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Validation of DigCompEdu Framework Among Higher Education Lecturers

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The DigCompEdu serves as a theoretical foundation for evaluating lecturers' digital competence current level. The framework outlines six areas: Professional Engagement (PE), Digital Resources (DR), Teaching and Learning (TL), Assessment (AS), Empowering Learners (EL), Facilitating Learners' Digital Competencies (FC). However, limited studies utilizing this model among Chinese lecturers in higher education (HE). Few studies have evaluated the model's validity in the Chinese context. To address these gaps, this study employed a DigCompEdu Check-In questionnaire, which is developed by the European Commission (2018). It is a validated self-assessment tool grounded in the DigCompEdu framework, comprising 22 items. The questionnaire was administered to 382 lecturers from 19 universities in Shandong Province.. The Partial Least Squares Structural Equation Model (PLS-SEM) was utilized to evaluate the validity of the evidence of the model's internal structure. The results revealed that the mean scores for each domain were concentrated in the range of 2.8 to 2.97 (with a maximum score of 4), which is upper medium level. Moreover, the results reported that the model has strong explanatory and predictive power, DR, TL, AS, and EL can explain 78.5% of the variance of FC. Meanwhile, the model path analysis noted that there were significant positive effects of PE on four variables: DR, TL, AS, and EL ($p < 0.001$), but FC ($p = 0.067$).

Keywords: DigCompEdu, Chinese lecturers, current level, PLS-SEM, validity

INTRODUCTION

The significance of digital competence is evident from the vibrant discussions surrounding it. In today's digital age, improving the digital competency of the entire population is a vital pathway to achieving personal development, social progress, and national competitiveness (Upadhyaya, 2024). Since the advent of the digital age and the

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growth of artificial intelligence, everyone must possess digital skills to remain employable. The teaching profession is no exception. Notably, universities and higher education institutions are crucial in cultivating digital competency among the population (Quraishi, 2024). Correspondingly, the demand for digital competency in education has significantly increased (Olasile, B. A. & Emrah, S. 2020). This foundation is particularly relevant when combined with other more complex peripheral issues. It is essential to comprehend how these pupils currently use digital tools (Drljić, K., & Doz, D., 2025). Thus, universities have set up compulsory courses on students' digital skills, ensuring all students develop essential digital skills (Wang & Si, 2024). Specifically, higher education institutions have developed open courses, distance education platforms, and digital competency programs to enhance public digital knowledge and literacy (Vitalis, 2025). Building on this, HE imparts digital skills, cultivates practical ability, and promotes digital equity. It also serves as the backbone of digital competency building for everyone.

HE lecturers must possess the necessary digital competencies to adapt to the evolving demands of teaching as traditional instructional methods increasingly shift towards digitalization and intelligence (Ren, L., 2024). Digital competencies comprise a variety of skills, including information retrieval and evaluation such as the ability to retrieve and evaluate information, use digital technologies effectively, the creation and development of online courses (Ferrari, A., 2012). Hence, achieving proficiency in these areas is essential for enhancing educational standards and advancing students' learning objectives. For instance, by utilizing online teaching platforms to implement distance learning, resource sharing, and two-way communication, lecturers can overcome barriers related to time and location. This, in turn, provides students with a more convenient learning experience (Dhawan, S., 2020). Furthermore, lecturers can effectively provide students with more individualized and diverse learning experiences by utilizing digital technology (Cao. Q., 2024). According to Zhou, C. (2025), digital platforms can also enhance the effectiveness and atmosphere of learning by facilitating communication and interaction among students and between lecturers.

In the context of educational digital transformation, lecturers must understand how to effectively utilize digital technology to instruct and guide students' learning (Yang, Y., 2023). This necessitates that lecturers possess adequate digital competencies to adapt to new curriculum designs (Wu, D., et al., 2023). Despite a rise in research on digital competence globally, there is a lack of theoretical models for evaluating university lecturers' digital competence in China's higher education context. That is, most studies focus on K-12 lecturers or students, resulting in insufficient research on university educators. Additionally, existing assessment tools are often unsystematic and lack comparability, limiting their effectiveness in informing policy.

The digital competence of lecturers is vital for improving teaching quality and educational equity. Therefore, a systematic investigation into the present level of digital competence among HE lecturers is essential for advancing digitalization in education. The DigCompEdu Framework from the European Union offers a theoretical basis for assessing lecturers' digital competencies. However, its practical application in Chinese higher education is limited and lacks a structured pathway. To address this gap, the present study aims to examine the validity of the DigCompEdu framework and assess the digital competence of HE lecturers in Shandong Province, China.

Review of Literature

Digital competency

Digital literacy evolved with the rise of computers and email, transitioning from basic social interactions to the ability to navigate the Internet effectively. As the Internet expanded, users accessed information through various channels (hypermedia), making discernment of useful information essential (Cartelli & Giovannella, 2015). It is a fundamental trait for individuals in the digital economy, encompassing critical thinking, ethics, and moral awareness online. While artificial intelligence offers vast information, it cannot filter it. Alternatively, people must critically evaluate information, a key aspect of digital competency vital for responsible Internet use and bridging the digital divide.

The rise of social software and digital business in the latter part of the decade highlighted the concept of digital literacy. Reisoğlu and Çebi (2020) stated that literacy is often confused with digital competency and that assessment focuses on competency rather than subject matter. In addition, effective use of digital environments requires more than technical skills. Digital competency encompasses various abilities (Røkenes & Krumsvik, 2014). It includes basic computer skills and other literacies, social skills, and workplace competencies that enhance social interaction (Cartelli & Giovannella, 2015). Additionally, digital competency emphasizes the analytical, collaborative, and creative use of digital technologies (Youth Theory Study Group of the Party Branch of the Ministry of Human Resources and Social Security, 2021).

On the other hand, digital competency was defined as the knowledge, attitudes, and skills needed to apply digital technologies in various areas, including work, life, security, and privacy (Janssen et al., 2013). They highlighted that it extends beyond using applications and devices to include effective communication with Information and Communication Technology (ICT), strong information skills, and a balanced perspective on technology, privacy, and security.

Mainstream studies often view digital literacy and digital competence as synonymous, with only slight differences in emphasis. This study defines digital literacy as the knowledge mastered, while digital competence includes knowledge and the ability to capacity to utilize digital technologies efficiently in practice. For clarity, the two concepts will be distinguished, yet their core ideas are similar.

DigCompEdu framework

DigCompEdu serves as a theoretical foundation for evaluating lecturers' digital pedagogical competence. It was proposed by the European Commission, providing guidelines for fostering digital skills in pedagogical design, student engagement, and professional collaboration (Caena & Redecker, 2019). This framework systematically classifies the digital capabilities of educators across six dimensions, including: (1) professional engagement, (2) digital resources, (3) teaching and learning, (4) assessment, (5) empowering learners, and (6) facilitating learners' digital competence.

There may also be specific sub-capabilities or metrics under each dimension. Accordingly, the framework consists of 22 specific competencies (see Table 1).

Table 1
DigCompEdu framework

Competency areas	Specific ability description	Sub-competencies
Professional Engagement	Leveraging digital technologies for professional collaboration, continuous learning and innovation.	1.1 Organisational communication; 1.2 Professional collaboration; 1.3 Refective practice; 1.4 Digital CPD
Digital Resources	Find, create, share, and evaluate digital educational resources.	2.1 Selecting; 2.2 Creating & modifying; 2.3 Managing.protecting. sharing
Teaching and Learning	Integrate digital tools (e.g., virtual classrooms, AI-assisted tools) in the classroom.	3.1 Teaching; 3.2 Guidance; 3.3 Collaborative learning; 3.4 Self-regulated learning
Assessment	Formative and summative assessments using digital tools (e.g., online quizzes, learning analysis).	4.1 Assessment strategies; 4.2 Analysing evidence; 4.3 Feedback & planning
Empowering Learners	Develop students' digital literacy, critical thinking and self-directed learning.	5.1 Accessibility&inclusion; 5.2 Differentation& personalisation; 5.3 Actively engaging learners
Facilitating Learners' Digital Competence	Ensure students use digital technologies safely and responsibly (e.g., cyber security, digital ethics).	6.1 Information &media literacy; 6.2 Communication; 6.3 Content creation; 6.4 Responsible use; 6.5 Problem solving

Modern educators need a solid foundation in digital competency and the ability to critically evaluate and adapt digital tools for pedagogical needs, differing from traditional teaching methods (Redecker & Punie 2017). Note that the DigCompEdu Framework is usually employed to assess and enhance educators' competence in applying digital technologies (Caena & Redecker, 2019). It serves as a reference for assessing abilities at various educational levels and in different fields. In today's educational landscape, digital competencies are crucial for delivering quality education. Hence, this model bridges the gap between theory and practice, enabling educators to meet the demands of 21st-century learners.

It is essential to contextualize their digital skills when implementing the DigCompEdu Framework. This research explores the local adaptation of the European standardized scheme within the context of higher education in China. It also enriches empirical data on international comparisons of lecturers' digital competence. Thus, the framework was applied to the empirical context of higher education lecturers in China for the first time to assess its adaptability and measurement validity.

Digital Competency in Chinese Higher Education

Chinese research on digital competency frameworks mainly interprets foreign models like DigComp and United Nations Educational, Scientific and Cultural Organization (UNESCO) ICT framework for teachers. Hu and Sun (2022) proposed a digital competency framework for Chinese residents based on the EU, the American Library Association, and UNESCO definitions. They defined digital competency in terms of skills and awareness, creating a comprehensive evaluation system with 13 indicators. In particular, factor analysis revealed four domains: professional knowledge, life application, entertainment information, and social interaction literacy. Using data from the China Family Panel Studies (CFPS) 2016 and 2018, they assessed residents' digital competency levels and drew conclusions.

However, research remains largely centered on literature generalization and strategic analysis, with limited empirical studies on higher education teachers across different fields. Most research targets higher vocational education (Dong & Zhang, 2025; Liu, 2024), and relied on literature analysis and theoretical methods, which creating a gap in studies on higher education lecturers (see Table 2). Hence, this study aims to address that gap.

The application of digital technology by university faculty in China has rapidly evolved, especially since the COVID-19 outbreak in 2020. Consequently, the digitalization of education has accelerated, with universities adopting online platforms and blended learning models and integrating technologies like artificial intelligence and virtual reality. As a result, research papers on this topic have significantly increased since 2021 (Wu et al., 2024). Much research has focused on frameworks for lecturers' digital competency (Yang & Zhou, 2019) and practical skills (Ge, 2017). Following the Ministry of Education of China's "Industry Standards for Digital Competency for Lecturers" (2022), research in 2023 suggests a notable increase in technology application in areas such as instructional design, resource development, and student assessment.

Table 2
Research on digital competency framework in Chinese Education Institutions

Author(s)	Research Subject	Research Method
Dong, H. & Zhang, Y. (2025)	Vocational Colleges	Literature analysis and strategy research
Song, H., et al. (2024)	Primary and Secondary Schools	Literature analysis and theoretical research
Lu, C., et al. (2024)	Vocational Colleges	Literature analysis and strategy research
Tang, Z., et al. (2024)	Vocational Colleges	International case study analysis
Liu, T. (2024)	Vocational Colleges	Empirical research (Master's thesis)
Yang, L., & Yu, H. (2024)	Primary and Secondary Schools	Literature analysis and trend research
Chu, X. (2024)	Vocational Colleges	Empirical research (Master's thesis)
Luo, L. (2024)	Primary and Secondary Schools	Literature analysis and international comparison
Fang, X., & Wang, Y. (2024)	Vocational Colleges	Literature analysis and strategy research
Xie, M., & Wang, S. (2024)	Primary and Secondary Schools	Data analysis and survey research
Qin, B., et al. (2024)	Primary and Secondary Schools	Theoretical research and philosophical perspective analysis
Yu, P. (2024)	Primary and Secondary Schools	Literature analysis and theoretical research
Hu, J., & Zhang, T. (2023)	Foreign Language Lecturers in Universities	Survey research and interviews
Hu, X., et al. (2023)	Primary and Secondary Schools	Literature review and international comparison
Cao, Y., et al. (2023)	Primary and Secondary Schools	Conference summary and literature research
Guo, X. (2022)	Primary and Secondary Schools	Literature analysis and theoretical research
Huang, L. (2021)	Primary and Secondary Schools	Literature research and case study analysis

Research on lecturers' digital competency in China is still exploratory, indicating a lack of cooperation among universities (Wu et al., 2023). The lecturer evaluation system favors research achievements and teaching hours, neglecting innovation in digital education and reducing faculty motivation (Yang & Zhou, 2019). Key issues include (1) Developing frameworks for integrating digital technology into interdisciplinary education, particularly in new liberal arts (Yang, 2025), and (2) Transforming digital competency into practical skills, as theoretical frameworks exist. Nonetheless, the practical application remains insufficient (Wu et al., 2024) (see Table 3).

Table 3
Researchers' framework contents

Scholars	Framework	Contents
Ge, W. S., Han X.B. (2017)	Framework for University Lecturers' Teaching Competency Standards	This framework proposes three development stages: application, deepening, and innovation, as well as four content dimensions: awareness, literacy, ability, and research of integrating ICT into teaching.
Wu, J. Q., et al. (2021)	Framework for Lecturers' Digital Competency	This framework divides lecturers' digital competency into basic digital competency, digital learning competency, and digital teaching competency.

On the other hand, Rubio-Gragera, M. et al. (2023) conducted a questionnaire survey on 104 teachers using the DigCompEdu Check-In questionnaire, and the results passed Cronbach's Alpha reliability examination. Research using the DigCompEdu Framework as a self-reflection tool, 183 Hungarian teachers were surveyed through an online questionnaire (Horváth, L., M. et al., 2025). Consequently, the Partial Least Squares Structural Equation Model (PLS-SEM) was employed to assess the validity of internal constructs. The findings revealed the internal construct validity of the model was insufficient, and a new empirical model was proposed. The author believed that the study's sample size may limit such a biased result. However, there is almost no research using the DigCompEdu Check-In questionnaire in the Chinese literature. Note that no research has been conducted on its reliability and validity.

Research Purpose

This research aims:

1) To investigate and examine the current level of digital competency among lecturers in Shandong Province.

2) To establish validity evidence and assess the tool's reliability of DigCompEdu Check-In scales.

METHOD

Participants

In total, 420 questionnaires were gathered from lecturers at 19 public undergraduate schools in Shandong Province, yielding 382 valid responses (218 online and 164 hardcopy). Accordingly, participants were made aware that the study was voluntary. They were provided with written consent and completed an eight-page questionnaire pack within 20 minutes. Respondents with females at 50.5% and males at 49.5%, and the majority were between the ages of 30 and 39, totaling 173 individuals (see Table 4).

Table 4
Demographic information about participants

Variables	Categories	Frequency	Percent (%)
Gender	Female	193	50.5
	Male	189	49.5
	Total	382	100.00
Age Group (Years)	25-29	63	16.5
	30-39	173	45.3
	40-49	92	24.12
	≥50	54	14.1
	Total	382	100.0

Measures

This instrument adopts the DigCompEdu Check-In questionnaire and contains 22 items. The items targeted for these six domains are listed on the table below (see Table 5). A 5-point Likert scale, ranging from 0 to 4, was employed in the scales.

Table 5
Instruments of DigCompEdu

Dimensions	Code Items	N of Items
Area 1: Professional Engagement	PE	4
Area 2: Digital Resources	DR	3
Area 3: Teaching and Learning	TL	4
Area 4: Assessment	AS	3
Area 5: Empowering learners	EL	3
Area 6: Facilitating Learners' Digital Competence	FC	5
Total		22

Data analysis

Descriptive statistics, including means and standard deviations, were used to examine the current level of digital competence among lecturers in Shandong Province. Given that the DigCompEdu framework is a robust theoretical construct, we aimed to assess the structural validity and reliability of this theoretical model through factor analysis utilizing the Partial Least Squares (PLS) method, as executed in SmartPLS 4. It was selected for its capacity to model complex constructs with multiple indicators, its robustness with small to medium sample sizes, and its suitability for exploratory research. As highlighted by Hair et al. (2022), PLS-SEM is particularly effective when validating multidimensional theoretical frameworks in novel empirical contexts, making it well-suited for assessing the DigCompEdu model in this study.

FINDINGS

Descriptive analysis

This study conducted a thorough examination of the evaluation data for the six key educational domains. Specifically, the domains of professional engagement (M = 2.841, SD = 0.972) and digital resources (M = 2.853, SD = 1.005) demonstrated strong consistency of practice with small standard deviations. This reflects a more mature pattern of professional commitment and educators' use of technological tools.

The domains of teaching and learning (M = 2.878, SD = 1.009) and facilitating learners' digital competence (M = 2.870, SD = 1.026) maintained high quality with a slightly higher standard deviation. This suggests a need to pay attention to differentiated instructional strategies and digital skills training in different instructional scenarios.

The areas of assessment (M = 2.800, SD = 1.072) and empowering learners (M = 2.967, SD = 1.067) demonstrated significant gaps (see Table 6).

Table 6
Means of each item

Items	Mean	Std. Deviation
PE1	2.9188	1.22151
PE2	2.7749	1.28859
PE3	2.8325	1.25833
PE4	2.8377	1.34177
DR1	2.8822	1.23562
DR2	2.8246	1.26455
DR3	2.8534	1.26925
TL1	2.8115	1.34421
TL2	2.9686	1.23342
TL3	2.8377	1.20578
TL4	2.8927	1.29667
AS1	2.8455	1.25897
AS2	2.7120	1.34606
AS3	2.8429	1.31474
EL1	2.9005	1.29426
EL2	3.0157	1.23584
EL3	2.9843	1.24642
FC1	2.8089	1.33699
FC2	2.7513	1.37600
FC3	2.9084	1.32984
FC4	2.9450	1.29185
FC5	2.9346	1.29136
PE	2.841	0.972
DR	2.853	1.005
TL	2.878	1.009
AS	2.800	1.072
EL	2.967	1.067
FC	2.870	1.026

The results revealed that the mean scores for each domain were concentrated in the range of 2.8 to 2.97 (with a maximum score of 4), indicating that digital competence was in the upper middle range (see Table 7). From the mean level, the mean ratio of each dimension is above 2 points, ranging from 2.8 to 2.97 (with a maximum score of 4). Therefore, it is believed that the digital competency of lecturers in Shandong Province is basically at the upper middle level. Among these, the mean ratio of Area 5 (empowering learners) is the highest (M=2.967), and the mean ratio of Area 4 (assessment) is the lowest (M=2.8). Furthermore, Area 5 (empowering learners) scored the highest, indicating that lecturers performing better in promoting self-directed student learning, possibly benefiting from the promotion of blended learning (e.g., flipped classroom). Conversely, Area 4 (assessment) received the lowest scores, reflecting a significant shortfall in data-driven assessment (e.g., learning analytics, adaptive test design). Based on results the lecturers overly rely on traditional exams and lack the depth of data mining for digital learning behaviors.

Table 7
Proficiency levels of digital competency

Dimensions	Mean（/4）	Level
Area 1: Professional Engagement	2.841	Upper medium
Area 2: Digital Resources	2.853	Upper medium
Area 3: Teaching and Learning	2.878	Upper medium
Area 4: Assessment	2.8	Upper medium
Area 5: empowering learners	2.967	Good
Area 6: Facilitating Learners' Digital Competence	2.87	Upper medium
Total	2.868	Upper medium

Reliability and Validity

Outer Loading

In this study, SmartPLS was adopted to validate the measurement model, which was mainly analyzed from three aspects: reliability, convergent validity, and discriminant validity. To sum up, the measurement model in this study performs well in terms of reliability and validity and can be employed for subsequent structural model analysis.

Table 8 summarizes the outer loadings of each measurement variable on its corresponding latent variable, which is used to evaluate the indicator reliability of the measurement model. According to the standard of Hair et al. (2017), a load coefficient greater than 0.70 is usually regarded as a well-representative indicator. Overall, except for PE4, the load coefficients of all the measured items are higher than 0.70, indicating that the overall reliability of the measurement model is good. In contrast, the load factor of PE4 is 0.668, slightly lower than the recommended threshold of 0.70. It is considered acceptable in cases where other external load factors are very high. Overall, there is a basis for further evaluation of the structural model.

Table 8
Outer loadings -Matrix

	AS	DR	EL	FC	PE	TL
AS1	0.809					
AS2	0.809					
AS3	0.843					
DR1		0.843				
DR2		0.764				
DR3		0.790				
EL1			0.849			
EL2			0.841			
EL3			0.854			
FC1				0.756		
FC2				0.742		
FC3				0.730		
FC4				0.832		
FC5				0.812		
PE1					0.813	
PE2					0.831	
PE3					0.730	
PE4					0.668	
TL1						0.815
TL2						0.823
TL3						0.758
TL4						0.779

Reliability

The stability of the DigCompEdu Check-In scale was evaluated in this study using Cronbach's Alpha coefficient value. It is widely acknowledged that Cronbach's Alpha above 0.80 is optimal, 0.60-0.80 is good, and below 0.60 is considered not internally consistent (Bujang, M. A., 2018). The result revealed that each dimension of DigCompEdu Framework's Cronbach's Alpha values of all facets is higher than 0.70 (spanning from 0.718 to 0.833). The Composite Reliability (CR) values are all higher than 0.80 (range from 0.842 to 0.884). This indicates that each facade has good internal consistency and reliability (see Table 9). Thus, it was suitable for further structural model analysis.

Validity

From a theoretical perspective, DigCompEdu is a well-established tool (Horváth, L., M., 2025), thus this study chooses to assess this theoretical model using factor analysis applying PLS-SEM as it is implemented in SmartPLS 4.

Table 9
Construct reliability and validity -Overview

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
AS	0.757	0.759	0.861	0.673
DR	0.718	0.724	0.842	0.640
EL	0.804	0.805	0.884	0.719
FC	0.833	0.840	0.883	0.601
PE	0.759	0.770	0.847	0.583
TL	0.805	0.808	0.872	0.631

An Average Variance Extraction (AVE) larger than 0.5 is necessary for convergent validity (Hair et al., 2017). The AVE of all latent variables exceeded 0.50 (range from 0.583 to 0.719), suggesting that the measurement items can effectively reflect their corresponding latent variables and have good convergent validity.

The Fornell-Larcker criterion states that all possible variables have discriminant validity if their square roots of AVE are larger than their correlation coefficients with other variables. For instance, 0.820 is the square root of the AS plane's AVE, which is higher than its correlation coefficient with planes such as DR (0.708) and FC (0.783) and meets the discriminant validity criterion. This implies a good discrimination ability (see Table 10).

Table 10
Discriminant validity-Fornell-Larcker criterion

	AS	DR	EL	FC	PE	TL
AS	0.820					
DR	0.708	0.800				
EL	0.725	0.765	0.848			
FC	0.783	0.783	0.827	0.775		
PE	0.705	0.765	0.732	0.750	0.763	
TL	0.777	0.780	0.771	0.788	0.799	0.794

Structural model and path coefficients

The path analysis results are presented in Table 11. Most of the path relationships reached statistical significance ($p < 0.05$). PE to DR ($\beta = 0.765$, $p < 0.001$) and PE to AS ($\beta = 0.705$, $p < 0.001$) demonstrated extremely strong positive effects. It indicates that personal factors play a decisive role in attitude support and the mastery of digital resources. At the same time, the positive effects of mediating variables such as AS, EL, and DR. AS on FC have also been statistically verified. Although the direct path of PE to FC is insignificant ($p = 0.067$), multiple indirect paths form a complete explanatory chain, suggesting a mechanism mediating. The overall model demonstrates good explanatory power and path robustness (see Figure 1).

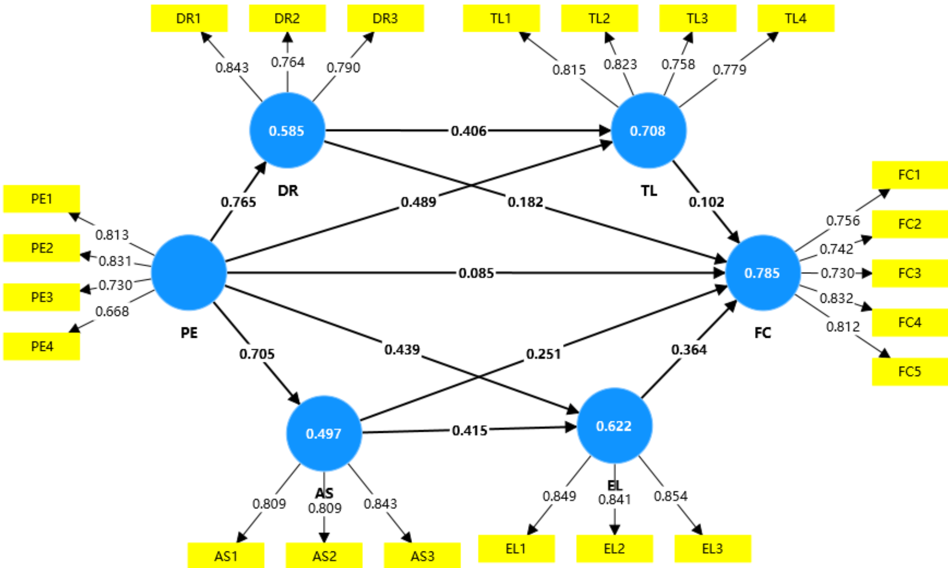

Figure 1
Structural model 1 (t-value)

Table 11
Path coefficients - Mean, STDEV, T values, p values

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
AS -> EL	0.415	0.416	0.047	8.921	***
AS -> FC	0.251	0.252	0.042	6.006	***
DR -> FC	0.182	0.182	0.045	4.085	***
DR -> TL	0.406	0.407	0.052	7.816	***
EL -> FC	0.364	0.367	0.058	6.310	***
PE -> AS	0.705	0.707	0.027	25.662	***
PE -> DR	0.765	0.767	0.024	32.445	***
PE -> EL	0.439	0.439	0.049	8.901	***
PE -> FC	0.085	0.082	0.047	1.830	0.067
PE -> TL	0.489	0.489	0.052	9.328	***
TL -> FC	0.102	0.102	0.052	1.967	0.049*

Noted: *p < .05, **p < .01, ***p < .001

The R^2 values in the model reported strong predictive power, especially FC ($R^2 = 0.785$) and TL ($R^2 = 0.708$), suggesting that the model was effective in explaining and predicting lecturers' teaching and learning and facilitating learners' digital competence behaviors (see Table 12). In addition, the f^2 effect size analysis revealed that Professional Engagement (PE) had a significant explanatory effect on four key variables, especially on Digital Resources (DR) with Assessment (AS) (see Table 13). These results emphasize the centrality of professional engagement in lecturers' adoption and use of digital technology.

Table 12
Coefficient of determination (R-square)

	R-square	R-square adjusted
AS	0.497	0.496
DR	0.585	0.584
EL	0.622	0.620
FC	0.785	0.782
TL	0.708	0.706

Table 13
Coefficient of determination (f-square)

	f-square
AS -> EL	0.229
AS -> FC	0.101
DR -> FC	0.045
DR -> TL	0.234
EL -> FC	0.192
PE -> AS	0.990
PE -> DR	1.410
PE -> EL	0.256
PE -> FC	0.010
PE -> TL	0.339
TL -> FC	0.011

DISCUSSIONS

Firstly, the overall level of lecturers' digital competence is at a medium-high level (total mean score 2.87/4), with uneven performance across dimensions. As such, empowering learners (Area 5) scored the highest (mean score of 2.967/4), indicating that lecturers performed better in facilitating students' self-directed learning. This has a probability related to promoting blended learning (e.g., flipped classroom) (Cabero-Almenara et al., 2020). On the other hand, assessment (Area 4) scored the lowest (mean score of 2.80), reflecting lecturers' significant shortcomings in data-driven assessment (e.g., learning analytics, adaptive quiz design) and their over-reliance on traditional forms of examination. Other dimensions, such as professional engagement (Area 1) and digital resources (Area 2) (mean scores of 2.84-2.85), demonstrated that lecturers were able to collaborate using digital tools in a basic way. However, they were not sufficiently innovative.

Among the six dimensions of digital competency, Area 5 (Empowering Learners), has the highest average score (M=2.967), indicating that lecturers are more concerned about students' active participation in the classroom, as well as the cultivation of digital resources, the application of digital technology and digital competency for students. Moreover, the Area4 (Assessment) has the lowest average score (M=2.80). This means that the ability to monitor, analyze, and obtain student evaluation feedback using digital technology is the least effective. Lecturers are the least capable of analyzing large amounts of digital data, especially about individual students' interactive behaviors as a way of providing more targeted feedback and support.

The difference in lecturers' performance in the dimensions of "empowering learners" and "assessment" reveals the disconnect between tool application and educational philosophy. Although technology is being utilized to support student autonomy, assessments are still dominated by traditional written tests, which probability stem from the regulation of universities. Consequently, lecturers cannot adequately access and use the large amounts of data generated by students' behaviors to provide feedback on teaching and learning. Possible reasons for this can be analyzed from two perspectives. (1) There is an imbalance in the 'power structure' (Li Z. F., Zhang K., 2024), whereby administrative power, as a visible presence, has a natural advantage in digital teaching and learning. (2) From a technical point of view, classroom intelligence analysis technology is more from the equipment and software provider companies to provide the output. Hence, the technology provider must train many data sets and test sets while introducing artificial annotations for correction. This includes constantly improving the multimodal data analysis model and enhancing its accuracy and reliability to achieve an intelligent analysis of classroom teaching.

Secondly, the reliability and validity of the scale DigCompEdu self-assessment scale presented excellent reliability (Cronbach's $\alpha = 0.954$), with the Alpha coefficients of the subdimensions ranging from 0.718 (Digital Resources) to 0.833 (Facilitating Learners' Digital Competence). This aligns with psychological measurement standards (Bujang, 2018). The model is evidenced by good convergent validity (AVE $>$ 0.5) and discriminant validity. Professional engagement (PE) is central to lecturers' adoption and use of digital technology. According to the model path analysis results, there was a significant positive effect of PE on all four variables DR, TL, AS, and EL ($p < 0.001$), with PE to DR having the largest effect ($\beta = 0.765$). However, the PE to FC path did not pass the test. The non-significant PE–FC path suggests that professional engagement alone may not directly influence lecturers' efforts to facilitate students' digital competencies, possibly due to gaps between professional activities and actual teaching practices.

In addition, TL to FC also reached a mildly significant level, and the remaining paths between variables with notable influence. In essence, the model effectively explains and predicts lecturers' TL and FC. These antecedent factors directly contribute to how lecturers integrate technology in their teaching practices and support students' digital skill development. Meanwhile, the explanatory power analysis of the structural model indicates that DR, TL, AS, and EL can explain 78.5% of the variance of FC. This asserts that the model has strong explanatory and predictive power. In addition, the Variance Inflation Factor (VIF) values of all the constructions are within a reasonable range (VIF< 3). It proposes that the model does not have the problem of multiple covariances, and that the structural relationship is credible.

The findings presented provide valuable insights for both pedagogical and policy formulation. Specifically, enhancing lecturers' digital competencies in evaluation and analysis is likely to improve educational effectiveness and student learning outcomes.

From an educational perspective, they highlight the critical need for specialized professional development initiatives aimed at improving lecturers' digital assessment literacy, which is essential for bridging the divide between student engagement and the implementation of effective digital education strategies. From a policy standpoint, the validated model may serve as a diagnostic instrument for the development of comprehensive university curricula, the allocation of resources, and the establishment of organization-wide digital strategies.

Future training programs should prioritize not only the promotion of digital tools but also the enhancement of understanding regarding data-driven education and personalized learning approaches. In alignment with curriculum transformation efforts, teachers should actively pursue continuous professional development through self-directed learning (Takyi, B., et al., 2025) Educational institutions ought to contemplate the integration of DigCompEdu-based assessments into their lecturer development frameworks to systematically evaluate and advance lecturers' digital competencies.

CONCLUSION AND LIMITATIONS

The general degree of digital proficiency among Shandong Province university lecturers demonstrates an upper medium level (mean score ranged from 2.80 to 2.967, out of 4). The whole digital competency of university lecturers in Shandong is characterized by "strong practice and weak evaluation." This reflects the lack of technology integration, and there is room for further improvement in the use of big data and the mining behind it. While prior research has explored aspects of digital competence among Chinese educators, few have employed the DigCompEdu Check-In tool in a validated manner. This study contributes to the limitations of research by empirically proving the structural validity and high internal consistency (Cronbach's α = 0.954) of the DigCompEdu framework in Chinese higher education. This provides a reference value for China's use of this scale in the future. Highly recommended, the DigCompEdu can be used as a self-assessment tool for educators, it needs to be combined with training to enhance specific dimensions, such as assessment. This can be achieved by training lecturers to analyze large amounts of digital data from students' interactive behaviors. Notably, providing more targeted feedback and supporting individualized education is more efficient.

Furthermore, the following are the study's limitations. Firstly, the sample did not include private universities and colleges, not fully representing the whole lecturers' population in Shandong Province. Secondly, there is insufficient research depth. Even though a plethora of additional elements could impact lecturers' digital competency, they are outside the purview of this investigation. Additionally, only the impact of individual traits on digital competency is examined in this study. Therefore, future research may focus on cultural and other influences.

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