Education Tech Research Dev (2023) 71:99–115
https://doi.org/10.1007/s11423-023-10205-4

RESEARCH ARTICLE

Effort expectancy mediate the relationship between instructors' digital competence and their work engagement: evidence from universities in China

Guoyuan Sang[1] · Kai Wang[1] · Shihua Li[2] · Jiao Xi[3] · Dong Yang[4]

Accepted: 22 January 2023 / Published online: 8 February 2023

Abstract
In a very short time, higher education transitioned to online and blended learning, in response to the global COVID-19 pandemic. Although research literature is replete with rationale for instructors to develop digital competence during the Great Online Transition, research on the correlates of digital competence and effort expectancy in relation to their work engagement has remained insufficient. Thus, the objective of this study is to investigate the effects of digital competence and effort expectancy and how they predict teachers' work engagement. A sample of 321 in-service teachers selected from universities in China took part in this study. The results of structural equation modeling indicated that teachers' digital competence positively and significantly correlated with their work engagement and their effort expectancy. In addition, effort expectancy significantly influenced teachers' work engagement. Lastly, effort expectancy, as the mediator variable, was found to mediate the relationship between teachers' digital competence and their work engagement. Implications were suggested for improving teachers' work engagement to support digital shifts.

Keywords Digital competence · Effort expectancy · Work engagement · Higher education

Introduction

The Covid-19 pandemic accelerates the radical transformational change of technology application and digitalization in global higher education (Krishnamurthy, 2020). The rapid change reflected in pedagogy is shown by the channel of instruction shift from traditional to online settings, and from personal to virtual context (Mishra et al., 2020). Given this era of transformation, digital competence occupies a prominent place in the current educational

✉ Kai Wang
wangkai.edu@outlook.com

1 Center for Teacher Education Research, Beijing Normal University, Beijing, China

2 School of Foreign Languages, Xidian University, Xi'an, China

3 School of Foreign Languages, Beijing Forestry University, Beijing, China

4 Smart Learning Institute, Beijing Normal University, Beijing, China

activity (Basilotta-Gómez-Pablos et al., 2022). Teachers play a crucial role in integrating various resources with digital media and technological devices to adapt the urgent transformation process from offline to online instructional activity (Trust & Whalen, 2020). Consequently, many university teachers are not only expected to develop their effective digital competencies to achieve the desired goal of education, but they are also asked to reflect on and redesign their teaching subject in the context of digital transformation. With regard to this aspect, Cabero-Almenara et al., (2020) underlined the digital competence in future is about to take on one of the front burners in teachers' professional development. On the other hand, the study by Damşa et al., (2021) indicated that teachers experienced many hurdles, such as the development of remote teaching methods and the need to re-design online teaching activities. In doing so, many teachers replicated face-to-face teaching online during the pandemic time, thus it wasted the additional possibility of other types of resources to work with and virtual activities to adopt (Usher et al., 2021; Portillo et al., 2020) proposed that teachers perceive a greater workload because of the lack of training in digital skills during the lockdown. Pedagogical continuity is only possible if teaching is taught in new and innovative ways using a variety of digital tools and resources.

Through reviewing the literature, we find that analyzing their self-evaluation and introspection when teachers are implementing their competencies of digital use, is taking a predominant role, and questionnaires or surveys are the dominant data collection method (Basilotta-Gómez-Pablos et al., 2022; Zhao et al., 2021). Although, in this digital age, digital competence as an important skill has been emphasized, the correlated relation between digital competence and work engagement of digital technology for instructional activities have not been empirically explored in higher education. Previous studies clarified the influence of teachers' digital competence on their operational practice of integrating ICT and using digital technologies in pedagogical activities (Blau & Shamir-Inbal, 2017; Hatlevik, 2017). High competence in digital literacy reduces the cognitive burden of the act of online learning because the interfaces, terminology, options, and norms are familiar to the individual who are using the new tools (Mohammadyari & Singh, 2015). Other studies explained that one's perception of effort expectancy can be positively related to one's digital competence (Meyers et al., 2013; Ungerer, 2016; He & Li, 2019). In university contexts, the adoption of technology system would be cognitive burden free, which leads to higher job engagement among academic staff (Abd Latib et al., 2014).

Over the past three years, the COVID pandemic has catalyzed a quick transition to and massive adoption of digital teaching and learning. However, it takes some time for teachers to adapt to the changes and redefine their identity and role (Philipsen et al., 2019). When universities have returned to face-to-face teaching, education would not be the same as it was before the pandemic and practices adopted during the GOT have been well integrated into teaching. Like their peers around the world, Chinese teachers also have to deal with the impact of the GOT and continue the old face-to-face teaching while embracing new practices and considering how to integrate them into current and future teaching. Therefore, this study aims to capture Chinese teachers' practices at the time of this great transition and investigate how teachers' digital competence and effort expectancy are related to one another and their work engagement.

Literature review

Teacher digital competence

Digital competence as a concept can be defined as abilities in the set to apply technology to enhance the effectiveness of our daily lives (Ferrari & Punie, 2013), illustrated as "the confident, critical and responsible use of the technologies from the society of information for work, entertainment and education" (European Commission, 2018, p. 9). Digital competence as one of the core competencies are required to master by citizens and teachers in particular in the contemporary society (Cabero et al., 2020).

Although the term teacher digital competence (TDC) holds varied definitions, there are coincidences in general aspects which underline the necessity of teachers to achieve a didactic and technological understanding of digital technologies that benefit teachers to make use of them in their professional practice (Basilotta-Gómez-Pablos et al., 2022). This broader concept of digital competence includes not only the skills of using technological devices and supplicating digital resources in an instructional activity, but also focuses on varied pedagogical dimensions in practice, such as attitude, strategies, and awareness which allow teachers to achieve teaching and learning goals by technology effectively (Cattaneo et al., 2022mäläinen et al., 2021; Reisoğlu & Çebi, 2020).

To demonstrate the multiple facets of teachers' digital competencies, there are some frameworks that have been designed (Zhao et al., 2021). Among these, the framework of "General Technology Competency and Use" (GTCU) has been selected by Blayone et al., (2017) to conceptualize and evaluate university teachers' competencies of using digital technologies. In the GTCU framework, digital competence is identified in three dimensions: epistemological, informational, and social. Additionally, six areas of competency are articulated in "European Framework for Digital Competence of Teachers: DigCompEdu", which are required for teachers to enhance their learning strategies to be effective, inclusive, and innovative through digital tools (Caena & Redecker, 2019; Lu et al., 2021). Typical developed digital competence of educators is detailed in DigCompEdu including 22 competencies in the matrix of six levels and six areas. The 22 competence, level descriptors, and proficiency statements are explicated one by one, providing detailed guidance to educators to locate their competency level and their further developmental needs. The framework aims to detail how digital technologies are adopted to promote and innovate educators' training and development.

Effort expectancy

Effort expectancy (EE) is defined as the degree to which an individual believes that using the system would be free of effort (Venkatesh et al., 2003). Eccles and colleagues (Eccles & Wigfield, 1995; Wigfield et al., 2009) proposed the contemporary expectancy-value theory (EVT), which attempts to show individuals' behavior of choice making, persistence, hardworking, and acting in academic context originally. About the EVT, it assumes that people's behaviors are the reactions to the self-evaluated beliefs about their personal competence and the value of the task.

In the context of this study, effort expectancy (EE) is defined as the degree of ease related to university instructors' adaptation to emergency remote teaching (ERT). EE relates to the TAM model in the perceived ease of use construct and in TAM, ERT

is that the easier to be perceived is more intended to use it (Saade & Bahli, 2005). An individual's behaviour is likely to be impacted by expectancies and values (e.g., effort and engagement) (Putwain et al., 2019). EE is the key factor to implicate technology-enhanced learning successfully. Shodipe & Ohanu (2021) found that the perceived ease of use of electrical/electronic technology to teachers shows a positive correlation to teachers' use of mobile learning in actuality. In terms of the effect of EE on work engagement, prior research (Statnickė et al., 2019), found that EE was a significant predictive factor of work engagement of mobile learning.

Work engagement

Work engagement is about the relationship between an employee with his work, and it is described as a mental state of a positive, fulfilling, work-related mind (Schaufeli, 2017). Work engagement portrays an individual's volition who is more likely to be an absorbed and resilient person during tasks, who is difficult to distract and can be able to focus their mind on the task at hand.

In the present day, vigor, dedication and absorption are the general and highly recognized conceptualizations of work engagement. Vigor (VI) means the high levels of energy and resilience of mental functions in work, not being easily fatigued, even facing difficult tasks. Dedication (DE) connects with the deep involvement in one's task and the undergoing feeling of importance, inspiration, passionate, pride, and challenging. Absorption (AB) is conceptualized as the concentration and positive feeling of highly focus on one's task, whereby the time passing is quick and it is not easy to detach oneself from his task in hand (Schaufeli et al., 2006). These concepts have been analyzed by many studies from multiple areas, as well among teachers (Van der Berg et al., 2013; Moreira-Fontán et al., 2019). Vigor is linked to the cognitive dimension, and dedication is an emotional component, while in terms of physical participation and involvement, absorption means spending a long time in an activity of working (Rayton & Yalabik, 2014). For educational employees, the cognitive dimension is about their teaching interest and dedication. Their emotional achievement and enthusiasm to work relate to the degree of their teaching enjoyment (Kirkpatrich, 2007) and their closeness with students (c). The way how teachers are involved in the educational practice of teaching and preparation is related to the behavioural dimension, in which teachers' effort is evaluated by the time of work etc. Among the conditions or the impetus of work engagement, personal resource is indicated by Schaufeli (2017) and Van Wingerden et al., (2017). Resources of individuals include the self-evaluation in a positive way which contains the sense of capacity to influence and control the situation of tasks.

Relationships among variables and research hypotheses

The constant change and rapid development of current digital technology underline the necessity to explore the influence of individuals' digital competence on online learning or blended learning to complete a work task. The expectancy in one's perception of technology may correlated with his/her digital competence positively (Meyers et al., 2013; Ungerer, 2016; He & Li, 2019; Hatlevik, 2017; From, 2017) illustrate that digital competence is an aspect that can explain variations in teachers' pedagogical use of digital technologies and that high levels of digital competence can contribute to a more critical and frequent use of digital technologies. Digital literacy has been found to lower stress

levels and reduce individuals' inclination to regard their achievements disparagingly (Eastin & LaRose, 2000), which should make them more confident about their expected performance. In the context of the UTAUT2 model, prior research by Mohammadyari & Singh (2015)has indicated that digital literacy is positively related to effort expectancy.

Moreover, individuals with a high level of digital competence have the capacity to minimize the distraction caused by digital tools during their work (Hargittai, 2010), which will enhance their performance and will make them accessible and evaluate the systems easier, and will be helpful to tailor it to achieve their learning requirements and priorities. On the one hand, some studies (e.g., He & Li 2019; Mohammadyari & Singh, 2015; Nikou & Aavakare, 2021) have suggested that individuals with high levels of digital competence may expect to put in less effort while using digital technology for teaching and learning activities. On the other hand, some other studies (e.g., Statnickė et al., 2019; Shodipe & Ohanu, 2021; Abd Latib et al., 2014) have shown that there is a relationship between work engagement and digital competence as well as effort expectancy.

Drawing on previous studies, the following hypotheses are put forward:

Hypothesis 1 There is a positive and significant relationship between teachers' digital competence and their work engagement.

Hypothesis 2 There is a positive and significant relationship between effort expectancy and teachers' work engagement.

Hypothesis 3 There is a positive and significant relationship between teachers' digital competence and their effort expectancy.

Hypothesis 4 Effort expectancy plays a mediating role in the relationships between teachers' digital competence and their work engagement.

A hypothetical model for this study is illustrated in Fig. 1.

Methods

Sample and data collection

The target participants were university teachers in China. After the initial sudden closure of the institutions in the spring semester of 2020, universities in China adopted remote

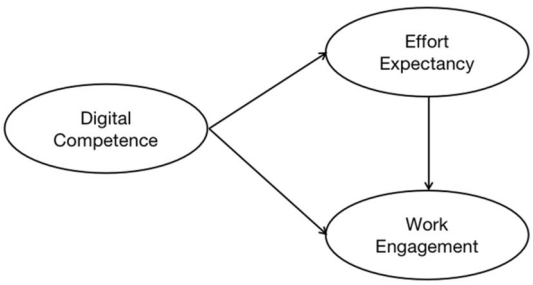

Fig. 1 The hypothesized research model

teaching. As the first wave of the COVID began to wane, starting from the fall semester of 2020 up until the spring semester of 2022, universities gradually reopened their campuses and returned to face-to-face teaching. Remote teaching was used temporarily when there was an outbreak of many positive cases in an area. A total of 427 teachers working at different higher educational institutions across China completed an online survey. These participants were recruited via the Internet using the convenience sampling and snowball sampling methods. A link of the online survey was distributed through personal social media accounts from the end of June to mid July 2022. An online consent form was sent with the questionnaire detailing the purpose of the research. As indicated in the consent form, to ensure the anonymity of data collected, no employment-related personal data would be collected (e.g., respondent's institution). Preliminary data screening was conducted to eliminate invalid responses (e.g., straightlining responses, too-fast responses, inaccurate data entry). This process resulted in the removal of 94 cases. Prior to statistical analysis, variables were checked for outliers and normal distribution properties. Univariable outliers were screened using standardized scores and an absolute value greater than 3.29 was considered as a potential outlier (Tabachnick & Fidell, 2014). This process identified 10 cases. Multivariate outliers were checked using casewise diagnostics and a case with an absolute standardized residual value larger than 3 was considered as potential outlier (Muijs, 2011). Two cases were identified. All 12 cases were removed and the remaining 321 cases were used for the subsequent analyses. The characteristics of the final sample ($N = 321$) are presented in Table 1.

Measures

The online questionnaire included two parts. The first part collected background information about the respondent including age, gender, the field of subject taught, and prior ICT training experience. The second part included 47 items that measured three aspects related to online

Table 1 Characteristics of the sample ($N = 321$)

Profile	Category	Frequency	Percentage (%)
Gender	Male	122	38
	Female	199	62
Age	≤ 35	98	30.5
	36–45	161	50.2
	≥ 46	62	19.3
Level of degree	PhD	178	55.5
	Master	125	38.9
	Undergraduate	18	5.6
Field of subject taught	Education	111	34.6
	Literature	29	9.0
	Science	68	21.2
	Management	27	8.4
	Other	86	26.8
Prior ICT training experience	No	92	28.7
	Yes	229	71.3

teaching: digital competence, effort expectancy and work engagement (see Appendix A). These measures were adapted from previous studies (Schaufeli et al., 2006; Venkatesh et al., 2012).

Digital competence

The European framework for the digital competence of educators (DigComEdu) proposed by Redecker and Punie (2017) was used to develop measures of teachers' digital competence. The DigComEdu framework consists of three dimensions that point to the essential knowledge and skills needed for online instruction: professional competences, pedagogical competences and learners' competences.

Professional competences were measured by one subscale: professional engagement (PE) with four items. Pedagogical competences included two subscales: digital resources (DR), empowering learners (EL). Each subscale had three items. Learners' competences were measured by one subscale: facilitating learners' digital competence (FLDC) with five items. All items were scored on a five-point Likert scale with 1 indicating strongly disagree and 5 indicating strongly agree.

Effort expectancy

Effort expectancy was measured using four items. These items were based on the study of Venkatesh et al. (2012). All items were scored on a five-point Likert scale with 1 indicating strongly disagree and 5 indicating strongly agree.

Work engagement

A short version of the Utrecht work engagement scale (Schaufeli et al., 2006) was used to measure teachers' work engagement. This scale measures three aspects of work engagement including vigor, dedication and absorption. Each of them had three items. All items were scored on a five-point Likert scale with 1 indicating strongly disagree and 5 indicating strongly agree.

Analysis procedure

Descriptive statistics were calculated using SPSS 25.0. Confirmatory factor analysis (CFA) and second order CFAs were conducted to examine the validity of the proposed model. Second order CFAs were conducted to check the measurement of the theorized structures of digital competence and work engagement. Then, a latent variable path analysis was conducted to test the hypotheses using the maximum likelihood estimation in AMOS 21.0. All statistical tests were evaluated at the $p < .05$ significance level and constituted two-tailed tests.

Results

Descriptive statistics and correlations

The means and standard deviations and correlations of the measures are presented in Table 2. As shown, skewness and kurtosis values fell between −1 and +1, indicating the data was roughly normal (George & Mallery, 2001). The variables had positive correlations with each other significant at 0.01 level.

Evaluation of the measurement model

The reliability and validity of the constructs in the proposed model were checked. Results are presented in T able 4. Construct reliability was assessed using composite reliability (CR). A CR value of 0.60 or more indicates good reliability (Hair et al., 2014). As shown in Table 4, all CRs were above 0.90; the internal consistency of all constructs as measured by Cronbach's alpha coefficients were greater than the cutoff value of 0.70 (Fornell & Larcker, 1981). Convergent validity of the constructs within the measurement model was assessed using CFAs and average variance extracted (AVE). Second-order CFAs were performed for digital competence and work engagement following the procedure suggested by Byrne (2009).

The CFA results for effort expectancy revealed a good model fit ($\chi^2 = 2.33$, $\chi^2/df = 1.16$, GFI = 0.996, CFI = 0.999, RMSEA = 0.023, SRMR = 0.013). Results of two separate second-order CFAs for digital competence ($\chi^2 = 139.84$, $\chi^2/df = 1.73$, GFI = 0.946, CFI = 0.980, RMSEA = 0.048, SRMR = 0.032.) and work engagement ($\chi^2 = 23.37$, $\chi^2/$

Table 2 Descriptive statistics and correlations between the measured variables

Variable	1	2	3	4	5	6	7	8	9	10
1. PE	1									
2. DR	0.73**	1								
3. EL	0.73**	0.70**	1							
4. FLDC	0.77**	0.72**	0.77**	1						
5. Vig	0.69**	0.59**	0.61**	0.68**	1					
6. Ded	0.54**	0.49**	0.43**	0.44**	0.45**	1				
7. Abs	0.67**	0.55**	0.61**	0.64**	0.79**	0.54**	1			
8. DC	0.90**	0.88**	0.90**	0.86**	0.72**	0.53**	0.69**	1		
9. EE	0.67**	0.56**	0.63**	0.67**	0.68**	0.40**	0.63**	0.71**	1	
10. WE	0.74**	0.64**	0.65**	0.70**	0.89**	0.76**	0.92**	0.76**	0.67**	1
Mean	3.98	3.98	3.71	3.74	3.48	4.18	3.67	3.86	3.65	3.78
SD	0.62	0.69	0.81	0.70	0.75	0.64	0.72	0.63	0.72	0.60
Skewness	− 0.28	− 0.22	− 0.23	− 0.15	− 0.15	− 0.36	− 0.10	− 0.11	− 0.07	− 0.01
Kurtosis	− 0.38	− 0.71	− 0.15	− 0.25	0.13	− 0.69	− 0.14	− 0.48	− 0.07	− 0.47

The numbers in diagonal brackets are the coefficients α; $N = 321$

PE professional engagement, *DR* digital resources, *EL* empowering learners, *FLDC* facilitating learners' digital competence, *Vig* Vigor, *Ded* Dedication, *Ab* Absorption, *DC* digital competence, *EE* effort expectancy, *WE* work engagement

**$p < .01$.

df = 1.38, GFI = 0.985, CFI = 0.995, RMSEA = 0.034, SRMR = 0.028) also demonstrated adequate model fits.

As shown in Table 3, the standardized estimates of factor loading values of all constructs ranged from 0.44 to 0.90, above the recommended value of 0.30 (Hair et al., 2014).

Table 3 Results for the measurement model

Construct	Item	Factor loading	Cronbach's alpha	CR	AVE
Digital competence			0.94	1.00	0.89
Professional engagement		0.96	0.76	0.93	0.47
	PE1	0.47			
	PE2	0.69			
	PE3	0.81			
	PE4	0.73			
Digital resources		0.94	0.71	0.94	0.47
	DR1	0.55			
	DR2	0.80			
	DR3	0.68			
Empowering learners		0.91	0.90	0.99	0.75
	EL1	0.81			
	EL2	0.90			
	EL3	0.88			
Facilitating learners' digital competence		0.96	0.85	0.95	0.53
	FLDC1	0.70			
	FLDC2	0.76			
	FLDC3	0.70			
	FLDC4	0.62			
	FLCD5	0.85			
Effort expectancy			0.85	0.95	0.60
	EE1	0.65			
	EE2	0.88			
	EE3	0.84			
	EE4	0.74			
Work engagement			0.87	0.98	0.69
Vigor		0.89	0.74	0.96	0.50
	Vig1	0.75			
	Vig2	0.82			
	Vig3	0.53			
Dedication		0.67	0.83	0.95	0.55
	Ded1	0.67			
	Ded2	0.91			
	Ded3	0.60			
Absorption		0.90	0.71	0.97	0.64
	Abs1	0.86			
	Abs2	0.71			
	Abs3	0.44			

Table 4 Discriminant validity

	1	2	3
1. Digital competence	(0.94)		
2. Effort expectancy	0.71**	(0.78)	
3. Work engagement	0.76**	0.67**	(0.83)

**$p < 0.01$

The numbers in parentheses on the diagonal are the square root of AVE

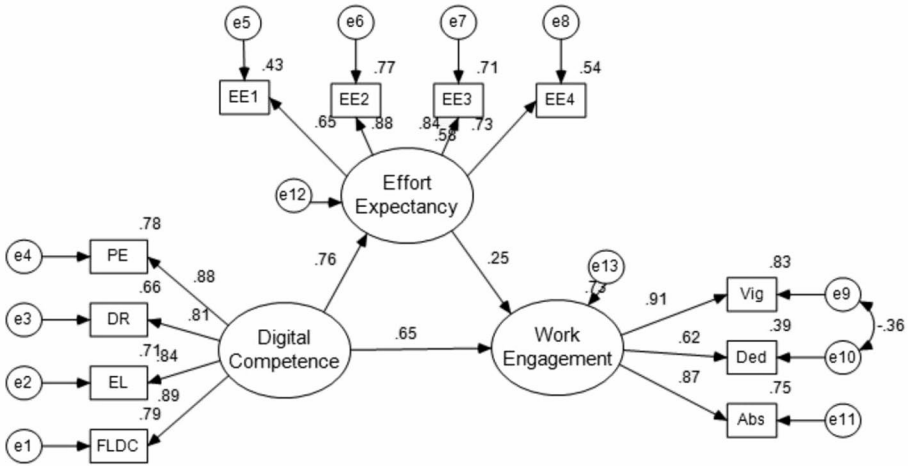

Fig. 2 Results for the Structural model

Except for two constructs (professional engagement and digital resources), the AVEs of all other constructs were above the recommended value of 0.50 (Hair et al., 2014), indicating an acceptable convergent validity. For the two constructs with relatively low AVEs, Fornell and Larcker (1981) suggest that the AVE may be a more conservative

measure and the convergent validity of a construct can still be established based on solely on CR. Given that both CRs exceeded 0.90, the convergent validity of the two constructs is deemed adequate. In sum, the items in the proposed measurement model demonstrated acceptable reliability and validity.

Results of the check for discriminant validity are presented in Table 4. The square roots of AVE were greater than the correlation between each construct and all others, indicating good discriminant validity.

Testing the structural model and hypotheses

The structural model demonstrated an acceptable model fit with $\chi^2 = 116.19$, χ^2 /df = 2.91, GFI = 0.937, CFI = 0.970, RMSEA = 0.077, SRMR = 0.046. As seen in Fig. 2, there was a positive and significant relationship between teachers' digital competence and their work engagement ($\beta = 0.25$, $p = .0001$).

The structural coefficients of the model are presented in Fig. 2. The path between digital competence and work engagement was significant statistically, $\beta = 0.63$, $p < .001$. Therefore,

the first research hypothesis (H1) was accepted. The path between effort expectancy and work engagement was also significant statistically, $\beta = 0.26$, $p < .001$, supporting the second research hypothesis (H2). The direct path between digital competence and effort expectancy was also significant statistically, $\beta = 0.76$, $p < .001$, suggesting that teachers with more developed digital competencies seemed to put in less effort while using digital technology for teaching and learning activities.

The bootstrap resampling method was used to test the mediation effect of effort expectancy on the relationship between digital competence and work engagement. Following the procedure proposed by Zhao et al., (2010), we performed 5000 bootstrap resamples with 95% confidence interval (CI) in Amos 21.0. The results showed that teachers' digital competence had a significant indirect effect on their work engagement, $\beta = 0.19$, $p = .005$, 95% CI [0.067, 0.312]. Overall, the results suggest that teachers' digital competence has direct and indirect effects on their work engagement. All hypotheses of this study were supported (see Table 5).

Discussion and conclusion

Due to the global COVID-19 pandemic, many higher education institutions have had to take classes online, leading to a series of huge challenges that need to be addressed properly (Toquero, 2020). Given the external challenges that teachers may encounter when integrating digital competence in their professional work, it was important for us to recognize the relationship between instructors' digital competencies and their work engagement by considering the mediating role of effort expectancy, so as to provide insights into the future of teaching and learning.

Our findings confirmed the first hypothesis, as teachers' digital competence has a positive and significant effect on their work engagement. The results of the survey mostly represent the teachers' beliefs about their competence instead of their actual level of competence. Thus, the investigation of digital competence through the DigCompEdu self-assessment tool is closely associated with the construct of perceived self-efficacy with regard to the use of technology in education. In this regard, the results of this study are consistent with previous studies, which indicate that self-efficacy is a significant personal resource associated with higher work engagement (Nielsen et al., 2017; Ventura et al., 2015; Moreira-Fontán et al., 2019) indicated that teachers who regarded themselves as more digitally self-efficacious engaged in their work more autonomously. This result reveals the significance of technology-related self-efficacy in the context of techno-work engagement.

Table 5 Structural equation modeling: hypotheses testing

Hypothesis	Path	Standardized Path coefficient	Conclusion
H1	Digital competence→Work engagement	0.65	Supported
H2	Effort expectancy→Work engagement	0.25	Supported
H3	Digital competence→Effort expectancy	0.76	Supported
H4	Digital competence→Effort expectancy→Work engagement	0.19	Supported

The results indicated that there was a significant relationship between effort expectancy and work engagement, which supported the second research hypothesis. This finding is consistent with many prior studies (Statnickė et al., 2019; Abd Latib et al., 2014; Shodipe & Ohanu, 2021), among which some directly explored the relationship between effort expectancy and work engagement. For instance, Abd Latib et al., (2014) found that higher perceived ease of use of using Facebook result in higher work engagement among the academic staff. Moreover, Mäkiniemi (2022) indicated that teachers seem to experience techno-work engagement when technology facilitates their work, for example, helped them achieve the main goals.In contrast, Hultell & Gustavsson (2011) identified that requiring the use of unfamiliar methods and instruments are negatively associated with work engagement.

In line with the third hypothesis, digital competence significantly predicted effort expectancy. This was a predictable finding during the Great Online Transition (GOT), due to the tremendous growth in the use of digital technologies in teaching of higher education institutions. This result is similar to the study done by Nikou & Aavakare (2021), who found that a higher level of digital competence would have a direct effect on effort expectancy regarding the use of digital technology for teaching and learning purposes. The survey results also in line with the results of prior studies (e.g., Mohammadyari & Singh 2015). This suggests that individuals with a high level of digital competence are familiar with the access options and norms of new technology, and individuals' level of comfort with new digital technology strongly affects the cognitive burden they encounter when utilizing a new technology.

As hypothesized 4, effort expectations mediated the relationship between teachers' digital competence and their engagement in the digital environment. And because effort expectancy was revealed to be an important mediator, the ease associated with university teachers' use of technology tools to design teaching and accomplish instructional goals should be considered significant in promoting teachers' engagement in their work. Therefore, administrators and researchers should be aware of the positive aspects of top-down technology use strategies and acknowledge the effort that teachers may make in the adoption process. Furthermore, Reisoğlu & Çebi (2020) argue that training in integrated digital competencies should provide teachers with knowledge and practice in professional engagement, digital resources, teaching and learning.

Overall, digital competence has both direct and indirect effect on work engagement and it exhibits a higher total effect than effort expectancy. These results imply that digital competence is a more important motivator for an instructor's work engagement than effort expectancy. In this study, effort expectancy was measured as teachers' perceived ease of use the ICT. In fact, many packaged online learning systems are making it much easier to operate an online learning system in than ever before. However, when it comes to online teaching, the crux of the problem does not lie in ICTs per se but rather lies in the ability to integrate ICTs into instruction.That is, digital competence is needed to conduct online teaching successfully. Therefore, the development of online learning during the GOT should not tenaciously chase after fashionable technological innovations. Instead, online learning developers and education practitioners should strive to educate digitally competent teachers. For this to be possible, support should be provided to help teachers overcome barriers and adjust to their new professional identity (Philipsen et al., 2019). On the one hand, educational institutions need to redefine teacher education and decide on what competences should be included in the curricula to ensure that teachers are prepared for current and future work engagement. On the other hand, teachers should be provided with the educational technologies (e.g., resource centres, digitalised rooms for teaching, etc.) to

make up for the shortcomings of their digital environment and thus ensure their optimal professional development of the digital competence that they can cope with the challenges of work and the professional world in a post-GOT age. Our results contribute to studies on online learning and emergency remote teaching, especially during the COVID-19.

Limitations and suggestions for future research

The first limitation of the study was that the discriminant validity with several factors in the first order is not a unidimensional construct. It is possible that the Chinese government attaches great importance to online teaching due to the global COVID-19 epidemic. In this case, online teaching-learning in higher education is not only starting early, but also moving fast with a high penetration rate. As a result, most of the respondents to the questionnaires have the similar options about the digital competence. Thus, following research is needed to consider intervention when examining the effects among these variables. The second limitation was that only two predictors were incorporated in the present model: digital competence and effort expectancy. Therefore, future studies need to consider other factors such as teaching autonomy and school support. Third, all members of the research group were from the department of education of a normal university, with the exception of one member. Questionnaire respondents were recruited using a convenience sampling and snowball sampling methods. Consequently, there was an over representation of respondents in the field of education. Fourth, certain job-related variables on work engagement of staff at the University (e.g., institutional level) could not be controlled for and so could have influenced their responses.

Appendix A

Factors
Digital competence
Professional engagement (PEn)
1. I systematically use different digital channels to enhance communication with students, parents and colleagues.
2.I use digital technologies to work together with colleagues inside and outside my educational organization.
3.I actively develop my digital teaching skills.
4.I participate in online training opportunities.
Digital resources (DR)
1. I use different internet sites and search strategies to find and select a range of different digital resources.
2. I create my own digital resources and modify existing ones to adapt them to my needs.
3. I effectively protect sensitive content, e.g. exams, students' grades, personal data.
Empowering learners (EL)
1. When I create digital assignments for students I consider and address potential digital problems.
2. I use digital technologies to offer students personalized learning opportunities.
3. I use digital technologies for students to actively participate in class.
Facilitating learners' digital competence (FLDC)
1. I teach students how to assess the reliability of information and to identify misinformation and bias.

Factors
2. I set up assignments which require students to use digital means to communicate and collaborate with each other or with an outside audience.
3.I set up assignments which require students to create digital content.
4. I teach students how to behave safely and responsibly online.
5. I encourage students to use digital technologies creatively to solve concrete problems.
Effort expectancy (EE)
1. My interaction with the online educational platforms would be clear and understandable.
2. It would be easy for me to become skillful at using the digital technologies.
3. I would find the online educational platforms easy to use.
4. Learning to operate the online educational platforms is easy for me.
Work engagement (WE)
Vigor
1. At my work, I feel bursting with energy.
2. At my job, I feel strong and vigorous.
3. When I get up in the morning, I feel like going to work.
Dedication
1. I am enthusiastic about my job.
2. My job inspires me.
3. I am proud of the work that I do.
Absorption
1. I feel happy when I am working intensely.
2. I am immersed in my work.
3. I get carried away when I am working.

Funding This study was supported by International Joint Research Project of Huiyan Internatinoal College, Faculty of Education , Beijing Normal University.

Declarations

Conflict of interest The authors declare that we have no potential conflicts of interest.

References

Abd Latib, L., Bolong, J., & Ghazali, A. H. A. (2014). Facebook usage and functionality as the predictive factors in contributing towards employee engagement. *Procedia-Social and Behavioral Sciences*, *155*, 289–294.

Alarcón, R., del Pilar Jiménez, E., & de Vicente-Yagüe, M. I. (2020). Development and validation of the DIGIGLO, a tool for assessing the digital competence of educators. *British Journal of Educational Technology*, *51*(6), 2407–2421.

Amhag, L., Hellström, L., & Stigmar, M. (2019). Teacher educators' use of digital tools and needs for digital competence in higher education. *Journal of Digital Learning in Teacher Education*, *35*(4), 203–220.

Byrne, B. M. (2009). *Structural equation modeling with AMOS: basic concepts, applications, and Programming, Second Edition (Multivariate Applications Series)* (2nd ed.).). Routledge.

Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L. A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education, 19*(1), 1–16.

Blau, I., & Shamir-Inbal, T. (2017). Digital competences and long-term ICT integration in school culture: The perspective of elementary school leaders. *Education and Information Technologies, 22*(3), 769–787.

Blayone, T. J., vanOostveen, R., Barber, W., DiGiuseppe, M., & Childs, E. (2017). Democratizing digital learning: Theorizing the fully online learning community model. *International Journal of Educational Technology in Higher Education, 14*(1), 1–16.

Cabero-Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A. (2020). Evaluation of teacher Digital competence Frameworks through Expert Judgement: The use of the expert competence coefficient. *Journal of New Approaches in Educational Research (NAER Journal), 9*(2), 275–293.

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital competence Framework for educators (Digcompedu). *European Journal of Education, 54*(3), 356–369.

Cattaneo, A. A., Antonietti, C., & Rauseo, M. (2022). How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors. *Computers & Education*, *176*, 104358.

Damşa, C., Langford, M., Uehara, D., & Scherer, R. (2021). Teachers' agency and online education in times of crisis. *Computers in Human Behavior*, *121*, 106793.

Eastin, M. S., & LaRose, R. (2000). Internet self-efficacy and the psychology of the digital divide. *Journal of computer-mediated communication*, *6*(1), JCMC611.

European Commission. (2018). *Proposal for a council recommendation on key competences for lifelong learning*. Brussels, Belgium: European Commission.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: the structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and social psychology bulletin*, *21*(3), 215–225.

Ferrari, A., & Punie, Y. (2013). *DIGCOMP: a framework for developing and understanding digital competence in Europe*. Publications Office of the European Union.

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with unobservable variables andmeasurement error. *Journal of Marketing Research, 18*(1), 39–50.

From, J. (2017). Pedagogical digital competence–between values, knowledge and skills. *Higher Education Studies, 7*(2), 43–50.

George, D., & Mallery, M. P. (2001). *Using SPSS for Windows step by step: a simple guide and reference. Boston*. Allyn & Bacon.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis (new int. Ed.)*. Pearson Education.

Hämäläinen, R., Nissinen, K., Mannonen, J., Lämsä, J., Leino, K., & Taajamo, M. (2021). Understanding teaching professionals' digital competence: what do PIAAC and TALIS reveal about technology-related skills, attitudes, and knowledge? *Computers in Human Behavior*, *117*, 106672.

Hargittai, E. (2010). Digital na (t) ives? Variation in internet skills and uses among members of the "net generation". *Sociological inquiry*, *80*(1), 92–113.

Hatlevik, O. E. (2017). Examining the relationship between teachers' self-efficacy, their digital competence, strategies to evaluate information, and use of ICT at school. *Scandinavian Journal of Educational Research*, *61*(5), 555–567.

He, T., & Li, S. (2019). A comparative study of digital informal learning: the effects of digital competence and technology expectancy. *British Journal of Educational Technology*, *50*(4), 1744–1758.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55.

Hultell, D., & Gustavsson, J. P. (2011). Factors affecting burnout and work engagement in teachers when entering employment. *Work (Reading, Mass.)*, *40*(1), 85–98.

Hung, M. L. (2016). Teacher readiness for online learning: Scale development and teacher perceptions. *Computers & Education, 94*, 120–133.

Kirkpatrich, C. L. (2007). To invest, coast or idle: Second-stage teachers enact their job engagement. In *American Educational Research Association Annual Conference*, pp. 1–32.

Krishnamurthy, S. (2020). The future of business education: a commentary in the shadow of the Covid-19 pandemic. *Journal of Business Research*, *117*, 1–5.

Lai, H. M., Hsiao, Y. L., & Hsieh, P. J. (2018). The role of motivation, ability, and opportunity in university teachers' continuance use intention for flipped teaching. *Computers & Education*, *124*, 37–50.

Lucas, M., Bem-Haja, P., Siddiq, F., Moreira, A., & Redecker, C. (2021). The relation between in-service teachers' digital competence and personal and contextual factors: What matters most? *Computers & Education, 160*, 104052.

Lu, L., Mirpuri, S., Rao, N., & Law, N. (2021). Conceptualization and measurement of digital citizenship acrossdisciplines. *Educational Research Review, 33*, 1–18.

Mäkiniemi, J. P. (2022). Digitalisation and work well-being: A qualitative study of techno-work engagement experiences related to the use of educational technology. *International Journal of Educational Management, 36*(2), 152–163.

Meyers, E. M., Erickson, I., & Small, R. V. (2013). Digital literacy and informal learning environments: an introduction. *Learning media and technology*, *38*(4), 355–367.

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, *1*, 100012.

Mohammadyari, S., & Singh, H. (2015). Understanding the effect of e-learning on individual performance: the role of digital literacy. *Computers & Education*, *82*, 11–25.

Moreira-Fontán, E., García-Señorán, M., Conde-Rodríguez, Á., & González, A. (2019). Teachers' ICT-related self-efficacy, job resources, and positive emotions: their structural relations with autonomous motivation and work engagement. *Computers & Education*, *134*, 63–77.

Muijs, D. (2011). *Doing quantitative research in education with SPSS* (2nd ed.).). Thousand Oaks, CA: Sage.

Nielsen, K., Nielsen, M. B., Ogbonnaya, C., Känsälä, M., Saari, E., & Isaksson, K. (2017). Workplace resources to improve both employee well-being and performance: Asystematic review and meta-analysis. *Work & Stress*, *31*(2), 101–120.

Nikou, S., & Aavakare, M. (2021). An assessment of the interplay between literacy and digital technology in higher education. *Education and Information Technologies*, *26*(4), 3893–3915.

Philipsen, B., Tondeur, J., Pareja Roblin, N., Vanslambrouck, S., & Zhu, C. (2019). Improving teacher professional development for online and blended learning: a systematic meta-aggregative review. *Educational Technology Research and Development*, *67*(5), 1145–1174.

Portillo, J., Garay, U., Tejada, E., & Bilbao, N. (2020). Self-perception of the digital competence of educators during the COVID-19 pandemic: a cross-analysis of different educational stages. *Sustainability*, *12*(23), 10128.

Putwain, D. W., Nicholson, L. J., Pekrun, R., Becker, S., & Symes, W. (2019). Expectancy of success, attainment value, engagement, and achievement: a moderated mediation analysis. *Learning and Instruction*, *60*, 117–125.

Rayton, B. A., & Yalabik, Z. Y. (2014). Work engagement, psychological contract breach and job satisfaction. *The International Journal of Human Resource Management*, *25*(17), 2382–2400.

Reisoğlu, İ., & Çebi, A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers & Education*, *156*, 103940.

Saadé, R., & Bahli, B. (2005). The impact of cognitive absorption on perceived usefulness and perceived ease of use in on-line learning: an extension of the technology acceptance model. *Information & management*, *42*(2), 317–327.

Schaufeli, W. B. (2017). Applying the job demands-resources model. *Organizational Dynamics*, *2*(46), 120–132.

Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a short questionnaire: a cross-national study. *Educational and psychological measurement*, *66*(4), 701–716.

Shodipe, T. O., & Ohanu, I. B. (2021). Electrical/electronics technology education teachers attitude, engagement, and disposition towards actual usage of Mobile learning in higher institutions. *Education and Information Technologies*, *26*(1), 1023–1042.

Statnickė, G., Savanevičienė, A., & Šakys, I. (2019). The relationship between work engagement of different generations and mobile learning. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *67*(6), 1627–1642.

Tabachnick, B. G., & Fidell, L. S. (2014). *Using multivariate statistics* (6th ed.). Boston: Pearson Education Limited.

Toquero, C. M. (2020). Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context.Pedagogical Research, *5*(4).

Trust, T., & Whalen, J. (2020). Should teachers be trained in emergency remote teaching? Lessons learned from the COVID-19 pandemic. *Journal of Technology and Teacher Education*, *28*(2), 189–199.

Ungerer, L. M. (2016). Digital curation as a core competency in current learning and literacy: a higher education perspective. *The International Review of Research in Open and Distributed Learning*, *17*(5), 1–27.

Usher, M., Hershkovitz, A., & Forkosh-Baruch, A. (2021). From data to actions: instructors' decision making based on learners' data in online emergency remote teaching. *British Journal of Educational Technology*, *52*(4), 1338–1356.

Van den Berg, B. A. M., Bakker, A. B., & Ten Cate, T. J. (2013). Key factors in work engagement and job motivation of teaching faculty at a university medical centre. *Perspectives on medical education*, *2*(5), 264–275.

Van Wingerden, J., Derks, D., & Bakker, A. B. (2017). The impact of personal resources and job crafting interventions on work engagement and performance. *Human Resource Management*, *56*(1), 51–67.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS quarterly*, *27*(3), 425–478.

Ventura, M., Salanova, M., & Llorens, S. (2015). Professional self-efficacy as a predictor of burnout and engagement: the role of challenge and hindrance demands. *The Journal of psychology*, *149*(3), 277–302.

Wigfield, A., Tonks, S., & Klauda, S. L. (2009). Expectancy-value theory. *Handbook of motivation at school* (pp. 69–90). Routledge.

Zhao, Y., Llorente, P., A. M., & Sánchez Gómez, M. C. (2021). Digital competence in higher education research: a systematic literature review. *Computers & Education*, *168*, 104212.

Zhao, X., Lynch, J. G. Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: myths and truths about mediation analysis. *Journal of Consumer Research*, *37*(2), 197–206.

Guoyuan Sang is a professor in the Center for Teacher Education Research of Beijing Normal University. The main topics and areas of the research of Prof. Sang include teacher education and project-based learning.

Kai Wang is a teacher in the Center for Teacher Education Research of Beijing Normal University. In more recent work, he is especially interested in exploring the interplay between teacher education and innovative learning.

Shihua Li is a teacher in School of Foreign Languages, Xidian University. Her studies normally focus on self-regulated learning and blended learning.

Jiao Xi is a lecture in the School of Foreign Languages, Beijing Forestry University. Her current research interests are Teacher Education, Additional Language Teaching and Learning.

Dong Yang is a post-doc in the Smart Learning Institute, Beijing Normal University. The main topics and areas of the research of him include smart learning and educational technology.