An empirical analysis of EFL teachers' digital literacy in Chinese higher education institutions

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Abstract

In 2022, China's Educational Ministry, for the first time, released an industry standard for teachers' digital literacy. This standard provides a holistic framework for teachers' digital literacy (TDL) in five dimensions. Since few studies have investigated EFL teachers' digital literacy, the relationships among the five dimensions proposed for EFL teachers' digital literacy remain unknown. Therefore, this research applied a quantitative method using a five-point Likert questionnaire designed based on TDL. Ninety-two EFL teachers from two universities and one higher vocational college in China participated in this questionnaire research. Partial least squares structural equation modeling was used to assess the relationships between these five dimensions. The relationships between the five TDL dimensions were highlighted by the findings, which supported the proposed model. In addition, implications for enhancing EFL teachers' future digital literacy have been provided to facilitate and favor EFL teachers' digital literacy development.

Keywords: Digital literacy, EFL teachers, Teachers' digital literacy, 21st century abilities, Teachers' professional development

Introduction

Digital technology has been a significant enabler in transforming each industry. As a crucial digital application scenario, education in the digital age possesses new features that usher in a completely new pedagogical paradigm. A growing acknowledgment is that "These emerging technologies present immediate as well as far-reaching opportunities, challenges, and risks to educational systems" (UNESCO, 2023). With the emergence of online learning, especially during the COVID-19 pandemic, online and offline hybrid teaching and learning, and the current rise of CPT-4 and similar generative language models, the application of digital technologies such as artificial intelligence, big data, virtual reality, and cloud computing in EFL teaching has gained worldwide attention. English language learning is expected to be the most frequently utilized subject for educational AI applications (Crompton & Burke, 2023). Under such circumstances, EFL education faces both challenges and opportunities. How can EFL teachers turn these challenges into opportunity?

According to the Artificial Intelligence and English Language Teaching Report released by the British Council in 2023, EFL teachers confirmed the potential of

artificial intelligence as a supplementary tool in EFL teaching. Meanwhile, they believed that English language teaching (ELT) would continue to be taught by humans. Moreover, the key to ELT in the hands of teachers is to enhance their digital literacy. Digital technology enables education transformation and is the key to overcoming obstacles. In contrast, the digital literacy enhancement of EFL teachers is a practical measure for transforming EFL education.

Digital literacy is the ability of an individual to use information and computer technology for learning, living, and working in a digital environment. It includes information literacy, data literacy, network literacy, innovative thinking literacy, and many other aspects. In 2022, the education industry standard "Digital Literacy for Teachers" (DLT), issued by China's Ministry of Education, made it clear that the connotation of digital literacy for teachers includes "the awareness, ability, and responsibility of teachers to appropriately make use of digital technology to acquire, process, use, manage and evaluate digital information and resources, to identify, analyze and solve educational and teaching problems, and to optimize, innovate and change educational and teaching activities." It is essential for developing teachers' digital literacy by education administrations, schools, and educational organizations.

In the digital age, multimedia technology, big data, virtual reality, artificial intelligence, and other modern digital technologies have been necessary for teaching foreign languages (Lianzhen, 2020). Teachers should consciously change their roles, gradually transforming from educators in the traditional teaching model to learners in the new era. The digital literacy of higher education EFL teachers is not only a skill but also a critical factor in adapting to the development of the digital era and promoting innovation in higher education. As the main body of education, enhancing EFL teachers' digital literacy is the key to seizing this opportunity. Enhancing the digital literacy of college foreign language teachers will help them effectively use digital technology tools in the teaching process, build an intelligent foreign language teaching environment that integrates digital technology, and carry out efficient research activities with the help of information technology. Therefore, foreign language teachers in colleges and universities should improve their information literacy to adapt to the new requirements of the development of university foreign language teaching in the information technology environment.

This study pursued two questions to achieve this objective.

1. What is the relationship between the five TDL dimensions?
2. How do we enhance EFL teachers' digital literacy based on the five TDL dimensions?

In recent years, research on digital literacy in the field of language education has focused on the theoretical construction of teacher literacy and related pedagogical practices (Wang et al., 2021). With the current limited research on EFL teachers' digital literacy enhancement, this research developed a 5-point Likert questionnaire based on this standard to assess the digital competence of EFL teachers in higher education for facing the digital transformation of foreign language education and to determine the relationships among the five aspects of the TDL standard. This is the significant contribution of this research.

Literature review

Digital literacy framework

International organizations and countries have been paying attention to teachers' digital quality and have proposed frameworks or standards for teachers' digital technology applications. For example, in 2011, UNESCO released the ICT Competency Framework for Teachers, which provides a comprehensive description of the competencies that teachers should have to use technology for effective teaching; in 2016, Austria released the Digital Literacy Framework for Teachers, which is used to guide the development and assessment of teachers' digital literacy; in 2017, the United States released the ISTE Standards for Educators, which, based on the teachers' role they are in, put forward a reasonable standard of technological competence; in 2017, the EU released the Digital Competence Framework for European Educators, which provides educators at all levels and in all types of schools with a framework that can comprehensively evaluate and develop their digital competence; in 2017, Spain released the General Digital Competence Framework for Teachers, which helps teachers acquire digital competence through self-appraisal and updating; in 2017, Norway released the Professional Digital Competence Framework for Teachers, which aims to promote the professional development and practice of teachers in the digital age; and in 2019, the United Kingdom released the Professional Framework for Digital Teaching to help teachers clarify how digital technologies can enhance teaching and learning.

In 2008, China's CPC Central Committee and the State Council issued the Opinions on Comprehensively Deepening the Reform of Teacher Team Construction in the New Era, which put forward the requirement that "teachers take the initiative to adapt to new technological changes such as artificial intelligence and actively and effectively carry out education and teaching"; in 2021, the General Office of the Ministry of Education issued the Notice on Carrying out the Second Batch of Pilot Recommendations and Selection of Artificial Intelligence-Promoting Teacher Team Construction, which put forward the requirement of "constructing the intelligent education system of teachers"; and in 2022, the Ministry of Education issued the "Teachers' Digital Literacy" industry standard, which pointed out the direction for the enhancement of the digital literacy of teachers in colleges and universities (Ministry of Education of the People's Republic of China, 2022).

Digital literacy

The definition of digital literacy has developed with the development of digital technology. Paul Gilster, in 1997, first proposed the concept of digital literacy; Paul defined it as "the ability to properly use and evaluate digital resources, tools, and services, and apply it to lifelong learning processes" (Gilster P., 1997). According to Eshet, digital literacy is the capacity to use software and digital technology, along with cognitive, sociological, motor, and emotional skills, to fulfill users' needs (Eshet, 2002). Other similar definitions have been proposed, such as internet literacy (Harrison, 2017), media literacy (Wulff, 2020), and multimodel literacy (Heydon, 2007). Digital literacy is the ability to access, analyze, and generate information using digital tools, requiring cognitive capacity (Pratolo & Solikhati, 2021). Consequently, digital literacy is a multidimensional concept based on the concepts of media, information, and network literacy and is an

indispensable "survival skill" for people in the digital age; of course, EFL teachers are no exception.

Digital literacy involves the awareness of and the ability to use technological tools (Bawden, 2008). Digital awareness covers digital cognition, digital willingness, and digital will. Digital willingness includes the willingness to explore and be open to updating to enable efficient technology in various contexts (Harris et al., 2009). EFL teachers' understanding of and attitudes toward digital technology can affect their digital teaching practices (Farjon et al., 2019).

In UNESCO's ICT Competency Framework for teachers, Application of Digital Skills has been listed as a crucial competency. As the most significant dimension in the TDL framework, digital application refers to the ability of teachers to apply digital resources to carry out educational and pedagogical activities, including digital teaching design (Fawns, 2019), digital pedagogical implementation (Väätäjä & Ruokamo, 2021), digital learning evaluation (Karademir et al., 2021) and digital collaborative education (Langset et al., 2018).

According to the TDL, Digital Social Responsibility denotes teachers' responsibilities regarding ethical conduct and behavior in digital activities, including the rule of law ethics and digital security and protection. Tomczyk's findings stressed that digital literacy is one of the most critical protective elements for teachers regarding digital safety in the classroom (Tomczyk, 2020). Lucas's findings revealed that teachers still lack sufficient knowledge and skills in digital technology-related areas, such as copyright issues, user licenses, and fake online news, indicating a low digital literacy and safety skill levels among teachers. Consequently, educational support is necessary for providing digital safety-related courses to develop solutions for the most vulnerable areas, especially for the legal consideration of emerging, high-risk online behaviors (Tomczyk, 2019).

In addition to fundamental digital skills, digital competence enhances professional development and teaching (Esteve-Mon et al., 2020). The concept of professional development in the TDL framework refers to the capacity of teachers to utilize digital technology resources for their professional development, covering digital learning, research and study, and digital pedagogical research and innovation. Digital literacy can be enhanced through professional development (Pianfetti, 2001). Conversely, professional development also plays a crucial role in enhancing digital applications.

Pradas-Esteban noted that EFL teachers lack knowledge about the use of some digital tools. Therefore, digital literacy training is important for overcoming the obstacles to improving EFL teachers' digital literacy (Pradas-Esteban, 2024). However, other scholars believe that although EFL teachers have some knowledge of using digital tools, their practical use of digital tools is insufficient (Adeniyi-Egbeola, et al., 2021). The situation is similar in China. Many EFL teachers suffer from a lack of digital literacy, largely due to limited access to new technologies, lack of time and lack of professional technology training. According to the results of studies by Hui Zhao and other scholars, electronic information teachers have significantly higher levels digital literacy than teachers of other major categories across all five dimensions of digital literacy, especially digital awareness and digital application, and these levels are significantly higher than teachers of general education and public administration and service majors. Further, teachers of transportation and finance and commerce majors have significantly higher levels

digital literacy than teachers of general education and public administration and service majors in the dimensions of digital technology knowledge and skills, and teachers of education and physical education majors have significantly higher levels digital literacy than teachers of general education majors in the dimension of digital application (Hui Z. et al., 2023). Since most EFL teachers are teach general education majors or basic public courses, EFL teachers' digital literacy needs to be improved.

Compared with other disciplines, foreign language teaching has a close internal relationship with digital technology. Information and technology methods can be used to deliver the pedagogical content and process of foreign language teaching. Therefore, the deep integration of information technology and foreign language teaching has a unique theory and logic (Jiasheng & Jianlin, 2013). In recent years, the research on digital literacy in language education has focused mainly on the theoretical construction of literacy enhancement among teachers and related teaching practices. Other research has investigated EFL teachers' attitudes or beliefs toward integrating digital literacy in EFL classrooms (Laksani et al., 2020; Alfia et al., 2020). There is also research on EFL teachers' digital literacy through the technological pedagogical content knowledge (TPACK) framework (Falloon, 2020). Empirical research on EFL teachers' digital literacy based on the existing digital literacy framework is scarce.

Theory, conceptual model and hypothesis development

The conceptual model of this study was constructed based on the technology acceptance model (TAM) and the theory of planned behavior (TPB). The TAM is predicated on the human behavior model of beliefs-attitudes and behavior that was expanded upon from Fishbein and Ajzen's theory of reasoned action (TRA) (Premkumar & Bhattacherjee, 2008). The TPB is used to explain and predict behaviors and posits that behavioral intentions directly determine behavior. Subjunctive norms, perceived behavioral control, and attitudes all play a role in determining behavioral intentions (Icek Ajzen, 1985). Both theories can be used to predict behavioral achievement.

Conceptual model and hypothesis development

This research integrates the technology acceptance model (TAM) and the theory of planned behavior (TPB). The reason for integrating these two models is that both are concerned with behavioral intention, and actual behavior is determined by behavioral intention. On the one hand, the TAM model focuses on the characteristics of the technology itself, i.e., the perceived usefulness. Behavioral intention is determined by the perceived usefulness of technology, and the actual use of technology is determined by behavioral intention. The acceptance of digital technology is key to constructing an EFL teachers' digital literacy enhancement model. On the other hand, the TPB states that subjective norms determine behavioral intentions and that behavioral intentions determine actual behavior. The integration of the two models is shown in Fig. 1, which inspired the construction of the following conceptual model.

Based on the integration of the two theories, the research model is constructed, as shown in Fig. 1.

The conceptual model is proposed based on the previous integration of two theories, as shown in Fig. 2.
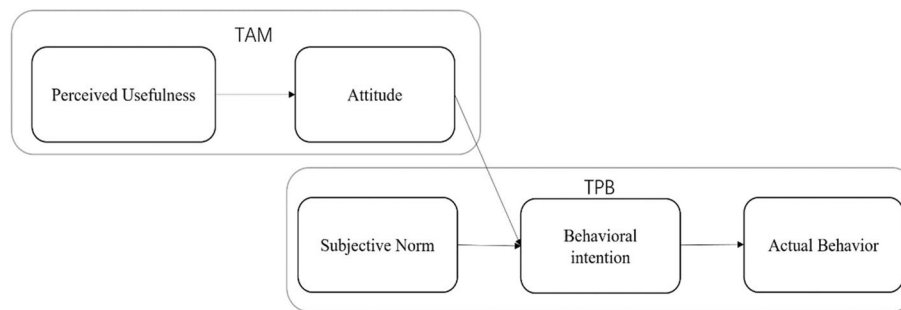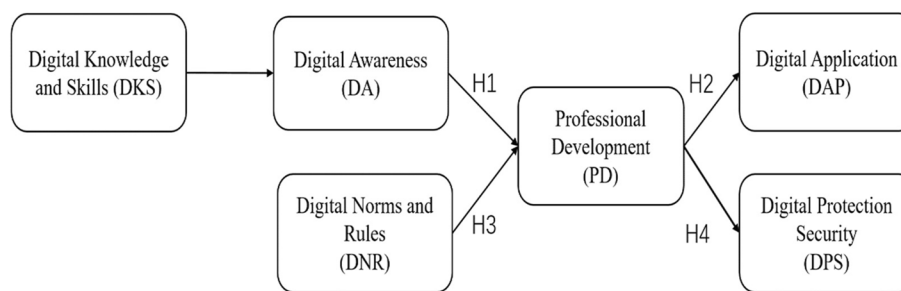
Fig. 1 The integration of two theories

Fig. 2 Conceptual model

The digital literacy framework consists of 5 Level 1, 13 Level 2, and 33 Level 3 dimensions. The primary dimensions include digital awareness, digital technology knowledge and skills, digital applications, digital social responsibility, and professional development. Each primary dimension comprises several secondary dimensions, and each secondary dimension covers several tertiary dimensions.

Hypothesis development

In the conceptual model of this study, one primary dimension, digital social responsibility, was divided into two secondary dimensions (digital norms and rules and digital protection security) to determine the predicted inner relationship between them. Digital awareness refers to the attitude toward the use of digital technology in education and pedagogy. Professional development refers to the intention to enhance digital literacy by using digital technology. Digital knowledge and skills refer to the perceived use of digital technology knowledge and skills. Digital application refers to the actual use of digital technology in EFL education and pedagogy. Consequently, according to the TAM theory, behavioral intention is determined by the perceived usefulness, and the actual use of technology is determined by behavioral intention. As a result, the actual digital application is determined by the intention to use digital technology. Therefore, the first two hypotheses are proposed as follows:

Hypothesis 1

Digital knowledge and skills have an indirect impact on professional development through digital awareness.

Hypothesis 2

Digital awareness has an indirect impact on digital application through professional development.

Digital norms and rules refer to the subjunctive norms that EFL teachers should obey when using digital technology; professional development refers to the intention to enhance digital literacy by using digital technology; and digital protection security refers to the actual behavior of digital and internet security. Therefore, Hypotheses 3 and 4 are developed as follows:

Hypothesis 3

Digital norms and rules have an indirect impact on digital protection security through professional development.

Hypothesis 4

Digital norms and rules have an indirect impact on digital application through professional development.

Methodology

Measurement instrument

In the questionnaire, all the questions in the three dimensions – digital awareness (DA), digital knowledge skills (DKS) and digital application (DAP) – are from the digital literacy standard without adaptation. The digital awareness dimension includes five questions on digital recognition, digital willingness, and digital will. The digital knowledge and skills dimension contains three questions concerning digital knowledge and digital skills. The digital application dimension has fourteen questions about digital pedagogy, digital teaching, digital academic evaluation and digital collaborative education – the actual behavior of digital application. In the professional development dimension, five questions were adapted to focus on the intention for digital learning and research. The last dimension, digital social responsibility, has been adapted into two specific dimensions—digital norms and rules (DNR) and digital safety protection (DSP). Digital norms and rules include three questions on the subjunctive norms in using digital technology in education, and digital safety protection contains three questions on the actual behavior of using digital technology for safety protection purposes (the online questionnaire can be found in the appendix).

This research employed a purposive sampling method through an online questionnaire via the Wen Juanxing Form. The questionnaire link was distributed via a WeChat app group. Data collection began on December 23rd, 2023, after 14 days of form filling. Thirty-three questions employing a 5-point Likert scale were adapted based on the teachers' digital literacy standards. The pilot test was administered to thirty EFL teachers. Then, a formal survey was conducted among 92 EFL teachers. After collecting the data, Smart PLS was employed to evaluate the eight hypotheses.

Table 1 Demographic profile

Demographic factor	Categories	Frequencies	Percentages
Sex	Male	11	12.0
	Female	81	88.0
Age	21-30	13	14.1
	31-40	37	40.2
	41-50	36	39.1
	51-60	5	5.5
	61or above	1	1.1
Professional Title	Assistant Lecturer	16	17.4
	Lecturer	35	38.1
	Associate Professor	36	39.1
	Professor	5	5.4
Years of teaching	Less than 3 years	12	13.1
	3-15	43	46.7
	15 or above	37	40.2
Years of using digital technology	Less than 1 year	2	2.2
	1-3 years	20	21.7
	3-5 years	21	22.8
	Over 5 years	49	53.3

Sample size

Table 1 shows the sample profile based on the basic information of this research. Female EFL teachers accounted for 88% of the sample population. Three schools were selected as the research schools, including two universities (one located in the southern part of China and the other located in the northern part of China) and one higher vocational college (located in the middle part of China). Among the 92 EFL teachers, 41 had a senior professional title, accounting for 44.5% of the sample, and young and middle-aged teachers accounted for 54.3% of the sample. More than half of the EFL teachers had used digital technology for more than 5 years, indicating that EFL teachers also proactively embrace digital technology.

PLS-SEM version 4.0 was employed to evaluate the measurement and structural model. Since the research sample size was small, PLS-SEM was implemented for theory development and prediction. Consequently, PLS-SEM has significant advantages over other methods. First, PLS has less demand for samples; it is unnecessary for the data to have a normal distribution (Hair et al., 2019; Henseler et al., 2009), and most importantly, PLS is particularly suitable for prediction.

Results and findings

Descriptive analysis results

Figure 3 below displays the mean values for the 33 items in the online survey. The data suggest that EFL teachers have high levels of digital awareness, willingness, and will, as indicated by the mean distribution of each item, which shows that all items have scores above 4.000. The average scores for knowledge and abilities related to digital technology are low; the mean score for DKS1, or digital technology knowledge, is 3.435. The digital technology scores (DS1 and DS2) are 3.457 and 3.435, respectively, which are less than 3.500, indicating that EFL teachers are not proficient in using digital technology. The
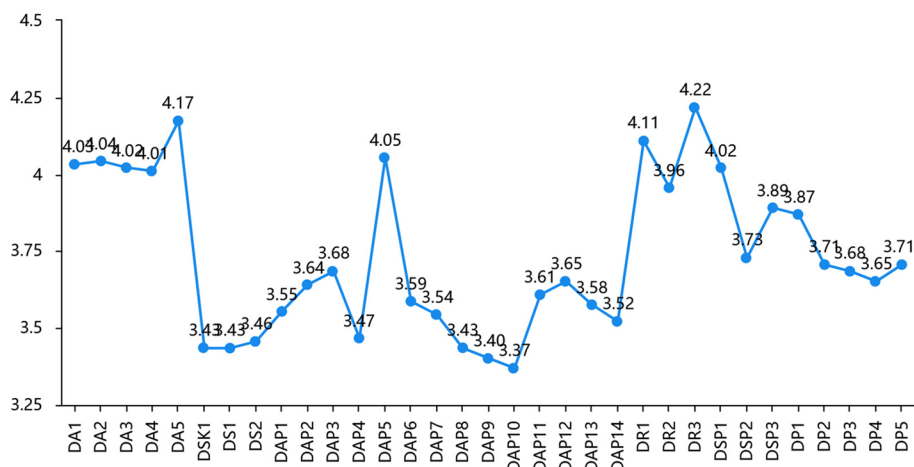
Fig. 3 Distribution of the mean values for each item of the digital literacy scale for EFL teachers

mean values of these 15 digital application items for EFL teachers were comparatively low, particularly the mean value of item DAP10, which requires EFL teachers to visually present the results of academic data analyses and use digital tools to interpret them rationally. This item had the lowest mean score of any of the items in the set (3.370). With a mean score of 4.054, the ability to use digital resources to support the management and organization of English language teaching activities (DAP5) was the item with the highest score. EFL language teachers were generally able to comply with the rule of law and ethics in digital activities and thus had higher mean scores on the DR questions, with the lowest score being 3.957. Accordingly, the digital security protection scores were high, revealing that current EFL teachers have basic data security protection and network security protection abilities. EFL teachers' professional development items scored higher than the digital application competence items, with the mean value of each item exceeding 3.500 and the highest score being 3.870 for the question on EFL teachers' use of digital resources to support continuous learning (DP1).

Partial least squares structural equation modeling results

The Cronbach's alpha of this study was greater than 0.7, indicating that the scale has good reliability. The loading indicators, composite reliability (CR), and average variance extracted (AVE) should be ≥0.5, ≥0.7, and ≥0.5, respectively (Hair et al., 2019). Table 2 shows that all factor loadings for the 33 factors exceeded 0.5; the AVE values of the six constructs were greater than 0.5, and the obtained AVE values ranged from 0.639 to 0.773; thus, the study scale had excellent convergent validity. Further, the CR values of the five constructs were greater than 0.5, with the smallest being 0.841 (DNR). Acceptable heterotrait-monotrait (HTMT) values, according to Henseler, Ringle, and Sarstedt (2015), should be less than 0.85 or 0.9. There were no values higher than 0.782 based on the results in Table 3, indicating that discriminant validity was established. This study's specification model has been shown in Fig 4.

The coefficient of determination (R^2) was used to assess the model's predictive precision. An R-squared value of approximately 0.670 is regarded as substantial, an R-squared value of approximately 0.333 is regarded as moderate, and an R-squared value of

Table 2 Measurement model

Construct	Items	Loadings	Composite Reliability	AVE	Cronbach's Alpha
Digital Awareness (DA)	DA1	0.822	0.925	0.721	0.899
	DA2	0.855			
	DA3	0.872			
	DA4	0.835			
	DA5	0.836			
Digital Application (DAP)	DAP1	0.818	0.963	0.652	0.958
	DAP2	0.667			
	DAP3	0.818			
	DAP4	0.870			
	DAP5	0.636			
	DAP6	0.802			
	DAP7	0.860			
	DAP8	0.863			
	DAP9	0.817			
	DAP10	0.802			
	DAP11	0.788			
	DAP12	0.826			
	DAP13	0.819			
	DAP14	0.881			
Professional Development (PD)	DP1	0.895	0.944	0.773	0.926
	DP2	0.883			
	DP3	0.870			
	DP4	0.881			
	DP5	0.865			
Digital Norms and Rules (DNR)	DR1	0.860	0.841	0.639	0.721
	DR2	0.739			
	DR3	0.796			
Digital Knowledge and Skills (DKS)	DS1	0.798	0.854	0.662	0.745
	DS2	0.796			
	DKS1	0.846			
Digital Security Protection(DSP)	DSP1	0.857	0.908	0.766	0.848
	DSP2	0.882			
	DSP3	0.886			

Table 3 Discriminant validity (HTMT)

	Discriminant Validity					
	DA	DAP	DNR	DKS	DSP	PD
DA						
DAP	0.649					
DNR	0.552	0.406				
DKS	0.717	0.782	0.319			
DSP	0.490	0.763	0.607	0.554		
PD	0.549	0.734	0.520	0.622	0.705	
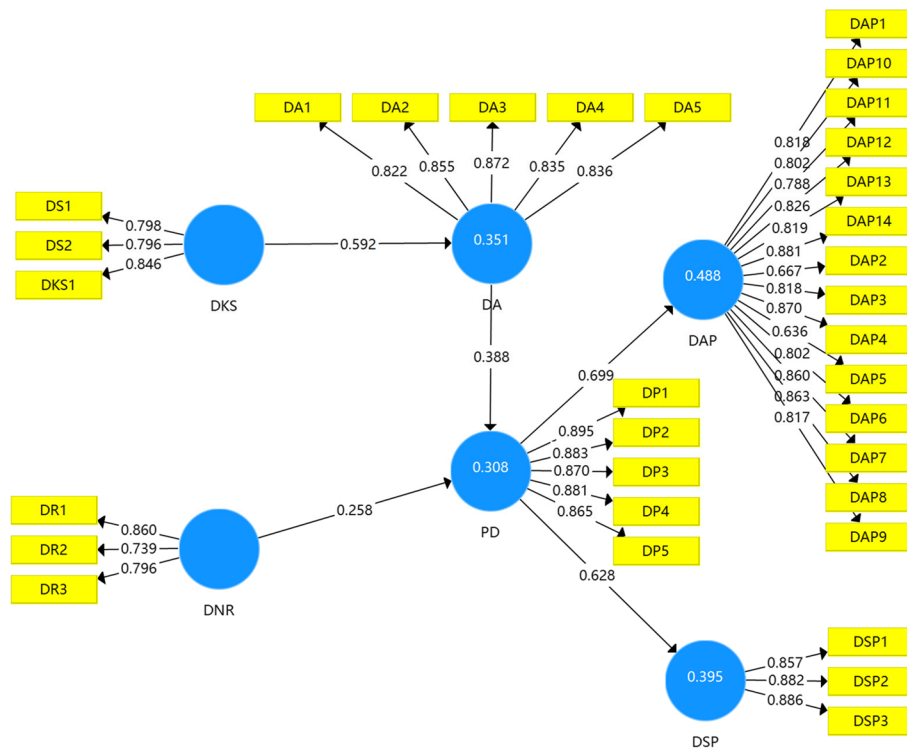
Fig. 4 EFL teachers' digital literacy enhancement model

Table 4 R-Square (R^2) values

	R^2
DA	0.351
DAP	0.488
DSP	0.395
PD	0.308

approximately 0.190 is regarded as weak (Chin, 1998). The R square values in Table 4 show a moderate predictive accuracy for digital awareness (DA), digital security protection (DSP) and digital application (DAP), and weak predictive accuracy for professional development (PD).

Cross-validated redundancy evaluation was carried out. The Q square was used to measure the predictive relevance of a block of manifest variables. The Q^2 values were categorized as small (0.000), moderate (0.250), or substantial (0.500), and the proposed threshold value was $Q^2 > 0$ (Hair et al., 2014). The values are shown in Table 5 and indicated that the predictive relevance of the model (Q^2) had a moderate value.

With 5000 basic bootstrapping iterations, the path coefficients of the study are shown in Table 6. The formulated hypothesis was analyzed based on this procedure. The standardized value of the path coefficient was between -1 (strong negative relationship) and +1 (strong positive relationship) (Hair Jr et al., 2014). A t-statistic > 1.96 indicates a strong positive relationship with the model. The values of (H1), (H2), (H3) and (H4) were

Table 5 Predictive relevance (Q^2)

	SSO	SSE	Q^2 (=1-SSE/SSO)
DA	460	348.875	0.242
DAP	1288	903.383	0.299
DNR	276	276	
DKS	276	276	
DSP	276	197.365	0.285
PD	460	353.840	0.231

Table 6 Path coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*P* Values
DA -> PD	0.388	0.389	0.113	3.431	0.001
DKS -> DA	0.592	0.600	0.064	9.249	0.000
DNR -> PD	0.258	0.267	0.103	2.497	0.013
PD -> DAP	0.699	0.705	0.060	11.672	0.000
PD-> DSP	0.628	0.631	0.081	7.759	0.000

Table 7 Effect size

	DA	DAP	DKS	DNR	DSP	PD
DA						0.173
DAP						
DKS	0.540					
DNR						0.076
DSP						
PD		0.955			0.652	

greater than 1.96, which means that the four hypotheses were supported. In summary, EFL teachers' digital awareness was strongly correlated with professional development and digital knowledge and skills, and digital norms and rules were strongly correlated with professional development. Professional development was significantly correlated with digital application and digital security protection. After the significance of the relationship was verified, the relevance of the significant relationship (f^2) was evaluated, with values of 0.020, 0.150, and 0.350 denoting small, medium, and large effects, respectively. Table 7 shows that digital knowledge and skills significantly impact digital awareness. Professional development significantly impacts digital application. Professional development significantly impacts digital security protection. Digital awareness impacts professional development on a medium scale, and digital norms and rules have a small impact on professional development.

Discussion

The results of this study confirmed the teachers' digital literacy standard, which consists of five dimensions. The internal relationships of the five dimensions were defined, which is a significant contribution of this study.

In TDL, digital awareness implies the dynamic reflection of objectively existing digitally relevant activities in the teacher's mind, involving digital cognition, willingness, and will. Digital cognition refers to emerging issues during education and pedagogy, including understanding the value of digital technology and the opportunities and challenges that digital technology brings to education and pedagogy. EFL teachers' attitudes toward applying digital technology resources in education and pedagogy includes the willingness to learn independently and use digital technology as well as the initiative to employ digital technology in educational digital practice, exploration, and innovation. Digital will indicate EFL teachers' confidence and determination in dealing with digital difficulties and challenges. According to the descriptive results, EFL teachers possessed strong digital awareness; however, such digital cognition and willingness did not transform into practical digital application or the acquisition of digital knowledge and skills. As a result, how to use digital technology to truly empower English language teaching and thus enhance the ability to apply digital teaching and learning is an urgent challenge for current EFL teachers.

The structural relationships that were found have several important implications. Similar to the ordinary least squares regression model proposed by Mota & Cilento, internet knowledge, skills, and attitudes predict internet use (Mota & Cilento, 2020). The model of this study also indicated that digital knowledge and skills, as well as digital attitudes (involved in digital awareness), predicted digital application. This result is consistent with Farjon et al.'s conclusion. Furthermore, a more specific relationship has been noted: digital knowledge and skills have the most vital relationship with digital awareness, digital knowledge and skills indirectly impact professional development through digital awareness, and professional development directly impacts digital application. Digital technology is evolving and developing rapidly; to achieve positive awareness and intension toward professional development, EFL teachers need to improve how they update their digital knowledge and master new digital skills.

According to the structural model, digital literacy includes two actual behaviors or abilities—digital security protection and digital application—both of which are directly impacted by professional development. Consequently, EFL teachers' digital literacy enhancement faces three significant transformations: changing from mastering knowledge and skills to enhancing digital application ability, shifting from mastering single or decentralized digital skills to developing integrated digital literacy, and transforming from achieving general knowledge and skills to mastering professional ability, which is useful for professional development. In our research, we found that EFL teachers needed more opportunities to access digital training programs to avoid a decrease in their digital awareness of new digital applications, which leads to a lag in the operation of digital applications. This finding follows Jiehui and Tiefu's conclusion that EFL teachers may lack confidence or try to avoid using digital tools due to a lack of relevant guidance and training and a diminished will to conquer the difficulties and challenges of digital

applications. Consequently, to enhance EFL teachers' knowledge and skills, sufficient training and practice will support EFL teachers' digital literacy enhancement.

In line with Farjon et al.'s findings (Farjon et al., 2019), digital awareness significantly impacts digital applications indirectly. In addition to EFL teachers' willingness to enhance digital literacy, the current digital climate is another crucial motivating factor for digital applications. In the digital age, digital literacy has become a critical professional competency for EFL teachers (Jiehui & Tiefu, 2023). Therefore, in future research, the digital environment should be considered. Among the digital application items, digital academic assessment, including selecting and using data collection tools and applying data analysis models for academic data analysis, visualization and interpretation, is the weakest aspect of EFL teachers' current application competencies, demonstrating the lack of EFL teachers' competencies in the application of digital technological resources for the assessment of students' academic performance. As Tomczyk claimed, digital safety has become a crucial component of digital literacy (Tomczyk, 2020). Digital safety can be achieved by digital security protection. Furthermore, obeying digital norms and rules is the key to digital security protection, which means that only if EFL teachers obey digital and internet norms and rules can they be able to protect their digital privacy, protect working data safety, and pay attention to internet safety. The influence of digital norms and rules on digital applications and digital safety protection via professional development is significant but needs to be stronger. Like digital application, digital safety protection is a digital literacy ability. Both digital norms and rules and digital safety protection belong to the digital social responsibility dimension. Furthermore, the inner relationship between them was specified in this study, and the results showed that digital rules and norms indirectly impact digital safety protection, which is an innovation of this study. Digital technology is a double edge sword: EFL teachers enjoy the convenience it brings but they must be careful of the potential threats or troubles that accompany it. For example, AI plagiarism instances are caused by using programs such as Chat GPT. Although anti-AI detectors have emerged, EFL teachers must enhance their digital literacy to guide their students to obey specific digital rules about the restrictions of using digital technology in academic work.

The influence of digital awareness on professional development is significant. In line with Pianfetti's study, professional development can improve digital literacy. Digital literacy can be considered a transformational agenda for teachers' professional development (Khalid et al., 2015). With respect to enhancing digital literacy by using digital technology in teaching and research, professional development refers to EFL teachers' intentions to promote their own professional development and that of the community by utilizing digital technology resources. University EFL teachers can form a community of teachers at several levels, thus effectively improving the relatively restricted professional development environment. Digital learning requires sharing and asking for help among colleagues; mutual assistance and learning will enhance the willingness for digital application, thus promoting professional development. Providing teachers with high-quality experiences and examples of digital professional learning and development is critical to enhancing their digital literacy (Xiaoying, 2023). Professional development is the key to future EFL transformation, especially for strengthening digital application in the long term.

Conclusion

This research introduces a new standard for evaluating current EFL teachers' digital literacy in China's higher education institutions. A structural model was proposed based on a quantitative questionnaire survey among 92 EFL teachers from higher educational institutions, and the internal relationships between the five dimensions of the TDL were specified. From this study, it can be concluded that this model can be applied in a broader educational context or in other countries. The internal relationships among the five dimensions of the digital literacy standard have been clarified. Therefore, the digital literacy model proposed in this study is universal in that it identifies effective ways to improve teachers' digital literacy. It is not limited to improving the digital literacy of only English teachers in China but can also be applied to various subject areas, cross-curricular areas or diverse educational fields in other countries. The specific limitations and implications are listed below.

Limitations

Research has shown high mean scores for digital awareness, willingness and will in digital literacy. The main potential reason is due to the support of policy or environmental factors, various digital technology teaching competitions and policies targeted at promoting digital literacy, which motivate teachers to enhance their digital literacy. Consequently, the major limitation of this research is the lack of consideration of the moderating effects and external factors. This research focuses on examining the internal relationships between the five dimensions of the teachers' digital literacy standard in order to provide implications for improving EFL teachers' digital literacy. However, other external factors should and must also be considered, e.g., sex, experience, background, organizational factors, environmental factors, and political factors. All these external factors can also influence the adoption and use of technology. Therefore, it is necessary in future research to test the relationship between these external factors and the adoption and use of digital technology. Another limitation is that due to the lack of diversity in the published research samples, more teachers should participate in research on improving digital literacy, including teachers from other disciplines, other regions and even cross-disciplinary areas, cross-border teachers, etc. In this study, the questionnaire employed may not have provided in-depth insights into teachers' motivations, emotions or experiences in promoting digital literacy and could not fully capture the effects of environmental and cultural factors on teachers' qualitative literacy. Qualitative research methods can be used to better explore these issues. By using qualitative research methods such as interviews and case studies, it is possible to gain a deeper and more detailed understanding of the current state of teachers' digital literacy and related past experiences, thus compensating for the limitations of questionnaires.

Implications

Although numerous studies have pointed out the need to improve EFL teachers' digital literacy, there is still a lack of concrete implementation measures, resulting in a research gap in improving EFL teachers' digital literacy. Based on the findings of previous research, two concrete recommendations are made in this study. The most effective way to improve EFL teachers' digital literacy is to provide them with targeted digital literacy

training that includes both theoretical knowledge and practical skills, as this will increase EFL teachers' readiness and confidence in digital technology. It is better to establish a virtual digital literacy research office to enhance communication between EFL teachers without space or time limitations. The existing digital platforms are suitable channels for practicing learned knowledge or skills. Moreover, awareness of digital social responsibility will promote long-term professional development. It is important for EFL teachers to realize that intelligent and personalized teaching will be the new development trend of foreign language teaching under the influence of digital technology so that they can consciously transition to their new roles as digital analysts, digital activity organizers and digital resource producers through long-term professional development and then gradually apply digital technology in the whole process of English teaching to transform digital achievement and ultimately improve digital literacy.

Abbreviations
EFL   English as a foreign language
TDL   Teachers' digital literacy

Declarations

Competing interests
The authors declare no conflicts of interest in relation to the conduct of this study.

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