MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2487-2491

Edge-Enabled Digital Literacy Development among Pre-Service Teachers in China: A Cross-Sectional Study toward Human-Centric Intelligent Education Systems

Fu Qiang
Universiti Tun Abdul Razak, Malaysia
Jilin Engineering Normal University, China
fuqiang@ur.unirazak.edu.my
https://orcid.org/0009-0008-4817-3481
Hamidah Mohamad
Tun Razak Graduate School
Universiti Tun Abdul Razak, Malaysia
hamidah_mohamad@unirazak.edu.my
Cheok Mui Yee
Tun Razak Graduate School
Universiti Tun Abdul Razak, Malaysia
cheokmy@unirazak.edu.my
https://orcid.org/0009-0006-2000-0095
Mao Chunyu
Jilin Engineering Normal University, China
Azrul Fazwan Kharuddin
Tun Razak Graduate School
Universiti Tun Abdul Razak, Malaysia
azrul.fazwan@ur.unirazak.edu.my
https://orcid.org/0000-0002-6100-6129

Abstract
The transition toward edge-centric intelligent educational ecosystems requires future teachers to possess advanced digital literacy competencies that extend beyond basic technological proficiency. In the context of intelligent and distributed educational infrastructures, pre-service teachers must be capable of operating within privacy-aware, collaborative, and cyber-physical learning environments. This study investigates the multidimensional digital literacy levels of pre-service teachers enrolled in normal universities in China and examines demographic variations in digital competence. A total of 192 participants from five normal universities completed a validated questionnaire encompassing eight dimensions: access and understanding, evaluation, ethics and well-being, interaction, collaboration, creating, problem-solving, and civic engagement and responsibility. Descriptive, comparative, and multivariate regression analyses were conducted to assess overall proficiency and demographic influences. Results indicate that overall digital literacy remains at a moderate level. Participants demonstrated relatively strong competencies in interaction and ethics and well-being, while significantly lower performance was observed in creating, problem-solving, and civic engagement dimensions—competencies essential for edge-enabled, intelligent educational systems. No statistically significant differences were identified across gender, academic major, university affiliation, or household registration status after controlling for confounding variables. The findings suggest that while foundational digital skills are well established, higher-order and application-oriented competencies necessary for human-centric edge intelligence integration remain underdeveloped. The study underscores the need for systematic, infrastructure-aware, and pedagogically grounded digital literacy development frameworks within teacher education programs to prepare future educators for secure, resilient, and distributed intelligent learning environments.
Keywords: digital literacy; pre-service teachers; edge intelligence; intelligent education systems; human-centric computing; China; teacher education

Background

The inaugural World Conference on Digital Education, convened in Beijing in February 2023, underscored the imperative of "advancing the integration and development of digital technology within traditional education, fostering innovative educational concepts, methods, and forms, and ultimately harnessing digital technology to empower education and better serve the fundamental nature of human learning" (World Digital Education Conference, 2023). This policy discourse reflects a global consensus that digital transformation is no longer supplementary to education but foundational to its future development. The rapid evolution of digital technologies including artificial intelligence, cloud and edge computing infrastructures, big data analytics, and intelligent learning platforms has profoundly reshaped educational systems worldwide, accelerating systemic transformation across all levels of schooling. A central implication of this transformation is the increasing demand for enhanced digital literacy among teachers, which has become a focal issue in contemporary educational research and policy discussions (Sánchez-Cruzado et al., 2021; Basilotta-Gómez-Pablos et al., 2022). In digitally mediated learning environments, teachers function not merely as technology users but as designers, facilitators, and evaluators of technology-enhanced pedagogy. Digital literacy for educators thus extends beyond operational competence to encompass the ability to access, analyze, evaluate, create, and ethically apply digital information and tools within pedagogical contexts (Audrin & Audrin, 2022; Falloon, 2020). Over the past two decades, substantial progress has been achieved in educational digitalization, including the establishment of national policy frameworks, the expansion of digital infrastructure, and the widespread adoption of educational technologies (OECD, 2019; Forbes, 2017). These developments provide a structural foundation for advancing teachers' digital literacy in a systematic and sustainable manner.

Within this broader transformation, pre-service teachers represent a particularly significant group. Positioned at the intersection of student identity and professional teacher identity, they constitute the future teaching workforce and play a decisive role in sustaining digitally competent educational ecosystems. As future educators, pre-service teachers are expected to acquire sufficient digital literacy during their initial teacher education to effectively integrate digital technologies into classroom instruction and to adapt to increasingly intelligent and distributed learning environments. However, access to digital tools alone does not guarantee digital literacy. Pre-service teachers must cultivate not only technical proficiency but also critical judgment, ethical awareness, data responsibility, and pedagogical adaptability in technology-rich contexts (Borthwick & Hansen, 2017). Ensuring that pre-service teachers develop comprehensive digital literacy within initial teacher education programs is therefore essential. Teacher education institutions serve as pivotal agents in shaping future educators' digital competencies by embedding digital literacy across curricula, instructional design, practicum experiences, and professional development modules. A systematic understanding of the current status of digital literacy among pre-service teachers, together with the demographic factors associated with its development, can provide empirical evidence to inform curriculum reform and targeted interventions. Strengthening digital literacy at this

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2487-2491

foundational stage may facilitate a smoother transition into professional teaching roles and contribute to the long-term sustainability of digitally competent educational systems.

Literature Review

Digital Transformation, National Competitiveness, and Teacher Preparation

The digital transformation of education is increasingly regarded as integral to national competitiveness, innovation capacity, and sustainable development (Miao et al., 2023). Intensified global competition has prompted governments to formulate strategic initiatives that embed digital technologies across educational systems, thereby extending their influence into economic modernization and social governance (Machmud et al., 2021; Buchholz et al., 2020). Within this strategic landscape, higher education institutions assume a critical role in cultivating digitally competent professionals. Teacher education institutions, in particular, function as foundational sites for preparing educators capable of navigating and shaping digitally enriched learning environments.

Conceptualizing Teacher Digital Literacy

Teacher digital literacy is commonly conceptualized as a multidimensional construct encompassing awareness, knowledge, skills, and ethical responsibility in the use of digital technologies. It includes the ability to access, process, manage, and critically evaluate digital information, as well as to identify pedagogical challenges and address them through innovative technological solutions (Audrin & Audrin, 2022; Falloon, 2020). Beyond technical operations, digital literacy involves higher-order competencies such as problem-solving, creative production, collaborative engagement, and civic responsibility in digital spaces. For pre-service teachers, digital literacy serves both academic and professional functions. Empirical research suggests that teachers' digital literacy significantly influences instructional effectiveness, classroom innovation, and student learning outcomes (Damanik & Widodo, 2024). Consequently, fostering digital literacy during teacher preparation is essential for enhancing educational quality and ensuring that future teachers can respond effectively to rapidly evolving technological contexts.

Digital Technologies in Teacher Education

Digital technologies have become deeply embedded in teacher education programs. Learning management systems, digital assessment platforms, online collaborative tools, and multimedia resources are increasingly integrated into instructional design, classroom management simulations, and teaching practicum experiences. Such technologies not only enrich pre-service teachers' learning experiences but also facilitate the development of pedagogical strategies aligned with contemporary educational needs (Basilotta-Gómez-Pablos et al., 2022; Asagar, 2025). Through active engagement with digital tools during training, pre-service teachers can better internalize technology-enhanced pedagogical approaches and transfer them into future classroom practice (Ottestad et al., 2014). The integration of digital literacy within teacher education contributes not only to individual competence but also to systemic adaptability in digitally mediated educational ecosystems. As education systems increasingly incorporate intelligent infrastructures, teachers must demonstrate readiness to operate within complex, technology-integrated environments.

Emerging Generative Artificial Intelligence and Digital Literacy

The rapid emergence of generative artificial intelligence technologies, particularly Chat Generative Pretrained Transformer (ChatGPT), has further transformed discussions of digital literacy in education (Gosak et al., 2024; Adeshola & Adepoju, 2024; Zhai, 2022). Powered by large-scale language models, ChatGPT exhibits advanced capabilities in generating human-like responses, supporting academic writing, and assisting in instructional planning (Bin-Nashwan et al., 2023). These functionalities present both opportunities and challenges for educational practice. On the positive side, generative AI tools may enhance lesson planning, instructional differentiation, and personalized feedback. Conversely, concerns have emerged regarding academic integrity, overreliance on automated systems, data privacy, and ethical usage (Bin-Nashwan et al., 2023). While some institutions have imposed restrictions on the use of generative AI tools, professional organizations increasingly advocate for guided, responsible, and pedagogically sound engagement with such technologies (Jin et al., 2025; Nguyen, 2025). For pre-service teachers, the ability to critically evaluate and ethically employ emerging digital tools constitutes an essential extension of digital literacy in the AI era.

Digital Literacy Standards and Policy Frameworks

The establishment of digital literacy standards provides a structured approach to systematically enhancing educators' competencies (De León et al., 2023). Internationally, multiple frameworks have been developed to conceptualize teacher digital literacy. The International Society for Technology in Education (ISTE) has proposed widely adopted standards delineating educators' roles and competencies in digital environments (Crompton, 2017). Similarly, the Organisation for Economic Co-operation and Development (OECD) has identified digital literacy as a core competency underpinning educational reform and innovation (OECD, 2019). In China, the Ministry of Education promulgated the industry standard *Digital Literacy for Teachers* in November 2022, introducing a comprehensive indicator system encompassing five primary dimensions: digital awareness, digital technology knowledge and skills, digital application, digital social responsibility, and professional development (Ministry of Education of the People's Republic of China, 2022). These dimensions are operationalized through detailed secondary and tertiary indicators addressing pedagogical design, digital assessment, ethical considerations, and professional growth. This policy framework underscores the importance of systematic and standardized digital literacy development and calls upon teacher education institutions to align curricula with national benchmarks.

Despite growing scholarly attention to teacher digital literacy, empirical evidence regarding the current status and demographic variations of digital literacy among pre-service teachers remains limited. Given their pivotal role as future educators, understanding their preparedness is essential for ensuring the sustainable integration of digital technologies into education. Addressing this empirical gap will contribute to evidence-based curriculum reform and policy development within teacher education programs.

Research Methodology

Study Design

This study employed a cross-sectional survey design to examine the digital literacy levels of pre-service teachers at a specific point in time. Cross-sectional designs are appropriate for capturing a comprehensive snapshot of prevailing conditions and identifying associated factors without requiring longitudinal follow-up (Polit & Beck, 2010). The design enabled systematic assessment of participants' current digital literacy status and the exploration of demographic variables potentially associated with variations in digital competence. Data were collected using a structured, self-administered questionnaire incorporating a validated digital literacy scale adapted from Chang and Kuo (2025). The instrument was specifically designed to assess multidimensional aspects of digital literacy within teacher education contexts. Given the study's objectives of evaluating current literacy levels and examining demographic differences, the cross-sectional design was considered methodologically suitable.

Participants, Setting, and Sampling

Purposive sampling was adopted to recruit pre-service teachers enrolled in teacher education institutions in China. Participants were drawn from multiple normal universities and teacher-training colleges to enhance sample diversity and representativeness within the teacher education context. Eligibility criteria included being currently enrolled as a pre-service teacher in an undergraduate or postgraduate teacher education program, being aged 18 years or above, possessing adequate physical and cognitive capacity to independently complete an online questionnaire,

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2487-2491

and providing informed consent to participate. Individuals who were temporarily suspended from their studies for academic, personal, or health-related reasons at the time of data collection were excluded. To ensure adequate statistical power, the minimum required sample size was estimated using the Soper online sample size calculator. Based on an anticipated medium effect size ($f^2 = .15$), a desired statistical power level of .90, and a significance level of $\alpha = .05$, the recommended minimum sample size was 166 participants. The final sample exceeded this threshold, indicating sufficient power to support inferential statistical analyses, including multivariate regression modeling.

Measures

The survey instrument consisted of two sections and required approximately 15 to 20 minutes to complete. A self-administered questionnaire format was selected to facilitate efficient and standardized data collection from a relatively large sample of pre-service teachers while minimizing interviewer bias. This approach allowed for structured assessment of multiple dimensions of digital literacy in a format suitable for quantitative analysis. The instrument was designed to align with contemporary digital literacy frameworks and the contextual realities of teacher education in China. The first section collected demographic and background information, including gender, age, year of study, major or subject specialization, and prior teaching practicum experience. Additional items assessed participants' familiarity with and perceptions of digital education technologies. The second section measured digital literacy using a validated questionnaire adapted from Chang and Kuo (2025). The instrument conceptualizes digital literacy as a multidimensional construct comprising eight dimensions: access and understanding, evaluation, ethics and well-being, interaction, collaboration, creating, problem-solving, and civic engagement and responsibility. The questionnaire included 54 items in total. Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with higher scores indicating higher levels of digital literacy. A composite digital literacy score was calculated by summing responses across all items, with higher total scores reflecting more advanced digital literacy competence.

Psychometric Properties

The digital literacy questionnaire has demonstrated satisfactory reliability and validity in prior research (Chang & Kuo, 2025). Reported Cronbach's alpha coefficients indicated acceptable to high internal consistency across the eight dimensions, ranging from .747 to .877. Construct validity was established through exploratory factor analysis and confirmatory factor analysis. The confirmatory factor analysis indicated acceptable model fit, with $\chi^2/df = 2.403$, root mean square error of approximation (RMSEA) = .041, comparative fit index (CFI) = .902, incremental fit index (IFI) = .903, and Tucker–Lewis index (TLI) = .896. These indices meet commonly recommended thresholds, supporting the robustness of the eight-factor structure underlying the digital literacy construct. Based on this evidence, the instrument was considered reliable and valid for assessing digital literacy among pre-service teachers in the present study (Li et al., 2025).

Data Collection Procedures

Data collection was conducted between August and October 2023 following approval from the relevant institutional ethics committee. The questionnaire was administered anonymously via the Wenjuanxing online survey platform. A QR code linking to the survey was distributed through digital communication channels commonly used by pre-service teachers, including course-related groups, teaching practicum groups, and institutional online platforms within teacher education programs. Participants completed the questionnaire independently. Data were retrieved through the platform's secure backend system (Kharuddin et al., 2020). Data screening procedures were implemented to ensure quality and completeness. Questionnaires with incomplete demographic information, missing item responses, or patterns indicative of inattentive responding were excluded from analysis. Access to the dataset was restricted to the research team. All electronic data were stored on a password-protected and encrypted computer designated exclusively for the study to ensure confidentiality and data security.

Data Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 22.0. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were calculated to summarize participants' demographic characteristics and overall digital literacy levels. Independent-samples t tests and one-way analyses of variance (ANOVA) were performed to examine differences in digital literacy scores across demographic groups. Multiple linear regression analysis was conducted to identify demographic factors associated with digital literacy while controlling for potential confounding variables. All statistical tests were two-tailed, and the level of statistical significance was set at $\alpha = .05$.

Results and Findings

Demographic Characteristics

A total of 192 pre-service teachers from five normal universities were included in the final analysis. The sample was predominantly female, with 143 participants (74.48%) identifying as female and 49 participants (25.52%) identifying as male. In terms of academic grade level, junior students represented the largest proportion of the sample (n = 53, 27.60%), followed closely by sophomores (n = 52, 27.08%), freshmen (n = 45, 23.44%), and seniors (n = 42, 21.88%). Participants were further categorized into two disciplinary groups. Students majoring in Humanities and Social Sciences constituted 57.81% of the sample (n = 111), whereas those enrolled in science, technology, engineering, and mathematics (STEM) programs accounted for 42.19% (n = 81). With respect to institutional affiliation, 25.00% (n = 48) of participants were from Jilin Engineering Normal University, 22.40% (n = 43) from Changchun Normal University, 19.79% (n = 38) from Tonghua Normal University, 17.19% (n = 33) from Northeast Normal University, and 15.63% (n = 30) from Jilin Normal University. Regarding place of household registration, slightly more than half of the participants (n = 104, 54.17%) reported an urban background, whereas 88 participants (45.83%) reported a rural household registration status.

Comparison of Digital Literacy Across Demographic Groups

Comparative statistical analyses were conducted to examine differences in overall digital literacy scores across demographic characteristics, including gender, grade level, academic major, university affiliation, and place of household registration. Independent-samples *t* tests revealed no statistically significant difference in digital literacy scores between male participants (M = 188.27, SD = 8.51) and female participants (M = 188.38, SD = 7.73), $t = 0.01$, $p = .920$. Similarly, no significant differences were observed between students majoring in Humanities and Social Sciences (M = 187.39, SD = 8.15) and STEM students (M = 189.67, SD = 7.42), $F = 3.02$, $p = .084$. With respect to university affiliation, one-way analysis of variance (ANOVA) indicated no statistically significant differences in digital literacy scores among participants from different institutions, $F = 1.26$, $p = .286$. Likewise, no significant difference was found between students with urban (M = 188.45, SD = 7.20) and rural (M = 188.23, SD = 8.73) household registration backgrounds, $t = 0.03$, $p = .863$. Although variations in mean digital literacy scores were observed across grade levels, these differences did not reach statistical significance, $F = 2.11$, $p = .099$. Sophomores (M = 190.04, SD = 7.29) and juniors (M = 189.75, SD = 8.56) demonstrated slightly higher average scores than freshmen (M = 187.18, SD = 7.66) and seniors (M = 185.74, SD = 7.41), but the overall pattern did not indicate statistically meaningful differences. Overall, these findings suggest that digital literacy levels were relatively homogeneous across demographic subgroups within the sample.

Overall and Dimensional Digital Literacy Scores

The overall digital literacy score among participants was 188.35 (SD = 7.91). When considering the average score per item across all 54 items, the mean was 3.49 (SD = 0.41), indicating a moderate level of digital literacy. Analysis of the eight dimensions revealed variation in

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2487-2491

performance across different domains. The highest mean scores were observed in Interaction (M = 28.19, SD = 2.92; item mean = 3.52), Ethics and Well-being (M = 24.55, SD = 2.82; item mean = 3.51), and Access and Understanding (M = 17.74, SD = 2.63; item mean = 3.55). Civic Engagement and Responsibility also demonstrated a relatively high item mean (3.52). Moderate scores were found in Collaboration (M = 24.32, SD = 2.85; item mean = 3.47), Evaluation (M = 24.20, SD = 3.01; item mean = 3.46), and Problem-solving (M = 17.35, SD = 2.34; item mean = 3.47). The comparatively lowest performance was observed in the Creating dimension (M = 30.86, SD = 3.12; item mean = 3.43), suggesting relatively weaker competence in creative digital production tasks. Taken together, these findings indicate that participants demonstrated stronger proficiency in interactive engagement and ethical awareness in digital environments, whereas relatively lower levels were observed in creative application and higher-order digital production skills.

Multiple Linear Regression Analysis

Multiple linear regression analysis was conducted to examine the extent to which demographic variables predicted digital literacy scores. Gender, grade level, academic major, university affiliation, and place of household registration were entered into the model as independent variables. The regression results indicated that none of the demographic variables significantly predicted digital literacy levels ($p > .05$ for all predictors). Specifically, gender ($\beta = .006$, $p = .940$), academic major ($\beta = .083$, $p = .196$), university affiliation (all p values > .395), and place of household registration ($\beta = .021$, $p = .756$) were not significantly associated with digital literacy scores. Although grade level showed a positive association with digital literacy in some categories, these relationships did not reach statistical significance after controlling for other demographic variables in the model (all $p > .05$). Overall, the regression analysis suggests that digital literacy among the sampled pre-service teachers was relatively consistent across demographic groups, with no significant demographic predictors identified.

Discussion

This study examined the digital literacy levels of pre-service teachers in Chinese normal universities to better understand their preparedness for digitally mediated educational environments. The findings indicate that the overall digital literacy level of participants was moderate. Although pre-service teachers demonstrated foundational digital competence, substantial room for further development remains, particularly in higher-order and application-oriented dimensions. These findings are consistent with previous research in teacher education and higher education contexts, which has similarly reported moderate rather than fully developed digital literacy levels among prospective educators (Sánchez-Cruzado et al., 2021; Basilotta-Gómez-Pablos et al., 2022; Damanik & Widodo, 2024).

An examination of dimensional scores revealed meaningful variation across components of digital literacy. Participants demonstrated relatively stronger performance in interaction and ethics and well-being. This pattern suggests that pre-service teachers are generally comfortable engaging in digital communication and demonstrate awareness of responsible and ethical digital behavior. Such strengths may reflect the pervasive integration of online learning platforms, social media, and digital communication tools into university life, which provide frequent opportunities for interactive engagement. Prior research has shown that sustained exposure to digital environments can enhance communicative competence and ethical awareness in online contexts (Forbes, 2017; Buchholz et al., 2020; Gosak et al., 2024). Moreover, contemporary digital competence frameworks emphasize interaction and ethical responsibility as core elements of teacher digital literacy, potentially contributing to the relatively higher scores observed in these domains (Falloon, 2020; Asagar, 2025).

In contrast, comparatively lower scores were identified in creating, problem-solving, and civic engagement and responsibility. These findings suggest limitations in participants' abilities to design original digital content, apply digital tools strategically to solve complex educational problems, and engage critically in broader digital civic contexts. The relatively lower performance in creative and problem-solving dimensions is particularly noteworthy, as these competencies are increasingly regarded as essential for effective teaching in digitally transformed educational systems. Previous studies have similarly reported that while pre-service teachers often demonstrate competence in routine digital operations, they frequently lack higher-order skills related to innovation, critical evaluation, and adaptive problem-solving (Audrin & Audrin, 2022; Borthwick & Hansen, 2017; Ottestad et al., 2014). This discrepancy underscores a persistent gap between operational digital skills and deeper cognitive and pedagogical dimensions of digital literacy.

The moderate level observed in civic engagement and responsibility further indicates that digital literacy development in teacher education remains primarily task-oriented and classroom-focused, with comparatively limited emphasis on broader societal participation and digital citizenship. Earlier studies have suggested that meaningful civic-oriented digital engagement requires explicit pedagogical scaffolding and institutional guidance rather than emerging spontaneously from routine technology use (Forbes, 2017; Buchholz et al., 2020). The findings of the present study reinforce the need to strengthen this dimension within teacher preparation programs.

With regard to demographic variables, both comparative analyses and multiple linear regression results revealed no statistically significant differences in digital literacy across gender, academic major, university affiliation, or place of household registration. Although minor variations were observed across grade levels, these differences did not remain significant after controlling for other demographic factors. These findings suggest a relatively homogeneous distribution of digital literacy competencies within the sample. One possible explanation is the widespread integration of digital technologies across higher education institutions in China, which may have reduced disparities in access and exposure to digital learning resources (OECD, 2019; Miao et al., 2023). The absence of significant demographic predictors indicates that digital literacy development is not confined to specific subgroups but represents a systemic issue requiring comprehensive institutional attention.

Overall, the findings demonstrate that pre-service teachers possess foundational digital literacy, particularly in interaction and ethical awareness. However, competencies related to digital creation, problem-solving, and civic engagement remain underdeveloped. These higher-order dimensions are increasingly critical for effective participation in digitally transformed educational systems (World Digital Education Conference, 2023; Falloon, 2020; Crompton, 2017). Therefore, strengthening these aspects of digital literacy should be prioritized within teacher education programs.

From a practical perspective, teacher education institutions should adopt a systematic and holistic approach to digital literacy development. Rather than focusing primarily on technical skills acquisition, programs should emphasize critical thinking, creative digital production, reflective practice, and the pedagogically meaningful integration of digital technologies. Structured opportunities for authentic digital tasks, interdisciplinary collaboration, project-based learning, and guided reflection may facilitate the development of transferable and higher-order digital competencies (Basilotta-Gómez-Pablos et al., 2022; De León et al., 2023; Gümüş & Kukul, 2023). Embedding these elements within curriculum design and teaching practicum experiences may better prepare pre-service teachers for future professional roles in digitally enriched educational contexts.

Reference

Adeshola, I., & Adepoju, A. P. (2024). The opportunities and challenges of ChatGPT in education. Interactive Learning Environments, 32(10), 6159–6172. https://doi.org/10.1080/10494820.2023.2253858

Asagar, M. S. (2025). Digital competence in education: A comparative analysis of frameworks and conceptual foundations. Synergy: International Journal of Multidisciplinary Studies, 2(1), 9–23.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2487-2491

Audrin, C., & Audrin, B. (2022). Key factors in digital literacy in learning and education: A systematic literature review using text mining. Education and Information Technologies, 27, 7395–7419. https://doi.org/10.1007/s10639-021-10832-5
Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L. A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. International Journal of Educational Technology in Higher Education, 19(1), Article 8. https://doi.org/10.1186/s41239-021-00312-8
Bin-Nashwan, S. A., Mouad, S., & Mohamed, B. (2023). Use of ChatGPT in academia: Academic integrity hangs in the balance. Technology in Society, 75, 102370. https://doi.org/10.1016/j.techsoc.2023.102370
Borthwick, A. C., & Hansen, R. (2017). Digital literacy in teacher education: Are teacher educators competent? Journal of Digital Learning in Teacher Education, 33(2), 46–48. https://doi.org/10.1080/21532974.2017.1291249
Buchholz, B. A., DeHart, J., & Moorman, G. (2020). Digital citizenship during a global pandemic: Moving beyond digital literacy. Journal of Adolescent & Adult Literacy, 64(1), 11–17. https://doi.org/10.1002/jaal.1076
Chang, C.-Y., & Kuo, H.-C. (2025). The development and validation of the digital literacy questionnaire and the evaluation of students' digital literacy. Education and Information Technologies, 30, 11549–11581. https://doi.org/10.1007/s10639-024-13216-7
Crompton, H. (2017). ISTE standards for educators: A guide for teachers and other professionals. ASCD.
Damanik, J., & Widodo, W. (2024). Unlocking teacher professional performance: Exploring teaching creativity in transmitting digital literacy, grit, and instructional quality. Education Sciences, 14(4), 384. https://doi.org/10.3390/educsci14040384
De León, L., Corbeil, R., & Corbeil, M. E. (2023). The development and validation of a teacher education digital literacy and digital pedagogy evaluation. Journal of Research on Technology in Education, 55(3), 477–489. https://doi.org/10.1080/15391523.2021.1974988
Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency (TDC) framework. Educational Technology Research and Development, 68, 2449–2472. https://doi.org/10.1007/s11423-020-09767-4
Forbes, D. (2017). Professional online presence and learning networks: Educating for ethical use of social media. International Review of Research in Open and Distributed Learning, 18(7). https://doi.org/10.19173/irrodl.v18i7.2826
Gosak, L., Pruinelli, L., Topaz, M., & Štiglic, G. (2024). The ChatGPT effect and transforming education with generative AI: A discussion paper. Nurse Education in Practice, 75, 103888. https://doi.org/10.1016/j.nepr.2024.103888
Gümüş, M. M., & Kukul, V. (2023). Developing a digital competence scale for teachers: Validity and reliability study. Education and Information Technologies, 28(3), 2747–2765. https://doi.org/10.1007/s10639-022-11213-2
Jin, Y., et al. (2025). Generative AI in higher education: A global perspective of institutional adoption policies and guidelines. Computers and Education: Artificial Intelligence, 8, 100348. https://doi.org/10.1016/j.caeai.2024.100348
Kharuddin, A. F., Azid, N., Mustafa, Z., Ibrahim, K. F. K., & Kharuddin, D. (2020). Application of structural equation modeling (SEM) in estimating the contributing factors to satisfaction of TASKA services in east coast Malaysia. Asian Journal of Assessment in Teaching and Learning, 10(1), 69-77.
Li C., Zhuolin, Z., Cheok. M.Y., & Kharuddin, A. F. (2025). Analyzing behaviour of safety technologies in construction: An empirical study using the UTAUT Model in Guangdong Province, China. Multidisciplinary Science Journal, 8(6), 2026374. https://doi.org/10.31893/multiscience.2026374
Machmud, M. T., Widiyan, A. P., & Ramadhani, N. R. (2021). The development and policies of ICT supporting educational technology in Singapore, Thailand, Indonesia, and Myanmar. International Journal of Evaluation and Research in Education, 10(1), 78–85.
Miao, X., Dawod, A. Y., & Phaphuangwittayakul, A. (2023). The implications, challenges, and pathways of digital transformation of university education in China. In Proceedings of the 7th TICC International Conference.
Ministry of Education of the People's Republic of China. (2022). Digital literacy for teachers (industry standard). https://www.gov.cn/zhengce/zhengceku/2023-02/21/content_5742422.htm
Nguyen, K. V. (2025). The use of generative AI tools in higher education: Ethical and pedagogical principles. Journal of Academic Ethics. https://doi.org/10.1007/s10805-025-09607-1
OECD. (2019). OECD skills outlook 2019: Thriving in a digital world. OECD Publishing. https://doi.org/10.1787/df80bc12-en
Ottestad, G., Kelentrić, M., & Guðmundsdóttir, G. B. (2014). Professional digital competence in teacher education. Nordic Journal of Digital Literacy, 9(4), 243–249. https://doi.org/10.18261/ISSN1891-943X-2014-04-02
Polit, D. F., & Beck, C. T. (2010). Essentials of nursing research: Appraising evidence for nursing practice. Lippincott Williams & Wilkins.
Ray, P. P. (2023). ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. Internet of Things and Cyber-Physical Systems, 3, 121–154. https://doi.org/10.1016/j.iotcps.2023.04.003
Sánchez-Cruzado, C., Santiago Campión, R., & Sánchez-Compaña, M. T. (2021). Teacher digital literacy: The indisputable challenge after COVID-19. Sustainability, 13(4), 1858. https://doi.org/10.3390/su13041858
World Digital Education Conference. (2023). Digital transformation and the future of education. Ministry of Education of the People's Republic of China. https://en.moe.gov.cn/features/2023WorldDigitalEducationConference/
Zhai, X. (2022). ChatGPT user experience: Implications for education. https://doi.org/10.2139/ssrn.4312418