

Assessing the Impact of University Teachers' Digital Leadership on Enhancing Student Learning Effectiveness

Peipei Dong^{1,2,*}, RHENE C. TABAJEN¹

¹ College of Education and Liberal Arts Graduate School Faculty, Adamson University, Manila, CO 0900, Philippines

² College of Chemical and Biological Engineering, Guangxi Minzu Normal University, Chongzuo, Guangxi, 532200, China

* Corresponding author: Peipei Dong (Email: 25980855@qq.com)

Abstract: This research investigates the digital leadership exhibited by university instructors and its significant impact on students' learning effectiveness in higher education. Key aspects of digital leadership evaluated include technical expertise, innovative teaching methods, promotion of digital literacy, data-driven decision-making, and ethical technology use. Using a mixed-methods approach, data was collected through surveys and interviews with educators and students to assess the effectiveness of digital leadership strategies. Findings reveal that while instructors demonstrate moderate competence in technology and teaching methods, they excel in fostering digital literacy and ethical technology use. However, there is room for improvement in data-driven decision-making, which is crucial for enhancing learning efficacy. The study also examines students' learning outcomes related to digital literacy, engagement, metacognitive abilities, and analytical skills, finding modest improvements in these areas. A notable correlation exists between instructors' digital leadership and students' learning efficacy, particularly in data-driven decision-making and digital literacy promotion. Additionally, challenges faced by university educators include keeping up with technological advancements, effectively utilizing data, and maintaining student engagement in digital learning environments.

Keywords: Digital Leadership; Technical Expertise Creative; Teaching Methods Promotion of Digital Literacy; Decision-Making; Ethical Considerations in Technology Use.

1. Introduction

In recent years, the rapid growth of digital technology innovations and data applications has led to the pervasive integration of information technology in the field of education. Technologies such as artificial intelligence, blockchain, cloud computing, big data, and 5G communication have deeply merged with "Internet + education," making the construction and application of digital educational resources in higher education a focal point of attention. In this context, the role of teachers as digital leaders has garnered significant interest. Digital leadership among university teachers is crucial for the effective construction and successful application of digital educational resources.

The emergence of digital technologies has transformed traditional classrooms into dynamic and interactive learning environments. With abundant online resources, collaborative platforms, and multimedia content at their disposal, university teachers now have unprecedented opportunities to enrich their teaching practices and foster deeper student engagement (Ally, M. 2021). However, effective utilization of these digital tools requires more than technical proficiency; it demands visionary leadership that inspires innovation, cultivates digital fluency among educators and students alike, and nurtures a culture of continuous learning and adaptation.

At the core of digital leadership in higher education lies the ability of teachers to leverage technology to meet diverse learning needs, stimulate critical thinking, and cultivate essential skills for the 21st-century workforce. By embracing digital innovation, university teachers can personalize learning experiences, provide timely feedback, and empower students to become active participants in their education.

Furthermore, digital leadership encompasses the ability to navigate the complexities of digital citizenship, ensuring that students develop the digital literacy and ethical awareness necessary to thrive in an increasingly interconnected world.

Despite the potential benefits, the extent to which university teachers' digital leadership influences student learning effectiveness remains a topic of ongoing inquiry. While anecdotal evidence and case studies suggest a positive correlation between effective digital leadership and improved student outcomes, empirical research systematically examining this relationship is limited. Moreover, the subtle nuances of digital leadership across diverse disciplinary domains, institutional settings, and student populations warrant further investigation.

This paper aims to bridge this gap by conducting a comprehensive assessment of the impact of university teachers' digital leadership on enhancing student learning effectiveness. Drawing upon theoretical frameworks from educational leadership, technology integration, and learning sciences, this study will explore the various dimensions of digital leadership exhibited by university teachers and examine their implications for student engagement, academic performance, and lifelong learning skills development. By synthesizing existing literature, analyzing empirical data, and offering practical insights, this research seeks to inform educational policymakers, institutional leaders, and faculty members on strategies for fostering effective digital leadership practices that optimize student learning outcomes in higher education.

Background of the Study

In recent years, with the rapid development of digital technology, the field of education is also increasingly affected

by digitalization. Digital education has become an important part of higher education, which promotes the reform of teaching mode and the diversification of learning methods. The digital leadership of university teachers is of great significance to the improvement of teaching quality, student learning effectiveness and students' comprehensive literacy, and is one of the key factors to promote the digital transformation of higher education and improve education quality.

The role of teacher digital leadership is of utmost importance in contemporary education, as it significantly influences the learning experiences and equips students with the necessary skills to thrive in an ever-changing digital landscape. The significance of digital leadership among teachers may be analyzed from various perspectives, all of which contribute to the improvement of teaching and learning methodologies. The incorporation of technology into classroom practices is facilitated by teacher digital leadership, which plays a crucial role in preparing students for the digital needs of the 21st century (Puentedura, 2017). According to Harris and Hofer (2017), educators who exhibit digital leadership abilities possess the proficiency to effectively utilize diverse digital tools and resources to generate captivating and dynamic educational encounters. Educators may accommodate various learning preferences through the efficient integration of technology, encourage active participation, and cultivate a more profound comprehension among students (Mishra & Koehler, 2017).

Additionally, teacher digital leadership is crucial in fostering the development of digital literacy abilities among students. Digital literacy is the capacity to efficiently acquire, assess, and employ digital information (Martin, 2018). According to the OECD (2018), educators who exhibit digital leadership exemplify adept utilization of digital resources and actively foster the development of critical thinking skills, information literacy, and responsible digital citizenship. By employing guided instruction and modeling techniques, educators enable students to effectively and ethically navigate the digital environment, preparing them with crucial competencies necessary for academic and professional accomplishments.

In addition, teachers' digital leadership promotes innovation and creativity in pedagogical approaches, thereby facilitating the acquisition of 21st-century skills and abilities among students (Zhao, 2019). According to Siemens and Long (2017), educators who actively embrace digital leadership positions are more inclined to incorporate inventive pedagogical strategies, including project-based learning, flipped classes, and collaborative online activities. According to Fullan (2014), these methodologies not only augment student involvement but also foster the development of critical thinking, problem-solving, and collaborative abilities, all of which hold significant importance in the contemporary knowledge-driven economy. The digital leadership of teachers plays a significant role in facilitating personalized learning experiences specifically designed to cater to each student's unique requirements and interests (Warschauer, 2018). Teachers can offer specific assistance and scaffolding to students, enabling them to advance at their speed and optimize their capabilities by employing adaptive learning technology, making decisions based on data, and implementing differentiated instruction (Thompson & Simonson, 2019). The individualized method of teaching and

education improves student drive, belief in one's abilities, and academic performance.

The landscape of teacher digital leadership in China is characterized by a multitude of problems and complexities, which can be attributed to a combination of systemic and cultural reasons. A significant concern pertains to the insufficiency of professional development opportunities available to educators. Despite the increasing focus on the integration of digital technologies in the field of education, a significant number of instructors continue to face challenges in acquiring the requisite training and support to proficiently employ technology in their instructional methodologies. The aforementioned inadequacy was apparent in a case study carried out in Shanghai, wherein educators recognized the significance of digital tools but encountered difficulties in integrating them as a result of inadequate training and direction. Consequently, there is a disparity between the capabilities of technology and its actual application in educational settings (Wang & He, 2018).

Furthermore, the existence of inequalities in the availability of technology and digital resources fosters a digital divide among educational institutions and geographical areas in China. Rural schools encounter difficulties in obtaining high-speed internet and contemporary digital gadgets, which restricts instructors' capacity to utilize technology for educational purposes. The presence of digital disparity serves to worsen pre-existing disparities in educational chances and sustains inequities in academic achievements (Wei & Li, 2020). The presence of resistance to change presents a substantial barrier to the development of teacher digital leadership in China. The adoption of novel digital activities among educators may be impeded by traditional teaching methods and cultural conventions. Certain educators may exhibit hesitancy in adopting novel technology owing to apprehensions regarding their effectiveness or anxieties about relinquishing authority in the educational setting. The significance of addressing cultural attitudes and beliefs regarding technology integration in education is shown by the resistance to change observed (Chen et al, 2017).

In addition, the progress of teacher digital leadership projects may be hindered by governmental limits and laws. Government policies are designed to facilitate the integration of digital technologies in education. However, the implementation of stringent censorship restrictions and bureaucratic obstacles may impede teachers' ability to exercise autonomy and creativity in utilizing these tools. The necessity of adopting a nuanced approach to policy change that effectively manages regulatory control while also providing encouragement for innovation and experimentation in educational practices is emphasized by these policy constraints (Liu et al, 2018).

To effectively tackle these difficulties, it is imperative to allocate resources towards enhancing professional development, narrowing the digital divide, promoting cultural changes that encourage the adoption of technology, and advocating for policy changes that endorse teacher initiatives in digital leadership. By effectively tackling these institutional and cultural obstacles, China has the opportunity to fully harness the capabilities of technology in order to improve teaching and learning results throughout its education system.

Despite various studies on teacher digital leadership and students learning effectiveness, this research holds considerable significance as it specifically addresses the

obstacles and opportunities encountered within the Chinese educational landscape (Chen et al, 2019). Although there have been many studies on the general idea of teacher digital leadership, only a few have specifically examined how it is used in the Chinese context, taking into account the country's unique cultural, technological, and educational environment (Wang & He, 2018). This study addresses a significant research gap and provides valuable insights that are directly relevant to the educational context in China by analyzing the problems and opportunities related to teacher digital leadership.

The study's distinctiveness stems from its thorough investigation into the various complex aspects of teacher digital leadership and its influence on student learning outcomes in China. The extant body of literature offers significant insights into overarching principles and optimal approaches. However, this study provides a more nuanced comprehension of how these concepts materialize within the context of the Chinese educational system. This study adds to the creation of focused treatments and techniques customized to the Chinese environment by identifying the distinct issues faced by educators and students. This study offers advantages that go beyond academic investigation and result in concrete enhancements in student learning experiences and outcomes. The research conducted by Liu et al. (2018) aims to empower educators and policymakers by identifying impediments to successful teacher digital leadership and suggesting evidence-based solutions. The findings of this study provide valuable insights that can be used to develop interventions that improve teaching quality, increase digital literacy, and encourage creativity in pedagogy. The potential impact of the study's findings on student involvement, motivation, and academic accomplishment is significant, as it has the capacity to enhance the overall quality and competitiveness of China's education system.

Moreover, this research endeavor aims to fill a significant void in the existing literature by examining the distinct obstacles and prospects linked to teacher digital leadership within the context of China. Although the current body of literature provides useful insights from a global standpoint, there is a lack of study that specifically investigates these challenges within the distinct socio-cultural and institutional framework of China. This study aims to address the existing knowledge gap by offering a comprehensive analysis of the various elements that influence teacher digital leadership practices in China. Additionally, it identifies specific areas that warrant additional investigation and intervention.

2. Statement of the Problem

This study aims to assess the impact of university teachers' digital leadership on enhancing student learning effectiveness. Specifically, this study sought answers the following questions:

(1)What is the assessment of the respondents of the teachers' digital leadership in terms of:

- 1)Technological Proficiency
- 2)Innovative Pedagogy
- 3)Digital Literacy Promotion
- 4)Data-Driven Decision Making
- 5)Technological Ethics

(2)What is the assessment of the respondents of their learning effectiveness in terms of:

- 1)Digital Literacy Development
- 2)Maximum Learning Engagement

3)Metacognitive Skills

4)Ana-synthetic skills

(3)Does teachers' digital leadership significantly impact the students' learning effectiveness?

(4)What challenges do university teachers face in terms of digital leadership that significantly impact students' learning effectiveness?

(5)Based on the results of the study, what policy recommendation can be proposed to integrate digital leadership standards into teacher certification and licensure requirements?

3. Scope and Delimitation of the Study

This research aimed to investigate the impact of digital leadership used by university instructors on enhancing student learning achievements in Chinese higher education institutions. To guarantee representation from distinct geographical areas, academic disciplines, and kinds of institutions, a method of selected sampling was used to choose participants from five diverse universities around China. To get a comprehensive knowledge of the digital leadership behaviors of educators and their influence on student learning outcomes, the research methodology used surveys, interviews, and classroom observations. The research mainly aimed to assess many dimensions of digital leadership, including technical proficiency, innovative instructional approaches, digital literacy advocacy, data-driven decision-making, and ethical technology management. The research used data analytic methods, namely regression analysis, to investigate the predicted relationship between teachers' digital leadership and the efficacy of student learning. The primary aim of this study was to provide valuable insights that may benefit policymakers, educators, and academics committed to advancing the effective incorporation of technology and improving student learning outcomes in China's higher education system.

Nevertheless, it was crucial to acknowledge numerous constraints within this research's scope. Initially, self-reporting techniques, such as surveys and interviews, resulted in cognitive biases, such as social desirability bias. The presence of this bias can warp the accounts provided by respondents on their digital leadership methods and the results of student learning. Moreover, although a stratified sample approach was used to ensure variety, the generalizability of the findings may have been restricted since they directly pertained only to the chosen institutions in China. Furthermore, the methodology's focus on questionnaires, interviews, and observations may have theoretically limited the thorough understanding of teachers' digital leadership techniques and student learning outcomes. The study's findings may have been swayed by external variables such as institutional restrictions and resource availability, likely to have distorted the whole picture. Furthermore, the study's constrained time and resources may have necessitated making concessions in the scope and coverage of data collection and analysis, restricting the magnitude of the study's conclusions. Even with these limitations, the study sought to provide substantial insights into the complexities of digital leadership and the effectiveness of student learning in the Chinese higher education environment.

4. Research Design

This study aimed to comprehensively examine the impact

of digital leadership among University instructors on the effectiveness of student learning. To do this, a research approach was presented that integrated descriptive comparative and multiple regression analyses. A thorough framework was established using a descriptive comparative approach to describe and compare variables of interest across different groups or situations. The main objective of this study was to examine and compare the digital leadership strategies used by university instructors and the educational outcomes of students from various demographic backgrounds, such as gender, academic program, and level (Hair et al., 2018). By enabling the identification of possible patterns, trends, and inconsistencies in digital leadership practices and learning outcomes, the design improved the understanding of the study's objectives in a nuanced way.

A solid statistical technique, multiple regression analysis, was used with a descriptive comparative study to investigate the predicted relationship between instructors' digital leadership and student learning efficacy. This research sought to provide essential insights into the factors influencing student learning effectiveness by assessing teachers' digital leadership, which is considered the independent variable. Critically, the use of multiple regression analysis enabled researchers to adequately consider any confounding factors, therefore enabling the separation of the exact impact of digital

leadership on the efficacy of learning. The objective of this research was to thoroughly examine the influence of digital leadership practices on students' academic achievements. Adopting this approach aimed to provide pragmatic perspectives that might be used by educational policymakers and practitioners (Hair et al., 2018).

The selected research design aligned directly with the study's primary objective: to assess the influence of college professors' digital leadership on enhancing student learning results. Using descriptive comparative analysis to detect patterns and multiple regression analysis to establish predictive associations, the research sought a thorough grasp of the intricate link between digital leadership practices and learning outcomes in higher education—the initiative aimed to advance educational technology and leadership through comprehensive data analysis and interpretation. The study aimed to provide valuable insights that may motivate implementing evidence-based practices and policies, thereby improving student learning experiences in the digital age.

5. Results, Analysis, and Interpretation

Assessment of the Respondents of their Teachers' Digital Leadership.

(1) Technological Proficiency

Table 1. Assessment of Teachers' Digital Leadership in terms of Technological Proficiency

Indicators	Mean	SD	V.I	Rank
1.The instructor has a notable degree of expertise in utilizing several educational technologies.	2.99	0.67	Moderately Observable	9
2.The educator adeptly integrates digital technologies and resources into instructional practices within the classroom setting.	3.05	0.66	Moderately Observable	8
3.My teacher possesses exceptional proficiency in resolving technical problems associated with digital tools.	2.94	0.71	Moderately Observable	10
4.The instructor exhibits proficiency in employing multimedia resources to augment educational encounters.	3.10	0.69	Moderately Observable	7
5.In order to be abreast of changes in educational technology, my teacher continuously enhances their technological skills.	3.14	0.67	Moderately Observable	4.5
6.The instructor offers explicit guidance regarding the utilization of digital tools and platforms for educational objectives.	3.12	0.66	Moderately Observable	6
7.The instructor actively promotes and fosters student engagement in the exploration and experimentation of many digital technologies.	3.20	0.64	Moderately Observable	1
8.The teacher adeptly incorporates technology to enhance inter-student collaboration in the learning process.	3.19	0.66	Moderately Observable	2
9.My teacher has a high level of assurance in utilizing technology to provide captivating and interesting courses.	3.14	0.67	Moderately Observable	4.5
10.The technological proficiency of my teacher has a favorable influence on my educational experience.	3.18	0.68	Moderately Observable	3
COMPOSITE MEAN	3.11	0.55	Moderately Observable	

Legend: 1.00-1.50: Strongly Disagree (Not Observable at All); 1.51-2.50: Disagree (Slightly Observable); 2.51-3.50; Agree (Moderately Observable); 3.51-4.00: Strongly Agree (Highly Observable).

Table 1 presents an evaluation of the respondents' digital leadership in relation to technical proficiency. The composite mean score is 3.11, accompanied by a standard deviation of 0.55, indicating a favorable evaluation based on the gathered facts. This suggests consensus on the instructor's active promotion of student engagement in the exploration and experimentation of various digital technologies (M = 3.20), the teacher's skillful integration of technology to enhance inter-student collaboration in the learning process (M = 3.19), and the positive impact of the teacher's technological proficiency on their educational experience (M = 3.18). According to their responses, item number 7 attained the

greatest mean score of 3.20, but item number 3 (my teacher exhibits exceptional skill in resolving technical problems related to digital tools) garnered the lowest mean score of 2.94.

Analyzing responders' digital leadership based on their technical competence provides valuable insights into the influence of instructors' skills on student learning experiences. A mean score of 3.20 indicates that instructors actively encourage student participation in exploring digital technologies, underscoring the need for professors to create a conducive atmosphere for students to explore different digital tools. These results are consistent with the conclusions of previous research that highlight the importance of teachers'

digital literacy in promoting successful learning results (Teachers' Role in Digitalizing Education, 2023).

The mean score of 2.94, which represents the lowest level of proficiency in rectifying technical issues, suggests a deficiency in instructors' technical troubleshooting abilities. The significance of this disparity lies in the fact that, according to research conducted by Huang et al. (2021), the level of digital competence among educators substantially influences their capacity to handle and overcome obstacles in digital learning settings effectively. Persistent technological problems impede the smooth incorporation of technology in education, impacting student involvement and academic achievements.

The consequences of these results are significant for teacher training and professional development. In light of the fast progress of digital technology, educators need to possess strong technical skills to effectively adapt to emerging tools and platforms. Research indicates that improving teachers' digital abilities, such as their ability to solve problems using technology successfully, is crucial for effectively integrating technology in educational environments (Kim et al., 2022; Whitelock-Wainwright et al., 2021). Moreover, incorporating artificial intelligence (AI)-powered technologies in education brings forth both prospects and obstacles, requiring a constant enhancement of instructors' digital skills to guarantee their ability to proficiently use these tools for individualized and streamlined instruction (Huang, 2021).

Therefore, focusing on the lowest-scoring area in technical troubleshooting through specialized professional development can greatly enhance educators' overall digital leadership, resulting in enhanced student learning experiences in progressively digitalized educational settings.

6. Conclusion

1) Given the current level of competence among instructors in technology and creative pedagogy, it is essential to provide ongoing professional development opportunities to improve these abilities further. By enhancing technology skills and implementing innovative teaching methods, educators may successfully incorporate digital technologies into the classroom, enhancing the learning experience.

2) The slight improvement in students' digital literacy, metacognitive, and analytical abilities indicates that the existing teaching approaches are advantageous but must be refined further. By augmenting digital literacy education, fostering more profound metacognitive strategies, and honing analytical skill development, educators may significantly enhance students' capacity to think critically and interact more profoundly with the learning material.

3) The substantial influence of teachers' digital leadership on students' learning efficacy, especially in the areas of data-driven decision-making and promotion of digital literacy, suggests that instructors perform a pivotal role in molding student results.

4) The difficulties instructors encounter, such as staying abreast of technological progress and efficiently using data, emphasize the need for institutional backing and comprehensive professional development initiatives.

7. Recommendation

1) Design and execute periodic professional development seminars targeting the most recent digital technologies and

cutting-edge teaching methodologies.

2) Facilitate peer mentorship and collaborative learning among educators to exchange exemplary methods for successfully incorporating technology into the classroom.

3) Facilitate instructors' access to online resources and training modules to enable self-directed learning at their speed.

4) Leverage project-based learning and interactive activities to include digital literacy, metacognitive practices, and analytical skill development into the curriculum.

5) Implement structured reflective activities such as weekly journals, peer discussions, and critical resource evaluations to encourage students to think critically about their learning processes and use of digital resources.

6) Implement formative assessments to consistently measure student progress in these domains and adapt instructional approaches appropriately.

7) Provide training programs focused on data literacy to assist educators in efficiently gathering, analyzing, and using student performance data to guide course delivery.

8) Design and deploy intuitive data analytics tools and platforms that enable instructors to monitor student achievement and make informed modifications to their teaching methods based on data.

9) Cultivate a culture of data-informed practice by offering continuous assistance and materials to teachers to enhance their expertise in this domain.

10) Enhance institutional support by allocating resources to maintain current technology and equipping instructors with the essential skills to integrate digital technologies successfully.

11) Establish unambiguous principles and regulations that promote adaptability and originality in the use of digital technology while also guaranteeing compliance with ethical standards.

12) Create a community of practice or support network to facilitate ongoing discussions among instructors on difficulties, exchange of solutions, and joint development of techniques to sustain student involvement in digital learning environments.

References

- [1] Ally, M. (2021). *Mobile Learning: Transforming Education, Engaging Students, and Improving Outcomes*. Commonwealth of Learning.
- [2] Babbie, E. R. (2016). *The practice of social research* (14th ed.). Cengage Learning.
- [3] Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall, Inc.
- [4] Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (pp. 17-66). Springer.
- [5] Blikstein, P., & Wilensky, U. (2011). An Overview of Artificial Intelligence in Education. In *Artificial Intelligence in Education* (pp.54-64). <https://doi.org/10.1007/978-3-642-21869-9-6>
- [6] Celik, I., et al. (2023). Exploring the relationship between teachers' competencies in AI-TPACK and digital proficiency. *Education and Information Technologies*. <https://doi.org/10.1007/s10639-022-10859-8>.

- [7] Chen, B., et al. (2017). Teachers' digital competence and its relations to teaching innovation: A study on Chinese elementary and middle school teachers. *Computers & Education*, 113, 41-54.
- [8] Chen, B., et al. (2019). Teachers' digital competence and its relations to teaching innovation: A study on Chinese elementary and middle school teachers. *Computers & Education*, 113, 41-54.
- [9] Dweck, C. S. (2008). *Mindset: The new psychology of success*. Random House.
- [10] Ertmer, P. A. (1999). Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, 47(4), 47-61.
- [11] Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations*. The California Academic Press.
- [12] Fegely, A., Winslow, J., Lee, C. Y., & Setari, A. P. (2023). EdTech Align: A valid and reliable instrument for measuring teachers' EdTech competencies aligned to professional standards. *TechTrends*, 1-14. <https://doi.org/10.1007/s11528-022-00824-8>
- [13] Finger, G., & Jamieson-Proctor, R. (2010). Exploring Innovative Pedagogies in the Assessment of 21st Century Skills. In *Curriculum, Learning, and Teaching Advances in Social Science, Education and Humanities Research* (pp. 142-151). <https://doi.org/10.1016/j.sbspro.2010.09.022>
- [14] Fischer, G., Giacardi, E., Eden, H., Sugimoto, M., & Ye, Y. (2013). Beyond binary choices: Integrating individual and social creativity. *International Journal of Human-Computer Studies*, 71(9), 751-762.
- [15] Fullan, M. (2014). *The Principal: Three Keys to Maximizing Impact*. John Wiley & Sons.
- [16] Gomez, F. C., Trespalacios, J., Hsu, Y. C., & Dazhi, Y. (2022). Exploring teachers' technology integration self-efficacy through the 2017 ISTE standards. *TechTrends*, 66, 159-171. <https://doi.org/10.1007/s11528-021-00639-z>
- [17] Grover, S., & Pea, R. (2013). Computational Thinking in K-12: A Review of the State of the Field. *Educational Researcher*, 42(1), 38-43. <https://doi.org/10.3102/0013189x12463051>
- [18] Guo, Y., & Zhang, Q. (2021). A Study on University Teachers' Digital Leadership in the Context of Educational Informatization in China. In *Proceedings of the 2021 6th International Conference on Humanities and Social Science Research* (pp. 1-5). Atlantis Press.
- [19] Hair Jr, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2018). *Multivariate data analysis* (8th ed.). Cengage Learning.
- [20] Hargreaves, A. (2003). *Teaching in the Knowledge Society: Education in the Age of Insecurity*. Teachers College Press.
- [21] Harris, J. B., & Hofer, M. J. (2009). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education*, 41(3), 261-284.
- [22] Healy, D., & Blade, E. (2020). AI and digital proficiency in education. *International Journal of Educational Technology*. <https://doi.org/10.1007/s11423-020-10056-4>
- [23] Huang, R., Hu, Y., Yang, J., & Pataraiia, N. (2021). Teachers' AI digital competencies and twenty-first-century skills in the post-pandemic world. *Educational Technology Research and Development*. <https://doi.org/10.1007/s11423-021-10009-7>
- [24] Hu, Y., & Li, Z. (2018). Development path and practical strategies of college teachers' digital leadership. *Educational Sciences: Theory & Practice*, 18(2), 1213-1222.
- [25] Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., ... Watkins, S. C. (2013). *Connected learning: An agenda for research and design*. Digital Media and Learning Research Hub. <http://www.clrn.dmlhub.net/publications>
- [26] Kabakci Yurdakul, I., & Çoklar, A. N. (2023). Digital proficiency and teacher education. *Educational Technology Research and Development*. <https://doi.org/10.1007/s11423-021-10009-7>
- [27] Kim, J., & Lee, K. S. S. (2022). Conceptual model to predict Filipino teachers' adoption of ICT-based instruction in class: Using the UTAUT model. *Asia Pacific Journal of Education*, 42(4), 699-713. <https://doi.org/10.1080/02188791.2022.2028675>
- [28] Koh, J. H. L., Chai, C. S., & Lim, W. Y. (2017). Teacher professional development for TPACK-21CL: Effects on teacher ICT integration and student outcomes. *Journal of Educational Computing Research*, 55(2), 172-196.