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Development and Expert Consensus on a Context-Adapted Digital Competence Indicator System for Teachers in Chinese Private Universities

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Abstract. Rapid development in digital technologies has revolutionized higher education and raised teachers' digital competence to high standards. Despite many efforts from international bodies such as DigCompEdu and TPACK to theorize on teacher digital competence, none of the proposed theoretical models sufficiently reflect the context of Chinese private universities. To fill the research gap and address practical issues, the current study adopted a mixed-methods research strategy using content analysis and expert interviews in constructing a digital competence indicator system for teachers in Chinese private universities. Four dimensions and twelve indicators of digital competence of Chinese private university teachers were developed based on data collected. The results have shown that contextual factors exert a major influence on teacher digital competence, including lack of technological support, practice-oriented requirements in teaching, as well as ethical issues in the emerging context of digitization in higher education. With its focus on digital competence basics and responsibility and ethics in digital environment, the developed framework can be considered a contextualized development of existing universal models of teacher digital competence. It enriches the literature with empirical studies in the field of teacher digital competence and will benefit practices of evaluating, develop teachers' digital competence and carry out digital transformation projects in Chinese private universities as well as other universities facing similar conditions in developing countries.

Keywords: digital competence; Chinese private universities; indicator system; mixed methods

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1. Introduction

Digital technologies' rapid evolution has dramatically changed teaching and learning processes as well as governance practices in HEIs (Katsamakas et al., 2024). Platforms, artificial intelligence applications, learning analytics, and online learning environments are increasingly incorporated into higher education, giving rise to new requirements concerning teachers' professional roles and skills (Selwyn, 2021; Williamson et al., 2020). As a result, teachers' digital competence became a significant factor influencing the quality of education and an important component of global higher education reforms (Peters et al., 2022; Tondeur et al., 2023). Modern higher education teachers should possess not only necessary digital skills but also be able to design digitally enhanced learning environment, support students' digital activity, select digital learning resources critically, and develop sound pedagogical practices based on their use (Falloon, 2020).

There is a growing number of approaches aimed at defining digital competence of teachers and measuring its components. Some of them that had a great impact on understanding digital teaching include the European Framework for the Digital Competence of Educators (DigCompEdu) (Redecker, 2017), the UNESCO ICT Competency Framework for Teachers, and the ISTE Standards for Educators. Such concepts as digital teaching, digital professional engagement, digital citizenship, and technology-enhanced pedagogies were elaborated considerably due to those frameworks. However, the majority of those frameworks have been created against the backdrop of relatively stable technological infrastructure and considerable investment in both institutions and their professionals (Carpenter et al., 2024).

Recent research, however, tends to argue for the notion of teachers' digital competence as a construct dependent on particular contexts rather than being an invariant set of skills. The formation of competence is not determined solely by individual factors but is also influenced by the institutional context, professional culture, supportive leadership, IT infrastructure, and specific policy environment (Lucas et al., 2021). In other words, competence frameworks created within one educational context may prove insufficiently relevant for application in another context due to a lack of adaptation. However, many contemporary studies still tend to employ models of competence that imply the existence of rather similar contexts in the education sector (Basilotta-Gómez-Pablos et al., 2022).

In China, national education policy has placed growing importance on teachers' digital literacy, viewing it as an essential part of the broader push toward educational digitalization. The Ministry of Education's *Digital Literacy of Teachers Standards* defines teacher digital literacy across five key dimensions: digital awareness, knowledge and skills in digital technology, application of digital technology, digital social responsibility, and professional development. These domains reveal the expectation that teachers not only should employ the use of digital technology for instruction and learning but also involve themselves in digital resource management, instructional innovation, ethical use of digital technology, and professional development through the use of technology (Feng & Sumettikoon, 2024; Lei & Jiang, 2025). Nevertheless, while such national

guidelines offer a useful framework and standard for teacher development, current literature reveals that digital competence among teachers is shaped by various contextual factors such as institutional context, training opportunities, digital infrastructure, field of study, teaching experience, and geographic location (Lan et al., 2024; Peng et al., 2023). This suggests that a national framework may not adequately address the diverse needs of teachers in various higher education institutions in China, particularly those in private institutions where teachers' access to development resources and digital capacity differs significantly (Gu et al., 2023).

Among many different fields in Chinese higher education, private universities play a significant role although there has not been much research conducted in the field. In the context of the massification of higher education, private universities have made great contributions to providing broader educational opportunities and offering a wider variety of higher education by meeting growing students demand in addition to what is provided by the public sector (Liu, 2025). On the other hand, private universities can operate under certain organizational characteristics.

Private universities, in contrast to their public counterparts, may be more dependent on tuition revenue, face a high level of competition, and have limited resources, especially regarding their investment in digital technologies and training faculty members (Kang & Xu, 2025; Lee et al., 2020; Scott & Guan, 2023). Additionally, many Chinese private universities share a vocational focus that emphasizes graduate employment opportunities and industrial connections. This institutional approach may bring about unique professional expectations and competency standards compared to research-focused public universities that place more emphasis on scholarly publications (Zhang & Wei, 2024).

Based on the above discussion of the contextual features of the setting under consideration, it can be expected that teacher digital competence at private higher education institutions will exhibit differences relative to common assumptions made in popular international frameworks that tend to apply to educational situations in general (Tondeur et al., 2023). Furthermore, while there have been tremendous advances in research related to the assessment of teachers' digital competence, most empirical investigations in this area have focused on measuring teacher digital competence by means of surveys (Skantz-Åberg et al., 2022; Smestad et al., 2023). As such, the current state of knowledge does not offer clear insights into the conceptualization and adaptation of competence dimensions to the institutional context in question, which leaves open questions about the extent to which existing frameworks are relevant to teachers working in Chinese private universities.

In light of the aforementioned limitations in the literature, this study takes a contextualized approach to teacher digital competence and attempts to design a digital competence indicator system tailored to Chinese private higher education institutions. Specifically, by applying systematic content analysis and conducting expert consultations with the Delphi method, the present study aims to derive the

dimensions and indicators of teacher digital competence in private higher education institutions in China. From a theoretical standpoint, the investigation extends existing digital competence research beyond its conventional scope and emphasizes the impact of institutional circumstances on the process of competence development. At the practical level, the proposed model can serve as an important reference for developing competence-related policies in private universities and other resource-strapped educational settings.

2. Theoretical Background and Literature Review

2.1 Competence and Contextualized Competence

Competence is considered an important factor influencing professional performance. The first works on competence have refuted the idea that intellectual and educational competencies define professional success in favor of considering other factors such as knowledge, skills, attitudes, and personal qualities that contribute to effective professional activity (Škrinjarić, 2022; Dutta et al., 2022). Subsequently, more attention has been paid to the situational nature of competence, which means that it reflects the interaction between individual competencies and the institutional environment where they operate (Doblinger, 2022).

This approach to competence is highly relevant to teacher digital competence, which presupposes not only technical competency but also pedagogical competence and ethics, as well as professional development and use of appropriate digital tools in a specific context (Falloon, 2020; Nagel & Amdam, 2025). This indicates that teacher digital competence may be defined as professional competence situating within a specific organization and educational context (Peters et al., 2022).

2.2 Teacher Digital Competence and Existing Frameworks

Digital competence of teachers is the capacity of teachers to efficiently, critically, and responsibly apply digital technologies for facilitating education and learning, assessing progress, collaborating and working together, and engaging in professional development activities (Ghomi & Redecker, 2020). The DigCompEdu framework presents the concept of teacher digital competence as multi-dimensional in nature in its application within pedagogical, professional, and ethical aspects of technology usage. It has been repeatedly confirmed that teachers with higher digital competence can create more effective technology-based learning environments and foster innovation in pedagogy (Consoli, 2024; Kiryakova & Kozhuharova, 2024).

There are several theoretical frameworks that have contributed to the understanding of digital competence of teachers. The DigCompEdu framework describes digital competence of teachers through six dimensions including professional engagement, digital resources, teaching and learning, assessment, empowerment of learners, and learners' digital competence (Redecker, 2017; Momdjian et al., 2024). The ICT Competency Framework for Teachers (ICT-CFT) of UNESCO pays attention to the congruence between competence of teachers and educational policy, curriculum, pedagogy, and professional development

(Bitegeko et al., 2025). Similarly, the ISTE Standards for Educators consider teachers' agency, digital citizenship, collaboration, innovation, and decision-making informed by data in digitally enhanced education settings (Crompton, 2023). The Technological Pedagogical Content Knowledge (TPACK) theory elaborates on how teachers combine technological, pedagogical, and content knowledge in order to facilitate effective instructional activities (Schmid et al., 2024). In China, the standards of Teacher Digital Literacy set by the Ministry of Education define a national framework involving digital awareness, skills, application, responsibility, and professional development of teachers as participants in the process of educational digitalization.

Despite the major contribution these theoretical frameworks have made to the research area, their concepts differ substantially. This is why Table 1 provides an overview of their key features relevant to the study.

Table 1: Comparison of Existing Teacher Digital Competence Frameworks and the Present Study

Framework	Core Dimensions	Strengths	Limitations for Chinese Private Universities
DigCompEdu	Professional Engagement, Digital Resources, Teaching & Learning, Assessment, Empowering Learners, Facilitating Learners' Digital Competence	Comprehensive pedagogical framework with strong international recognition	Assumes relatively stable institutional support and technological infrastructure
UNESCO ICT-CFT	Policy, Curriculum, Pedagogy, ICT, Organization & Administration, Professional Learning	Connects teacher competence with educational system development	Broad policy orientation may not capture institutional-level constraints
ISTE Standards	Learner, Leader, Citizen, Collaborator, Designer, Facilitator, Analyst	Emphasize digital citizenship, innovation, and data-informed practice	Focuses on ideal professional roles and less on resource disparities
TPACK	Technology, Pedagogy, Content Knowledge	Explains technology integration in teaching practice	Limited attention to ethics, institutional context, and professional development
Chinese Teacher Digital Literacy Standards	Digital Awareness, Digital Skills, Digital Application, Digital Responsibility, Professional Development	Provides policy guidance for Chinese teachers	Universal design may underrepresent sectoral diversity within higher education
Present Study	Digital Technology Competence, Digital Teaching Competence, Digital Professional Development, Digital Responsibility and Awareness	Context-adapted framework reflecting institutional realities of Chinese private universities	Requires further empirical examination across different institutional contexts

Note. The table summarizes representative teacher digital competence frameworks identified through the literature review and highlights their relevance to the context of Chinese private universities. Compiled by the researcher.

2.3 Limitations of Existing Frameworks and Measurement Approaches

However, despite considerable advancements achieved in designing such frameworks, several problems have been noted. Firstly, the vast majority of frameworks maintain an overly universal perspective and ignore institutional diversity among institutions of higher education (Tondeur et al., 2023; Howard et al., 2023). They usually make unrealistic assumptions about the presence of proper technological infrastructure, regular training programs, and supportive institutions (Inamorato dos Santos et al., 2023).

Secondly, currently used methods of assessment predominantly focus on self-assessment tools. Even though they can be helpful in encouraging professionals to reflect, self-reported measures have proven susceptible to response biases, which means that they fail to properly measure teachers' skills (Horváth et al., 2025). Moreover, tools are frequently transferred from one context to another without proper modifications (Cid-Martínez et al., 2025).

Thirdly, modern frameworks tend to emphasize both technological and pedagogical dimensions while paying relatively little attention to other aspects such as digital ethics, data governance, data protection, and the application of artificial intelligence responsibly (Filo et al., 2024; Ng et al., 2023). The growing role of these aspects in higher education means that they must be incorporated into teacher competencies (Dringó-Horváth et al.,2025).

All of this highlights the importance of having an approach that is mindful of the context within which educators operate by incorporating existing theory with practice (Falloon, 2020; Tondeur et al., 2023).

2.4 Chinese Private Universities as a Distinct Context

There is little research on Chinese private universities, a unique sector of the higher education system. In the era of expanding higher education, private universities have made great contributions to making higher education more inclusive and diverse (Xu, 2021). Nonetheless, in comparison with their counterparts, private universities usually have other governance models, financial mechanisms, and resources (Duan et al., 2023; Liu, 2020).

It is important to point out that private universities in China can differ substantially. The difference is reflected in missions, the development level of the region where a university is located, financial capacity, and the level of technological equipment (Zhang & Wei, 2024). However, despite some differences between private universities, they all face similar challenges related to digital transformation such as lack of technological resources, limited opportunities for professional development, and increased pressures to make their curricula more relevant to the labor market (Miao et al.,2023).

All the aforementioned factors contribute to the formation of teacher digital competence which implies applying information technologies for implementing application-oriented curriculum, using blended learning methods, conducting skills trainings and employability education (Enăchescu, 2025). At the same time, teachers face various barriers to digitalization associated with scarce resources,

growing demands for innovations in teaching methods, and new ethical issues concerning the use of artificial intelligence technologies (Ng et al., 2023; Dringó-Horváth et al., 2025).

2.5 Research Gap and Study Positioning

Research suggests that digital competence among teachers is a multi-faceted concept and is highly context-dependent (Falloon, 2020). Earlier framework studies have contributed immensely to our theoretical understanding of digital pedagogy, professionalization, evaluation and digital responsibility (Zeng et al., 2025). But there are still some significant limitations. Firstly, the role played by institutional diversity among higher education institutions has not received much attention, especially the distinctive environment of private universities (Pettersson, 2021; Starkey, 2020).

Secondly, most studies have focused on measurement of competence but lack a contextualized exploration of relevant competence criteria. Lastly, the influence of institutional attributes such as resources, institutional mission, and professional development systems has not been sufficiently addressed in framework formulation (Scherer et al., 2019; König et al., 2020). In this research, a framework of digital competence is created from a contextualized competence perspective and aims at establishing competence criteria particular to Chinese private universities.

3. Research Design and Methodology

The study adopted a sequential exploratory mixed-methods design consisting of two phases and validating a context-based indicator system for teachers' digital competence in Chinese private universities. Specifically, the first phase utilized content analysis for the development of the initial framework, whereas the second phase used Delphi technique for the validation and refinement of the developed framework based on expert opinions. The rationale for using such design was that digital competence among teachers is a multi-dimensional concept which needs to be defined and validated from a contextual perspective.

3.1 Phase 1: Systematic Content Analysis

3.1.1 Literature Search

During the first phase, a systematic content analysis was undertaken to identify the key dimensions and indicators of teachers' digital competence. The literature search and screening process followed the PRISMA 2020 framework to ensure transparency, rigor, and reproducibility (Page et al., 2021). Relevant literature was systematically retrieved from Web of Science, Scopus, and China National Knowledge Infrastructure (CNKI). Search strings were constructed around concepts related to teacher digital competence, digital literacy, higher education, and private higher education institutions.

To ensure comprehensive coverage of both international and Chinese scholarship, equivalent search terms were applied across English- and Chinese-language databases using Boolean operators. The search was limited to publications published between January 2020 and December 2025, a period characterized by

rapid developments in educational digitalization, artificial intelligence, and digital competence research.

3.1.2 Inclusion and Exclusion Criteria

In line with PRISMA 2020, the inclusion and exclusion criteria were defined prior to commencing the review and were established via a test run with 20 articles. The inclusion and exclusion criteria have been summarized in Table 2.

Table 2: Literature Inclusion and Exclusion Criteria

Dimension	Inclusion Criteria	Exclusion Criteria
Research Population	Higher education teachers (including private institutions); practising HE teachers or teacher education cohorts	Studies focused on primary/secondary school students, corporate employees, or the general public unrelated to HE teachers
Research Content	Explicitly addresses digital competence, digital capability, digital literacy, or the measurement/construction/evaluation of related indicator systems	Covers only general information literacy, single ICT skill training, or lacks substantive connection to digital competence
Research Design	Empirical studies (surveys, quasi-experiments, longitudinal studies), systematic reviews, meta-analyses, Delphi studies, and indicator-construction studies	Commentary essays with no clear research design; conference abstracts or brief reports without extractable data
Source Quality	Published in peer-reviewed journals, doctoral dissertations, authoritative conference proceedings, or policy reports (e.g., UNESCO, OECD, European Commission); full text accessible	Non-academic texts (news articles, popular science, interviews); full text inaccessible via official subscriptions
Publication Period	Chinese- and English-language literature published January 2020–December 2025, to capture recent developments	Pre-2020 publications (except seminal foundational works admitted after explicit justification)
Duplicate Records	Unique records confirmed after de-duplication	Duplicate records identified by automated or manual checking; only the most complete version retained

Note. Criteria were developed based on the PRISMA 2020 statement (Page et al., 2021) and adapted to the objectives of this review. HE = Higher Education. The table was compiled by the researcher.

3.1.3 PRISMA 2020 Screening Procedure

Literature selection and screening were done following the PRISMA 2020 criteria. In total, there were 718 documents found in the databases Web of Science, Scopus,

CNKI, as well as manually through citation tracing. Of these, 257 duplicate articles were removed. In total, 461 articles underwent further screening based on their titles and abstracts. At this step, 266 articles that were not pertinent to the research theme or did not address digital competence framework development in higher education teachers were eliminated. In total, 195 papers entered into the full-text review phase.

Upon reviewing the papers in full, there were 68 articles included in the methodological quality assessment process. The criteria used here were from the Mixed Methods Appraisal Tool. Of these, 22 low-quality articles were excluded after conducting the quality assessment. In total, 46 articles entered into the NVivo-based content analysis phase.The literature selection and screening process is presented in Figure 1.

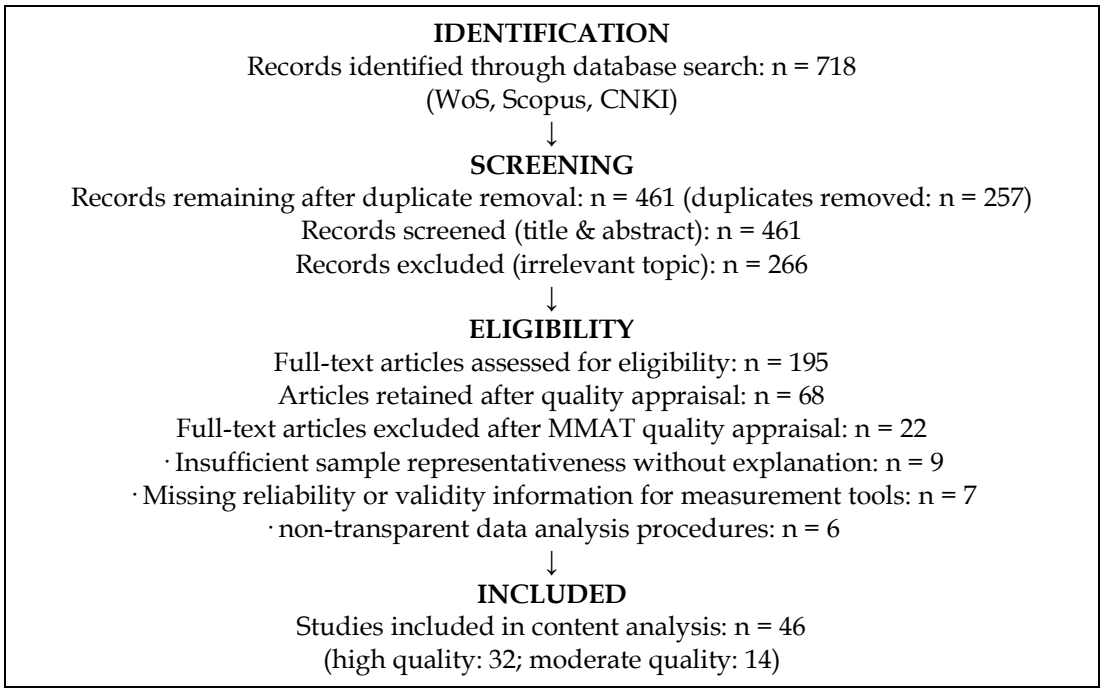

Figure 1: PRISMA 2020 Literature Selection Flow Diagram

Note. The literature selection process followed the PRISMA 2020 reporting guidelines (Page et al., 2021). Records were retrieved from Web of Science (WoS), Scopus, and CNKI databases. MMAT = Mixed Methods Appraisal Tool. The figure was developed by the researcher.

3.1.4 Quality Appraisal of Included Studies

In order to increase the validity of the methodology for conducting the review, the Mixed Methods Appraisal Tool was employed to evaluate the quality of the 68 full texts under investigation. The use of MMAT was dictated by the diversity of research designs represented in the literature (quantitative surveys, qualitative research, mixed-method studies, systematic reviews, and framework development). The assessment of quality included five dimensions, namely, research questions clarity, research design appropriateness, adequate sampling, data collection and analysis clarity, and interpretation credibility. Depending on

the criteria met, the studies were evaluated according to three quality grades: high quality, medium quality, and low quality.

Thus, out of the 68 full texts that underwent the assessment, 32 studies were considered high quality, 14 studies were evaluated as medium quality, while 22 were found to be of low quality. The low-quality category is associated with inadequate methodological information, lack of clarity in sampling, absence of reliability and validity testing, or vague description of data analysis techniques. Hence, 46 studies were included in the content analysis.

3.1.5 Coding Procedure and Reliability

NVivo software was utilized to aid coding and analysis. The meaning unit, which is a complete sentence or series of sentences conveying a single idea, was considered the unit of analysis.

Four phases were involved in the coding procedure: data preparation, pilot coding, open coding, and axial coding. First, 235 points of interest in literature were selected. By combining overlapping concepts and deleting unnecessary categories, 36 categories were left. The next step was to use axial coding, which helped in organizing the categories into four first-order dimensions and twelve second-order indicators.

As per the usual practice in qualitative content analysis, meaning units were utilized as the main unit of analysis (Schreier, 2023). Two coders analyzed the subset of included studies in order to increase coding reliability. Inter-coder reliability was calculated based on Cohen's Kappa coefficient. The value obtained for Cohen's kappa ($\kappa = .826$) was greater than the minimum value of .80 and suggested almost perfect agreement (Cohen, 1960). Finally, theoretical saturation was determined by an iterative approach that included coding, category development, and validation. Saturation was reached when no new dimensions or categories could be generated in later coding phases (Hennink & Kaiser, 2022).

3.2 Delphi Expert Consultation

3.2.1 Expert Selection and Sampling

Participants were selected through purposive sampling, taking into account their expertise in educational technology, higher education, teacher development, digital competence, or private higher education management. The Delphi panel was composed of 15 experts, encompassing university educators, educational technology specialists, teacher development researchers, and higher education administrators.

From a methodological perspective, a panel of 15 experts was considered appropriate for this study. Prior Delphi research has shown that expert panels with approximately 10 to 20 participants are generally sufficient to reach a stable and reliable consensus while preserving a diverse range of perspectives (Nasa et al., 2021; Shang et al., 2023). Consequently, 15 experts were deemed suitable, as this ensured both in-depth contextual expertise regarding Chinese private universities and broader insights into digital education and teacher development.

3.2.2 Delphi Procedure

The second stage employed the Delphi technique to validate and improve the indicators proposed via content analysis, an appropriate technique for developing a consensus among experts on complex concepts in education (Von der Gracht, 2012). Experts from educational technology, teacher training, higher education, digital literacy, and educational administration were recruited through purposive sampling. The composition of the Delphi panel consisted of seven members from public universities, five members from private higher education, two members from educational research institutions, and one member of industry based educational technology experts. While almost a third came from private universities, the panel comprised members who were theoretically, methodologically, and politically relevant for Chinese private universities.

The Delphi questionnaire comprised three sections based on the proposed four-dimensional twelve-indicator model. These sections included: (1) the expert background; (2) the Likert scale rating of indicator importance from five; and (3) revisions and recommendations.

Two sets of electronic consultations took place. In the first round, a total of 18 questionnaires were issued, and 15 valid questionnaires were obtained, resulting in an 83.3% return rate. Based on the ratings and comments collected, the framework's indicators' name, description, and boundaries were modified. For instance, one of the modifications recommended by the experts was the inclusion of the term "digital" to emphasize the digital nature of teaching and professional development. This resulted in changes from "Teaching Integration Competence" to "Digital Teaching Competence" and from "Professional Development Competence" to "Digital Professional Development Competence."

Moreover, it was suggested that the expert panel includes issues such as artificial intelligence, digital safety, data security, and constraints in private universities. The revised descriptions include Digital Technology Application, Digital Safety Awareness, among others. The second-round questionnaires were sent to the previous set of experts, which comprised 15 members, and all the questionnaires were completed without conducting any third round because it was found that the issues raised during the first round had already been sufficiently addressed.

The expert authority was analyzed using the coefficients of familiarity and judgment basis. The coefficient of familiarity was 0.733, while that of judgment basis was 0.867, with an overall authority of .800, which is above the suggested limit of .70. Expert consensus was evaluated using mean, standard deviation, full scores, coefficient of variation, mode, interquartile range, and Kendall's coefficient of concordance. Mode and interquartile range were added as per the recommendation of reviewers in order to make the central tendency and dispersion of judgments by experts clear. The calculation of Kendall's coefficient of concordance was done for all twelve second order indicators and not just the four first order dimensions.

4. Results

4.1 Results of Systematic Content Analysis

Content analysis results yielded a four-factor and twelve indicator model of teacher digital competence. Initial 235 reference codes were derived from open coding of the 46 selected articles. Following consolidation and purification procedures, 36 categories were kept as the most representative ones. Second order indicators consisting of these 36 categories were then classified into four first-order factors such as Digital Technology Competence, Digital Teaching Competence, Digital Professional Development, and Digital Responsibility and Awareness.

Digital Technology Competence was revealed as the base factor of this four-factor model of teacher digital competence. Technology Foundations, Technology Application, and Technology Innovation were the three indicators under this factor. They indicate teachers' competence to control fundamental technology operations, use educational technologies in teaching practices, and utilize innovative technologies.

Digital Teaching Competence can be viewed as the instructional core of the framework and comprises Digital Teaching Design, Digital Teaching Implementation, and Digital Teaching Assessment. The indicators of the core embrace all aspects of the teaching process, including lesson preparation, delivery of both online and blended classes, interaction with learners, assessment and evaluation techniques, and using learning analytics to inform the teaching process.

Digital Professional Development is related to the ongoing personal development of educators in the digital environment. It includes such components as Digital Learning and Growth, Digital Collaboration and Communication, and Digital Teaching Innovation. Indicators within this category stress the importance of lifelong learning, participation in digital training programs, professional networking, and knowledge collaboration, as well as the implementation of innovations in digital teaching that would result in transferable achievements.

Digital Responsibility and Awareness refer to the ethical and critical aspects of digital teaching. This component involves such indicators as Digital Security Awareness, Digital Ethics, and Digital Thinking Ability.

4.2 Results of the Delphi Consultation

4.2.1 Round 1 Results

In regard to the round 1 results, it should be noted that experts agreed to support the proposed preliminary framework. All first-order constructs scored highly with mean values varying between 4.33 and 4.73. All values for the coefficient of variation were less than .20, which was considered acceptable for achieving consensus. In this regard, Digital Teaching Competence was rated the highest ($M = 4.73$, $CV = .097$). This implies that experts considered the integration of pedagogy as the primary attribute of the teacher's digital competence. Digital Technology Competence scored slightly lower ($M = 4.33$, $CV = .166$), meaning that while technical competency was deemed relevant, some differences in the expert opinion existed regarding its importance.

Regarding second-order constructs, Digital Ethics and Digital Security Awareness were rated highest. The reason behind this was probably associated with the increasing significance of ethical behavior when using technological resources. At the same time, Digital Teaching Innovation showed slightly higher dispersion in Round 1. This means that experts' understanding of innovative approaches varies depending on their perception of private universities' specific needs. The descriptive statistics and consensus indicators for the four first-order dimensions are presented in Table 3.

Table 3: Delphi Round 1: Expert Ratings of First-Order Dimensions (N = 15)

First-Order Dimension	M	SD	Mo	IQR	CV	Full-Score Frequency	Consensus
Digital Technology Competence	4.33	0.72	5	1.00	.166	53.3%	Moderate
Digital Teaching Competence	4.73	0.46	5	0.00	.097	73.3%	High
Digital Professional Development	4.47	0.64	5	1.00	.143	53.3%	High
Digital Responsibility and Awareness	4.67	0.49	5	1.00	.105	66.7%	High

Note. M = mean; SD = standard deviation; CV = coefficient of variation; Mo = mode; IQR = interquartile range. Higher mean values indicate greater perceived importance of the indicator.

4.2.2 Round 2 Results

After Round 1, certain changes have been made to enhance clarity and appropriateness. To begin with, dimension names were modified to reflect the digital nature of each concept. Secondly, some second-order indicators were also renamed in order to become more precise and measurable. Finally, the operationalization of the indicators was refined by incorporating expert advice concerning AI-aided education technologies, data security, digital ethics, low-barrier technologies, and the specifics of teaching at private universities.

The outcome of the second round revealed an even greater consensus among the experts. Firstly, 100% of the experts participated in this round. Secondly, the criteria were met by all the indicators, which received mean scores ranging between 4.60 and 4.87 with CV values being less than .20. The value of Kendall's W increased from .523 in Round 1 to .680 in Round 2. In addition, chi-squares were statistically significant in both rounds. Tables 4 and 5 present the Round 2 evaluation results and the overall expert consensus across the two Delphi rounds, respectively.

Table 4: Delphi Round 2: Expert Ratings of First-Order Dimensions (N = 15)

First-Order Dimension	M	SD	Mo	IQR	CV	Full-Score Frequency	Consensus
Digital Technology Competence	4.60	0.51	5	0.50	.110	60.0%	High
Digital Teaching Competence	4.87	0.35	5	0.00	.072	86.7%	High
Digital Professional Development	4.80	0.41	5	0.00	.086	80.0%	High
Digital Responsibility and Awareness	4.82	0.39	5	0.00	.080	82.7%	High

Note. M = mean; SD = standard deviation; Mo = mode; IQR = interquartile range; CV = coefficient of variation.Higher mean values indicate greater perceived importance of the indicator.

Table 5: Expert Opinion Concordance Across Delphi Rounds

Round	Kendall's W	χ^2	Number of Experts	Number of Second-Order Indicators	Significance
Round 1	.523	85.8	15	12	$p < .01$
Round 2	.680	112.2	15	12	$p < .001$

Note. W = Kendall's coefficient of concordance; χ^2 = chi-square statistic. Kendall's W was calculated across the ratings of the twelve second-order indicators provided by 15 experts. Statistical analyses were conducted using SPSS Version 28.0.

4.3 Final Digital Competence Indicator System

Based on systematic content analysis and two rounds of Delphi consultation, the final indicators were determined. There are four first-level dimensions and twelve second-level indicators (Table 6). This reflects not only theoretical considerations concerning teacher digital competence but also the unique characteristics of Chinese private university context.

Table 6: Validated Digital Competence Indicator System for Teachers in Chinese private universities

First-Order Dimension	Second-Order Indicator	Operational Description
Digital Technology Competence	Technology Foundations	Mastery of basic digital operations, common educational software, information retrieval, and digital resource management.
	Technology Application	Ability to create digital teaching resources, manage online teaching platforms, and use multimedia and AI-assisted tools in instruction.
	Technology Innovation	Ability to explore emerging technologies, solve technical problems, and optimize digital teaching environments within available resources.

First-Order Dimension	Second-Order Indicator	Operational Description
Digital Teaching Competence	Digital Teaching Design	Ability to design digital lesson plans, develop online course content, and construct blended learning models.
	Digital Teaching Implementation	Ability to implement digital teaching strategies, organize online interaction, and manage remote or blended teaching processes.
	Digital Teaching Assessment	Ability to use digital tools for formative and summative assessment, provide online feedback, and analyze learning data.
Digital Professional Development	Digital Learning and Growth	Awareness and ability for continuous digital learning, participation in digital training, and digital teaching research.
	Digital Collaboration and Communication	Ability to participate in online professional communities, cross-platform collaboration, and inter-institutional knowledge sharing.
	Digital Teaching Innovation	Ability to conduct innovative digital teaching practices and transform teaching outcomes into practical applications.
Digital Responsibility and Awareness	Digital Security Awareness	Awareness of network security, privacy protection, student data protection, AI ethics, and data governance.
	Digital Ethics	Ability to follow digital teaching ethics, maintain academic integrity, respect intellectual property, and guide responsible digital behavior.
	Digital Thinking Ability	Ability to critically evaluate digital information and use digital thinking to solve teaching and management problems.

Note. The final indicator system was developed through systematic content analysis of 46 studies and validated through a two-round Delphi consultation involving 15 experts. The framework comprises four first-order dimensions and twelve second-order indicators.

As a result, it can be concluded that teacher digital competence within Chinese private universities represents a multifaceted concept influenced by aspects such as technology, pedagogy, development, and ethics. Contrary to being viewed as independent dimensions, these concepts influence each other to facilitate successful integration of teachers into digitally transformed contexts. It should also be mentioned that inclusion of indicators related to digital responsibility, data privacy, and awareness of AI can be regarded as an indicator of increased complexity of competence in terms of digital era.

In order to describe the relations between different indicators and dimensions included in the definition of digital competence, it seems appropriate to present the resulting framework illustrated on the basis of findings of literature review and Delphi procedure. Figure 2 below represents a conceptual framework of core

competences required from teachers within Chinese private universities institutions.

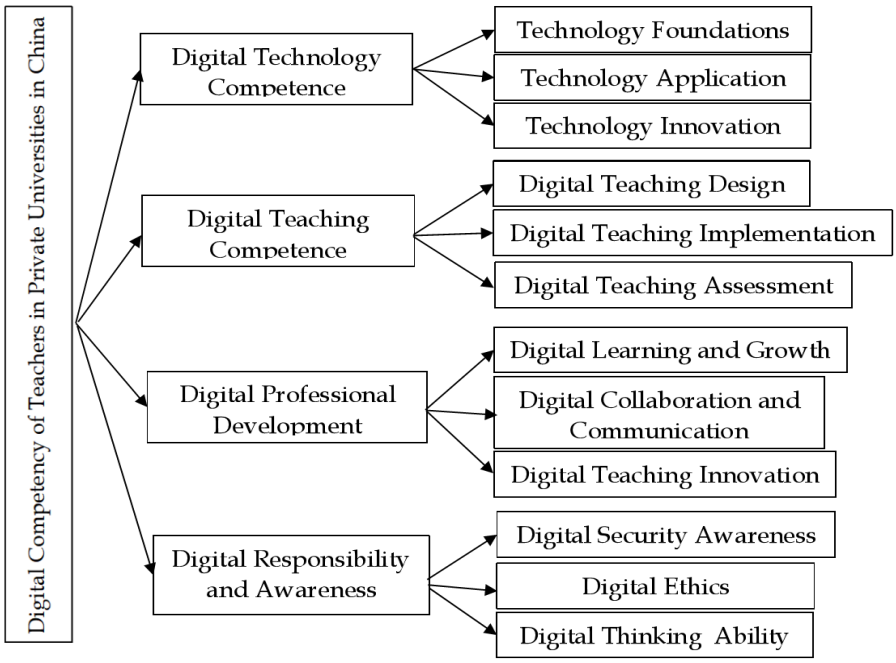

Figure 2: Digital Competence Framework for Teachers in Chinese Private universities

Note. The framework was refined and validated through two rounds of Delphi consultation involving 15 experts. The model consists of four first-order dimensions and twelve second-order indicators. Arrows indicate conceptual relationships among dimensions.

This perspective is particularly relevant to teacher digital competence. As shown in Figure 2, effective digital teaching involves not only technological proficiency but also teaching practice, professional development, collaboration, security awareness, ethics, and digital thinking. These dimensions together form an integrated framework for understanding teacher digital competence in Chinese private universities.

5. Discussion

5.1 Theoretical Contributions of the Indicator System

This study makes a valuable contribution to the development of a conceptual framework regarding the issue of teacher digital competence through developing a contextualized indicator system of teachers' digital competence in Chinese private universities institutions. Despite the fact that there exist international frameworks which have provided the foundation for the formation of teacher digital competencies (such as DigCompEdu, UNESCO ICT-CFT, and ISTE), these frameworks were elaborated for more universal settings of education, and, therefore, could hardly provide an appropriate interpretation of digital competence of Chinese private university teachers.

The validated conceptual framework includes four interconnected dimensions of teacher digital competence, namely, Digital Technology Competence, Digital Teaching Competence, Digital Professional Development, and Digital

Responsibility and Awareness. In this way, the findings support the position according to which teacher digital competence must be viewed not from the perspective of technical skills but rather as a complex multi-faceted competence that incorporates all mentioned dimensions (Falloon, 2020).

The findings indicate that Digital Teaching Competence received the strongest level of expert endorsement among all dimensions. This can be interpreted in a way that the integration of technologies in teaching, learning process organization, and assessments is still perceived as an integral part of the concept of teacher digital competence. As was already indicated by Redecker (2017), this concept loses its educational significance without integration into the process of instruction.

The final theoretical contribution lies in the separate consideration of Digital Responsibility and Awareness dimensions, which is included in addition to the mentioned three dimensions. Specifically, this dimension includes such elements as digital security, digital ethics, protection of privacy in data exchange, digital thinking, and responsible use of artificial intelligence.

5.2 Contextualizing Digital Competence in Chinese Private Universities

The results have also confirmed that the level of teacher digital competence is influenced by its institutional environment. It is obvious that private and public universities have different governance structures, different ways to allocate resources, different systems of teachers' professional development, and different pressures of a market-oriented society. That is why a direct application of existing international standards or public sector experiences could partially be misled with the local situation.

The heavy focus on the categories like Technology Application and Digital Teaching Implementation could be explained through practical considerations because teachers in private universities often lack technological assistance but are supposed to become more efficient and engage their students in a better way. Likewise, Digital Professional Development could be considered as an important category in view of the fact that teachers need to rely on self-development.

Nonetheless, Chinese private universities cannot be considered as a homogenous category because there are various regional peculiarities related to the university location, mission, funding potential, student profile, and technological development. For this reason, the presented framework should be considered as a flexible template. The value of such a model consists in offering institutions a solid structure based on which they can adjust their strategy depending on the actual conditions.

5.3 Interpreting the Divergence Around Digital Teaching Innovation

One interesting result is the relative difference of opinion among experts regarding the concept of Digital Teaching Innovation in the first round of the Delphi process. The divergence in expert opinions suggests that innovation remains a contested concept within the context of private higher education. While some experts might see innovation as applying new technology innovations,

others might see innovation as improving teaching methods within realistic limitations.

This distinction needs clarification. At limited-resource institutions, innovation cannot be associated merely with the application of advanced technologies. It should involve affordable, achievable, and educationally significant innovation in teaching methodology, interactivity, feedback processes, and learning evaluation processes. Similar to earlier studies, this research emphasizes that educational innovation should be assessed based on the extent to which it contributes to educationally significant change (Lai & Bower, 2020).

The decrease in disagreement between rounds shows that changing the definition has led to experts forming an easier-to-understand consensus. With the indicator's definition revised to Digital Teaching Innovation, it will be easier to avoid confusion between technology-driven novelty and more practical pedagogic innovations.

5.4 Practical Implications

This framework has significant practical value for policymakers, institutional administrators, teacher development centers, and teachers. First, the proposed framework serves as a context-aware tool for policymaking concerning the establishment of standards for the level of teachers' digital competence and corresponding teacher professional development policies. Policymakers will no longer need to adopt international frameworks of digital competence but create their differentiated mechanisms based on the four-dimensional framework.

Second, the framework can serve as a tool for designing educational processes at private universities. University administrators can use this framework for the creation of teacher training programs, planning institutional digitalization, as well as evaluating the effectiveness of teacher professional development in specific aspects, such as digital teaching design, learning analytics, AI-based instruction, digital ethics, and cybersecurity.

Third, the framework has significant implications for teachers. The proposed framework will help to see digital competence as a developmental process and not a set of skills that have already been acquired. Such an approach is essential in the context of private universities where teachers are required to respond to different teaching needs as quickly as possible.

Finally, students may also benefit from the implementation of the proposed framework since teachers with enhanced digital competence can provide an adequate learning environment, give timely feedback, facilitate personalized instruction, and promote students' digital literacy (Timotheou et al., 2023).

Nonetheless, there are several issues that may prevent the proper implementation of the framework in practice due to resource constraints, limited training budgets, uneven technological and organizational infrastructures, and others. Thus, it is necessary to consider that the successful introduction of this framework requires both teacher initiative and institutional involvement.

5.5 Limitations and Future Research

Some weaknesses need to be recognized here. Firstly, the development of the framework was based on systematic content analysis and Delphi consultations with experts. Even though these two strategies are highly theoretically and professionally sound, the current study did not involve direct consultations with teachers using this tool in practice. It would be worthwhile to explore how teachers view and use the framework in reality.

Secondly, the expert panel included only 15 experts. Although it is quite normal in terms of Delphi studies, one can assume that an even larger expert panel might have been beneficial for improving the representativeness of the resulting framework.

Thirdly, this study specifically targeted teachers in Chinese private universities. Thus, the resulting framework cannot be automatically used at Chinese public universities or higher educational establishments abroad. Comparative studies will be required to identify what aspects of competence remain universal and what needs to be changed.

Fourthly, the teacher's digital competence is dynamic and keeps changing in response to such developments as generative AI, learning analytics, immersive technologies, and digital governance (Chiu, 2024; Holmes et al., 2022). The framework thus requires periodical updates and revisions to be relevant.

6. Conclusion

The current research work established a teacher digital competence indicator system based on systematic content analysis and Delphi method consultations for two iterations among experts from Chinese private universities institutions. As a result of the research process, there emerged four first-level indicators: Digital Technology Competence, Digital Teaching Competence, Digital Professional Development, and Digital Responsibility and Awareness, together with twelve second-level indicators.

Through this research, it can be clearly seen that digital competence of teachers goes beyond technical skills in utilizing technology. Instead, it comprises multiple dimensions and aspects such as technological application, teaching practices, professional growth, and responsible behavior related to information communication technology usage. It is notable that components such as digital ethics, personal information protection awareness, and critical digital thinking expand the idea of teacher competence in today's society.

Originality of this research paper consists in adaptation of teacher digital competence theory under specific conditions of Chinese private universities. It could serve as a framework for further teacher training, digital transformation at higher educational institutions, as well as policy development. However, when using the indicator system, its flexibility and adaptability should be considered.

As for future research, one should conduct investigations in similar frameworks for other types of Chinese universities, various regions, and international education systems. In addition to that, it would be necessary to test the framework in pilot implementations and analyze its long-term effects. Overall, this paper provided an innovative framework for promoting teacher digital competence.

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