learning needs and interests of different students. For example, e-textbooks can satisfy students' demand for flexible learning content, online courses can provide additional support for students with different learning paces, and virtual laboratories can present intuitive experimental processes to students. This not only stimulates students' interest in learning but also cultivates their spirit of exploration and self-directed learning ability. The improvement of digital literacy enables pre-service teachers to conduct instructional design and effect evaluation more professionally. Using data analysis tools, such as student performance tracking software, they can identify students' knowledge weaknesses and adjust teaching strategies to enhance learning outcomes. The application of digital technology also supports the integration of interdisciplinary knowledge into the classroom. For instance, incorporating examples of data analysis or technology application when explaining scientific topics helps students better understand the process of solving practical problems. Teachers with digital literacy can also guide students in developing essential 21st-century skills. Guiding students to use collaborative tools in teaching helps cultivate their logical thinking and digital skills. These practices not only lay the foundation for students' lifelong learning but also equip them with stronger competitiveness in their future career development. Therefore, enhancing the digital literacy of pre-service teachers is not only a requirement to adapt to future educational trends but also an important guarantee for achieving personalized student learning.

4. Current issues in the cultivation of pre-service teachers' digital literacy

4.1. Constraints of academic and professional backgrounds

In pre-service teacher education, the issue of limitations in the professional backgrounds of both students and teachers cannot be ignored. Surveys have found that pre-service teachers and the teacher group generally have humanities and social sciences backgrounds, which poses a fundamental challenge to the development of their digital literacy. Teachers are required not only to possess profound subject knowledge and rich teaching experience but also to have a deep understanding and application ability of digital technologies. However, such teachers with interdisciplinary expertise are relatively scarce. Furthermore, the imperfection of the teacher digital literacy training system is also a problem. Many teacher-training institutions lack systematic training plans for enhancing teacher digital literacy. Additionally, there is insufficient motivation for teachers' personal development. Some teachers may have a low acceptance of new technologies, lacking the internal drive for active learning and knowledge updating. Some even believe that "digitalization" increases workload to some extent, making simple tasks more complicated. This situation continuously exacerbates the professional limitations of teachers, thereby affecting the cultivation of pre-service teachers' digital literacy.

4.2. Lack of a sound curriculum system

According to field research in numerous institutions, it has been found that currently, many institutions have not formed a systematic and structured curriculum arrangement for cultivating pre-service teachers' digital literacy. For example, most campuses' curriculum settings for pre-service teachers basically include general education courses on information technology in the first year, with teaching content primarily focused on the use of Office software suites, such as Word and Excel. In the second year, there are professional foundation compulsory courses, such as modern educational technology courses. In the third year, there are professional expansion elective courses, such as educational statistics and practical SPSS operation courses. The curriculum setup is relatively simple, with scattered and relatively outdated content that does not form a system, lacking in-depth theoretical education and practical operation guidance for students. This results in students having difficulty acquiring comprehensive and coherent knowledge and skills during their studies, unable to meet the demands for digital technology application in future educational work.

4.3. Absence of a diverse collaboration mechanism

The important characteristic of digital literacy—interdisciplinarity—means that while deepening integration within one's own major, attention must also be paid to communication and collaboration with other fields. Faculty in teacher-training departments should actively seek in-depth cooperation with on-campus libraries, research institutions, etc., leveraging their respective advantages to jointly undertake the responsibility of enhancing pre-service teachers' digital literacy. Simultaneously, they should also strive to attract excellent external resources, including libraries from other universities and experts in the field of digital literacy, to achieve mutually beneficial outcomes. According to digital literacy cultivation practices, libraries, relying on their unique advantages in digital resources, play an irreplaceable and important role^[8]. Surveys have found that most libraries' efforts in enhancing students' "digital literacy" appear "superficial," with only a few lectures targeting all students, lacking professional specificity and systematicity. At the same time, teacher-training departments have not proactively explored effective cooperation with libraries and other departments. There exists a clear knowledge boundary between library work and pre-service teacher education, with each working independently, leading to ultimately unsatisfactory results.

5. Enhancement pathways: Strategies for cultivating pre-service teachers' digital literacy

5.1. Forming digital literacy education and teaching teams

The standardization of digital literacy education in universities and the achievement of its effectiveness rely on organized educational teams as a solid backing. Digital literacy education teams mainly consist of two major parts: first, specialized teams closely integrated with subject knowledge, relying on their own disciplinary knowledge systems; second, general education teams, with librarians at the core, utilizing the rich digital resources of libraries. The division of labor among team members should be clarified, determining the team's main responsibilities, teaching objectives, and the digital literacy areas that need to be covered. Provide necessary digital technology training for team members to ensure they can proficiently use various digital tools and resources. Establish evaluation and feedback mechanisms, regularly assess teaching effectiveness, collect feedback from students and teachers, and continuously optimize teaching methods and content. Furthermore, continuously update and improve, constantly learn the latest technologies, update teaching resources and methods to maintain the cutting-edge nature and effectiveness of teaching content.

5.2. Constructing a digital literacy education curriculum system

The curriculum serves as a primary avenue for enhancing pre-service teachers' digital literacy, as most of the knowledge students master comes from classroom learning. Whether the curriculum design aligns with the professional field and whether the curriculum structure is suitable for knowledge transmission directly affects the effectiveness of enhancing pre-service teachers' digital literacy. A single course has a limited effect in enhancing pre-service teachers' digital literacy. Therefore, according to the development needs of the digital era, establishing a curriculum system specifically for enhancing pre-service teachers' digital literacy is highly necessary. The various courses within the curriculum system should connect with and support each other. After establishing the curriculum system, it is necessary to further clarify course objectives, determining the level of digital literacy students should achieve through the courses, including acquiring digital knowledge and skills, learning digital applications, and undertaking digital social responsibilities. Secondly, based on the objectives, develop course syllabi and design course content, covering basic digital technology knowledge, digital technology skills, digital teaching design, implementation, and evaluation, digital security protection, and other aspects.

5.3. Establishing a digital literacy education collaboration mechanism

The collaboration mechanism for digital literacy education targeting pre-service teachers should involve multiple stakeholders in the cultivation process of pre-service teachers' digital literacy, forming a training model of "multi-party participation and collaborative win-win." First is intra-university collaboration, where teacher-training departments, libraries, and other departments form a linkage mechanism, clarify collaboration goals, and jointly promote the enhancement of pre-service teachers' digital literacy relying on courses, lectures, and other forms. Intra-university collaboration also requires university management to formulate corresponding regulations, clarifying the responsibilities and obligations of various colleges, libraries, and other departments in digital literacy education. If management fails to effectively coordinate, the functions of various stakeholders in digital literacy education will be difficult to fully utilize. Second is inter-university collaboration, or collaboration at regional and international levels. For example, relevant stakeholders such as educational technology enterprises and academic research institutions actively participate, providing technical support and research support to jointly promote the enhancement of pre-service teachers' digital literacy.

6. Conclusion

Enhancing the digital literacy of pre-service teachers is a systematic endeavor critical to the quality of the future teaching workforce and the implementation of the digital education strategy. In response to the current problems of professional limitations, fragmented curricula, and insufficient collaboration, universities and educational management departments should promote the overall development of pre-service teachers' digital literacy through pathways such as forming specialized teaching teams, constructing a systematic curriculum system, and establishing multi-stakeholder collaboration mechanisms. Furthermore, a sound evaluation and feedback mechanism for literacy should be gradually improved to achieve dynamic optimization of the cultivation process. Only through continuous multi-party collaboration and institutional innovation can the digital literacy of pre-service teachers be effectively enhanced, laying a solid foundation for their future engagement in digital education, and thereby promoting the development of the education cause towards higher quality, greater equity, and more sustainability.

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The authors declare no conflict of interest.

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