ingegneria sismica
International Journal of Earthquake Engineering
Anno XLIII - Num. 3 - 2026

A Study on the Influencing Factors and Enhancement Strategies for Teachers' Digital Teaching Competency from the Perspective of Educational Digital Transformation

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SUMMARY: *With the progress of educational reform and the all-round development of students' minds and bodies, the use of digital technology in education has gradually become mainstream, thus increasing demands on teachers. Based on 216 high-quality international publications and policy documents from 2014 to 2025, this study will employ a systematic review, bibliometric analysis, theoretical integration and model induction method to examine the conceptual development, measurement system, influential factors and improvement strategies of teachers' digital teaching competence under the macro environment of educational digital transformation. Based on the above research, six core indicators of teachers' digital teaching ability have been proposed: technological literacy, digital instructional design, technological integration capability, digital assessment competence, data literacy, and digital ethics. The six systems of influence are: policy and institutional environment, school organisational support, technological infrastructure, teacher professional development, digital psychology and attitudes, and learner characteristics. The five connected links in the strengthening mechanism are: standardisation of competence frameworks, systematic organisation of teacher training, digitalisation of teaching scenarios, data-driven assessment mechanism, and ecological support system. Further building a system for strengthening teachers' digital teaching abilities and putting forward future research directions in this study.*

KEYWORDS: *educational digital transformation; teachers' digital teaching competence; technology integration; data literacy; teacher professional development; reconstruction of educational technology systems*

1 Introduction

Educational Digitalisation is now one of the main driving forces for all-around educational reform around the world. At its base, the deep embedding of digital technology in educational governance, teaching and learning activities, and resource systems aims to build an intelligent, precise and data-driven educational development model. With the continuous spread of artificial intelligence, learning analytics, smart classrooms (Figure 1), virtual reality (Figure 2), and blockchain, teachers are transitioning from being transmitters of knowledge to facilitators of learning, technology integrators, interpreters of learning data, and guides for digital ethics [1]. Therefore, teachers' digital teaching ability has become one of the main indicators of their core literacy in the digital age. However, many schools are still facing problems such as fragmented technology use, insufficient technological integration capability, weak digital instructional design skills, limited depth of learning-data application, and a lack of digital ethics

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https://doi.org/10.65102/is20261294 Published: 20 June, 2026

awareness; thus, the implementation of educational digital transformation at the teaching level is hindered. The above problems urgently require systematic research support [2]. Thus, according to the macro framework of educational digital transformation, this study systematically reviews the core concepts, influencing factors, development mechanisms and enhancement paths of teachers' digital teaching competence, and aims to construct an operational framework for schools and promote deep implementation of digital transformation in education. Although the above research has proposed some competency models and training suggestions, three problems have still not been solved. First, many studies have referred to teachers' digital competence as a general literacy construct and have not specified how the dimensions of competence are used in classroom teaching decisions. Second, school-level deficiencies in digital leadership, platform stability, data governance and technical support are often regarded as the background conditions rather than independent variables. Thirdly, most of the enhancement strategies are general training recommendations and do not indicate which parts of the school are weak or need targeted treatment. Therefore, this study has organised the existing literature into an operational chain of "competence dimension - influencing system - diagnostic indicator - enhancement mechanism". Thus, the review will move from an abstract explanation to provide a foundation for the school's assessment and improvement plan.

Figure 1: Smart Classroom

Figure 2: Virtual Reality Teaching

Figure 1 and Figure 2 are two representative cases of digital teaching. The smart-classroom scene shows multi-terminal interaction, real-time display and classroom collaboration; the virtual-reality scene shows immersive learning and simulation-based experience. The above situations are suitable for presenting the teaching content on teachers' digital instructional design, technology application, classroom management, and ethical use of student data.

2 Theoretical Foundations and Conceptual Evolution of Teachers' Digital Teaching Competence

2.1 Theoretical Foundation of Educational Digital Transformation

Educational digital transformation, as a profound manifestation of the societal digital revolution in the field of education, is based on information-based education theories, learning sciences, the technology acceptance model, educational change theories, and national frameworks for modernising educational governance [3]. Information-based education theory proposes that technology alters teaching and learning, modifies the system for educational administration, and thus is expected to be a key variable for restructuring all parts of the education ecosystem. Learning sciences also show that after the application of technology, learners' behaviour, cognition and emotions are all changing dynamically, and teachers' roles need to shift from knowledge transmission to designing and supporting learning processes. According to the technology acceptance model, the behaviour of teachers using technology in digital teaching can be explained by factors such as perceived usefulness, perceived ease of use, and self-efficacy; thus, the improvement in teacher competence is also driven by non-technological psychological factors. Theories on changes in education also indicate that, in line with the spirit of new technology, the whole educational system will be reformed to strengthen teachers' capabilities and provide them with new means of working. International strategies for digital education, AI-competency frameworks and education-data governance initiatives provide the institutional foundation for teachers' digital literacy and have become an important indicator of teacher professional development in the digital era [4].

2.2 Conceptual Evolution of Teachers' Digital Teaching Competence

The three stages in the development of the concept of teachers' digital teaching competence are: information technology skills, educational technology competence, and digital teaching competence. The first studies mainly focused on teachers' abilities in employing information technology, such as the use of equipment and courseware, online resource collection, etc., to see if teachers could "utilize" technology. With the development of technology in recent years, research on the application of educational technology has gradually taken shape, including technology-curriculum integration and technology-supported instructional design [5]. Teachers' digital teaching ability in the age of artificial intelligence now encompasses more than just the operation of technology; it includes digital design of instruction, application of new technologies, data analysis and utilization for learning, digital literacy, digital ethics, etc., and is based on a system of teaching renovation driven by technology. The European DigCompEdu framework, Japan's ICT Teaching Standards, and various regional teacher digital-competence frameworks all consider this a core element of teacher literacy and are in line with the global movement to enable teachers to use technology in education [6].

3 Dimensions of Teachers' Digital Teaching Competence

3.1 Technology Application Competency

The first level of a teacher's digital literacy is technological application ability, which refers to how well teachers can use hardware, software and other digital tools. Classroom equipment operation, smart-classroom system use, office software and courseware tools, online classroom platform management, and digital-resource processing are included. This ability will be used to conduct teaching activities in class and determine whether teachers can use smart boards, tablets, learning platforms and other virtual-simulation tools properly [7]. In the digital learning space, this ability also refers to using the technology in the class properly, switching devices, solving problems, etc. According to research, teachers' sense of technological self-efficacy and their application skills in teaching technology are positively correlated; therefore, further development in both is necessary to promote in-depth use of technology and learning-analytics abilities [8].

3.2 Digital Instructional Design Competence

Digital instructional design competence is a teacher's ability to use technology in conjunction with curriculum content and learner analysis to construct good technology-assisted teaching plans with specific instructional aims and activities. Teachers need to learn the traditional ideas of instructional design and then apply them in a new way in the age of technology by creating digital learning tasks, choosing appropriate tools, constructing blended and personalised learning paths, and integrating project-based learning, flipped classrooms and simulations [9]. Digital instructional design does not adhere to traditional design methods and is now more focused on the role of learners. For example, in a smart-classroom, teachers need to connect device functions with classroom activities, such as digital diagnosis before class, collaborative inquiry during class, and data-driven feedback after class [10]. Research shows that this level is the starting point for using technology to create new forms of teaching.

3.3 Technology-integrated Teaching Implementation Competence

A teacher's ability to use technology in their work refers to all kinds of situations, such as organising the classroom, guiding students, promoting student cooperation, regulating the process of using technology, and making adjustments in time. It decides whether the technology can be converted into teaching materials. Teachers need to know how to use technology differently for various purposes, such as substitution, enhancement[11], modification or rethinking. Teachers at the redefinition level often use multi-modal learning, interdisciplinary collaboration and real-time data-driven teaching. Classroom management ability, digital-psychological acceptance and pedagogical knowledge affect the degree of technology integration in promoting student interest and in-depth exploration[12].

3.4 Digital Assessment and Learning-Analytics Competence

It is a very rapidly changing and highly influential area now. Digital assessment literacy refers to teachers' application of online tests and questionnaires, real-time polling tools, learning-analytics platforms and assignment-management systems in the stages of formative assessment, diagnosis and remediation. Learning-analytics competence refers to the teacher's ability to analyse behaviour data, learning paths and performance data in order to guide learning diagnosis, differentiated instruction and personalised instruction [13]. The general direction of digital education now is data-driven decision-making. Teachers who can perform analysis will

use the school's data reports to identify students who are behind, understand why they are falling behind, and adjust their teaching plans accordingly. Based on the above research, teachers' learning-analytics competence is positively correlated with digital self-efficacy, training experience and the development of school data platforms [14].

4 Influencing Factors of Teachers' Digital Teaching Competence

4.1 Policy and Educational-Governance Environment

Policy Systems are the macro-level drivers of teachers' digital literacy. The government and relevant departments have issued various policies and plans. Digital curriculum standards, resource-sharing platforms, AI-powered teacher-training systems and digitalised teaching-research reforms have all affected teachers' motivation and development. Supportive policies will reduce the schools' resistance and increase the use of technology by teachers[15].

4.2 School Organisational Culture and Management Support

As the main place for teacher development, school culture, leadership, professional development systems and digital management platforms all affect teachers' abilities to teach. Digital leadership drives the pace of reform; innovative and open teaching cultures foster experimentation; and technology teams, instructional-support teams and platform-operation teams provide necessary support.

4.3 Technology Infrastructure and Digital Teaching Environment

Hardware, software, networks, digital-resource systems and smart-classroom facilities are the basic conditions for the development of competence. Mature technical environments can support more extensive technology applications; otherwise, due to weak infrastructure, teaching remains at the level of substitution or supplementation.

4.4 Teacher Professional Development, Digital Literacy and Psychological Traits

Digital literacy, technology self-efficacy, innovation consciousness, digital habits and professional identity are all related to an individual's competence. A higher self-efficacy predicts better Design and Integration Skills [16].

4.5 Learners' Digital Literacy, Learning Behaviors and Classroom Participation

Students are the recipients and primary drivers of changes in teacher-led technology integration. Learners' Digital Skills, Autonomy and Engagement Influence Teachers' Digital Strategies. The Richness and Interpretability of learner data also affect teachers' analytical skills.

4.6 Summary of the Causes

The Development of teachers' digital literacy is influenced by multiple factors, including policies and plans, schools' conditions, technology, individual attributes, professional-development experience, and learner characteristics. As shown in Table 1, the six influencing systems can be further turned into measurable diagnostic indicators for school-level

competence assessment.

The normalized and aggregated operation diagnosis are carried out by the following calculations on the raw indicators:

$$z_{ik} = \frac{x_{ik} - \min(x_k)}{\max(x_k) - \min(x_k)}, \quad 0 \le z_{ik} \le 1 \tag{1}$$

Formula (1) normalizes each raw indicator: x_{ik} is the original score of teacher i on indicator k, $\min(x_k)$ and $\max(x_k)$ are the minimum and maximum values of indicator k, and z_{ik} is the normalized value ranging from 0 to 1.

$$DTC_i = \sum_{k=1}^{K} w_k z_{ik}, \quad \sum_{k=1}^{K} w_k = 1, \quad w_k \ge 0 \tag{2}$$

Formula (2) calculates the composite digital teaching competence index: DTC_i denotes the overall competence score of teacher i, w_k is the weight of indicator k, and the weights sum to 1 with all weights non-negative.

$$P_{ij} = \frac{\beta_j (1 - DTC_i)}{S_{ij} + \varepsilon} \tag{3}$$

Formula (3) identifies the priority of targeted improvement: P_{ij} is the improvement-priority coefficient of teacher i under influencing system j, S_{ij} is the corresponding support score, β_j is the intervention weight, and ε prevents division by zero. A higher P_{ij} indicates a higher priority for intervention.

Table 1: Influencing Factors of Teachers' Digital Teaching Competence

Influencing System	Sub-Factors	Mechanism	Typical Manifestation
Policy and Institutional Environment	National strategies, regional policies, evaluation systems, resource investment	External regulation, resource provision, institutional guarantee	Stronger policies → more active digital application
School Organizational Support	Digital leadership, school-based training, technical teams, teaching-research culture	Organizational incentives, professional support, cultural shaping	Stronger support → deeper technology integration
Technological Infrastructure	Device quality, platform stability, network environment, smart-classroom environment	Resource supply, convenience, teaching-scenario reconstruction	Better conditions → easier innovative teaching
Teacher Individual Factors	Digital literacy, self-efficacy, innovation awareness, cognitive load, digital anxiety	Cognitive, emotional, behavioral intentions	Higher self-efficacy → deeper integration
Professional Development	Training quality, participation, peer collaboration, expert guidance	Knowledge renewal, skill development, reflective improvement	More training → greater competence gain
Learner Factors	Student digital literacy, engagement, data feedback, learning needs	Interactive feedback, task adaptation	Stronger student digital ability → more complex activities

As shown in Table 1, teachers' digital teaching ability is formed by the interplay of external policy conditions, school-level support, infrastructure, professional learning, individual psychological attributes and learner feedback. Therefore, the cultivation of competence should not be limited to general training in software; rather, one needs to conduct a diagnostic test on the deficiencies in the supporting system first and then provide focused help according to this diagnosis.

5 Enhancement Mechanisms for Teachers' Digital Teaching Competence

5.1 Constructing a Standardized System for Teachers' Digital Teaching Competence

The foundation of all the improvement measures is a scientific competence standard. According to foreign studies and policy practice on enhancing teacher competence, if there are no unified standards, teacher training may be scattered and monotonous or too focused on technical skills without direction for all-around development [17]. Therefore, many countries have developed systematic competence standards, and their functions in enhancement mechanisms are mainly divided into three parts: first, they offer a framework for training content to ensure that training aligns with educational objectives; second, they provide a basis for evaluating teacher development and enable schools to conduct staged assessments of competence growth; third, they offer clear paths for teachers' professional growth and allow teachers to engage in self-diagnosis, autonomous improvement and reflective practice based on the standards. The competence standard system will also serve as the foundation for the following training systems, classroom-innovation systems and evaluation systems.

5.2 Constructing a System of Professional Development for Teachers' Digital Competence Based on Patterns.

Teacher training can enhance the digital teaching abilities of teachers, and although many studies have been carried out, a single round of centralised training has not achieved this. The five modules of the improvement plan are: knowledge transfer, situation building, demonstration by experts, peer interaction and self-correction, and summary. Thus, an all-encompassing digital professional development system has been constructed as a basic strategy [18].

5.3 Promoting the Digitalization of Teaching Scenarios and Deep Reconstruction of Technology Integration

Teachers' digital teaching ability is also affected by changes in the digital environment of the teaching situation. Therefore, schools should build a digital teaching environment based on a smart classroom, learning platform and learning analytics system to allow teachers to apply technology in their teaching. Smart classrooms provide multi-terminal collaboration, real-time interaction, data feedback and multimodal presentation to help teachers create interactive, inquiry-based and collaborative learning in a real classroom setting [19].

5.4 Building Data-Driven and Intelligent Teaching Evaluation and Learning Analytics Systems

The Evaluation System is a Driving force for teacher development. With the development of

digital education in recent years, a variety of learning data have been generated; thus, at present, building a system that can use this data for diagnosis and improvement of teaching is required to boost teachers' capabilities. First, build an online assessment platform, learning analytics system and assignment management system for the school to provide teachers with access to students' learning path data, engagement data, behaviour pattern data and assignment performance data at any time. Second, schools should organize training sessions for teachers on learning-data literacy to help them understand the logic of data, data structure, data visualisation and models for data-driven teaching and learning, and thus provide teachers with the professional ability to recognise problems in data. Third, schools need to build a system for evaluating digital teaching, including teachers' digital instructional design competence, the depth of technology integration, and their ability to use learning data in the evaluation indicators, and thus avoid evaluations based solely on classroom observation or subjective judgment [20].

5.5 Constructing Sustainable Digital Support Systems and Governance Mechanisms

Establish a digital-teaching support centre or an educational-technology development office in the school to offer teachers prompt technical support, assistance in developing a digital curriculum, and support for learning-analytics technology. In addition, schools need to build digital-resource management systems, data-security systems, teacher technology-use regulations and digital-ethics norms to provide a safe environment for innovative practice by teachers. Strengthen incentives, set up reward systems for digital teaching innovation and outstanding smart-classroom teachers, and encourage continuous participation in digital teaching among teachers.

5.6 Summary of the Five-Ring Linked Mechanism for Improving Teachers' Digital Teaching Competence

Strengthening the digital teaching ability of teachers is a large-scale project that integrates policy support, school organization, optimisation of the technological environment, professional development for teachers, and feedback from learners. Build a multi-dimensional linked mechanism of standards, training, practice, evaluation and support. See Table 2.

Based on the above, Table 2 has been reorganized into a five-ring mechanism for enhancement strategies, and competence standards, training activities, digital scenarios, data-driven evaluation, and ecological support can all operate in a continuous improvement cycle.

Table 2: Five-Ring Linked Mechanism for Promoting Teachers' Digital Teaching Competency

Enhancement Link	Core Content	Mechanism	Typical Strategies
Standardization of Competence Framework	Constructing digital-competence systems, indicator systems, and behavioral standards for teachers	Clarifying direction, providing evaluation basis	Developing school-based standards, creating competence profiles
Systematic Training	Theoretical learning, skill training, scenario-based practice, peer collaboration	Competence building, reflection, internalization	Scenario-based training, case-based training, workshops
Digital Teaching Scenarios	Smart classrooms, learning platforms, virtual experiments, data platforms	Promoting deep technology integration	Discipline-specific scenario construction, technology demonstration lessons
Data-Driven Evaluation	Learning analytics, digital evaluation tools, intelligent feedback	Data-driven teaching improvement	Online assessments, behavior analysis, precision teaching
Ecological Support System	Organizational support, resource libraries, digital security, incentive mechanisms	Providing sustainable motivation and institutional guarantees	Establishing digital centers, incentive mechanisms, school-based resource libraries

As shown in Table 2, the enhancement links have individual purposes: Standards set the goals of competence; Training delivers updates to knowledge; Digital scenarios promote classroom applications; Data-driven evaluation generates feedback; and Ecological support ensures continuous participation. Therefore, the five links form a closed-loop mechanism and are not independent recommendations.

6 Summary

With the deepening of educational digitalisation, teachers' digital teaching abilities are now necessary to promote the all-round development of students, improve teaching quality, advance educational equity, and protect students' right to develop in the digital era. A systematic review of the literature from 2014 to 2025 indicates that teachers' digital literacy has changed from basic information technology operation to technological integration, and further to data literacy and digital ethics; thus, they have transitioned from a "technology-supportive competence" to a "teaching-innovation-driven competence", and now exhibit all-encompassing, well-structured and ecological characteristics. At present, many reasons cause the development of this to be different from others, such as policy, school environment, technology, staff training, etc. The five rings of strengthening are: standardised frameworks, organised training, digital teaching scenarios, data-driven evaluation and ecological support. Teachers' digital literacy will directly impact the high quality, speed and durability of educational digital transformation and is therefore a foundation for building a high-quality education system. With the progress of smart education, teachers will move from being mere users of technology to designers of learning innovation and professionals in data-driven education.

About the Author

Xinyue Ma was born in Lanzhou，Gansu, China, in 1999. She obtained a bachelor's degree from Northwest Normal University in China. She currently studying at the Graduate School, The Education University of Hong Kong. Her main research direction is digital transformation in education.

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