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Validation of the Teachers' Digital Competence Instrument Using Rasch Measurement Model

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Abstract

Digital competence (TDC) is essential for the effective integration of technology in education and is widely recognized as a key factor in fostering high-quality educational environments. Empirical studies consistently demonstrate that TDC is a significant predictor of technology integration, underscoring the importance of assessing and enhancing TDC. To address this, the DigCompEdu framework and its CheckIn Self-reflection Tool were developed, offering a robust measurement for evaluating TDC. While this tool has been validated in various international contexts, its application within the Chinese educational system, particularly in higher vocational and technical colleges (HVTCs), has not been explored using the Rasch measurement model. This study addresses this gap by adapting and validating the DigCompEdu CheckIn tool for the Chinese context using Rasch analysis. The instrument, covering six domains of the DigCompEdu framework—Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence—was culturally adapted and piloted with 417 teachers from Sichuan HTVCs. Rasch analysis confirmed that the adapted TDC instrument met all psychometric criteria, demonstrating strong reliability and validity. The validated instrument provides a reliable tool of TDC in Chinese HVTCs, supporting efforts to enhance digital competence and promote effective technology integration in teaching practices.

Keywords: *Digital Competence, Instrument, Validation, Rasch Measurement Model, Chinese Higher Vocational Education*.

Introduction

In recent years, digital competence has gained significant attention in educational policies due to the growing demands of a technology-driven society and workforce (Lucas et al., 2021). The widespread integration of digital technologies into education has given rise to new pedagogical models that extend beyond traditional classroom settings, highlighting the need to enhance teachers' digital competence (TDC) for effective technology integration in teaching practices (Santos et al., 2021). As digital technologies become pervasive, educators are not only expected to integrate these tools into their instructional strategies but also to equip students with the necessary skills to thrive in a digitally driven world (Basilotta-Gómez-Pablos et al., 2022; Guillén-Gámez et al., 2021). This aligns with global initiatives aimed at fostering sustainable and inclusive economic growth, placing an increasing emphasis on enhancing TDC.

Extensive research has consistently highlighted the critical role of TDC in the successful integration of technology in education. Voithofer & Nelson (2021) assert that teachers with well-developed digital competence—comprising essential knowledge, skills, and attitudes—are better equipped to create high-quality educational environments through effective technology use (Cantabrana et al., 2019; Casillas Martín et al., 2020; Spiteri & Chang Rundgren, 2020). Conversely, teachers lacking digital competence face challenges in using digital tools effectively in their instructional practices. Çebi & Reisoğlu (2022) further emphasized the importance of TDC in facilitating technology integration, making it a vital aspect of contemporary education. In higher education, Guillén-Gámez et al. (2023) identified TDC as a critical factor influencing educators' intentions to integrate ICT, reinforcing its foundational role in technology-enhanced teaching. Similarly, Syuhada et al. (2022) provided evidence from Malaysian secondary schools, showing that TDC is a significant predictor of technology integration, while Camarillo (2024) found similar results in Philippine elementary education, where improvements in TDC—particularly in digital content

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management, information processing, safety, communication, and problem-solving directly—enhance teachers' ability to integrate technology into their classrooms.

Despite increased academic focus on TDC, there remains a lack of empirical studies within vocational education contexts, and few studies have validated instruments designed to assess TDC. Validating such tools is crucial to accurately assess TDC levels and identify areas for improvement. Accordingly, this study seeks to address this gap by validating a TDC scale using the Rasch measurement model. The subsequent sections will provide a detailed literature review, theoretical framework, and empirical validation process of the TDC instrument, particularly from the Rasch model perspective, offering robust evidence to support the validity and reliability of the instrument.

Literature Review

Teachers' Digital Competence

Digital competence is widely defined as the ability to effectively use digital technology to address everyday challenges. It encompasses a wide range of knowledge, skills, and attitudes related to active citizenship, societal engagement, and communication, collaboration, and safety in digital environments (Çebi & Reisoğlu, 2022). Council of the European Union (2018) defines it as "the confident, critical, and responsible use of information society technologies for work, leisure, and education." This concept has gained significant attention in academic circles and policy discussions, often being referred to interchangeably with digital literacy (Suzer & Koc, 2024; Tomczyk et al., 2023; Zhao et al., 2021). Council of the European Union (2018) recognizes digital competence as one of the eight key life skills, defining it as a comprehensive set of knowledge, skills, attitudes, strategies, and awareness needed for confident, critical, and responsible engagement with digital technologies. This definition emphasizes the critical role digital competence plays in navigating information, communication, and social interactions while underscoring its importance in integrating technology into education and community programs (Ortega-Sánchez et al., 2020).

Research on TDC has proliferated in recent years, reflecting the importance of this concept in modern education. Research between 2019 and 2024 has consistently emphasized the alignment of TDC with core competencies necessary for effective digital integration in educational contexts. Ortega-Sánchez et al. (2020) describe TDC as the essential knowledge, skills, and attitudes that enable teachers to proficiently navigate digital teaching environments. Basantes-Andrade et al. (2020) expand on this by highlighting the role of techno-pedagogical and communicative skills, which are crucial for efficiently integrating digital tools into teaching and communication. Durán (2019) provides a more comprehensive perspective, framing TDC as a diverse set of competencies, including technological, informational, multimedia, communicative, collaborative, and collaborative skills, all anchored in pedagogical principles that are vital for integrating ICT into education.

Cabero-Almenara et al. (2021) emphasize the importance of TDC in addressing professional and pedagogical challenges in a digital knowledge society, highlighting how ICT-related skills enhance teaching effectiveness in technology-driven environments. Hämäläinen et al. (2021) broaden the concept, defining digital competence as a combination of skills, knowledge, and attitudes required to leverage digital technologies across various contexts, emphasizing adaptability. Guillén-Gámez et al. (2021) highlight that digitally competent teachers must possess not only a thorough understanding of digital technologies but also the ability to seamlessly integrate these technologies into their pedagogical practices, which is essential for meeting curriculum objectives while enhancing teaching effectiveness and student engagement. Wang & Chu (2023) identify seven key areas of TDC in higher education, including values, ethics and security, digital resources, teaching and learning, and continuous professional development, and fostering learners' digital competence, providing a comprehensive understanding of the diverse areas in which teachers must develop expertise, underscoring the complexity of TDC and its crucial role in educational innovation.

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These various perspectives underline the multifaceted nature of TDC, which involves more than just technical proficiency. In this study, TDC is defined as teachers' ability to effectively use digital technologies to enhance teaching, engage professionally with stakeholders, pursue continuous professional growth, and contribute to educational innovation. This comprehensive definition underscores the need for teachers to be adaptive leaders in an evolving digital landscape, where their influence extends beyond the classroom to shape the future of education.

Theoretical Foundation

Over recent years, multiple frameworks have emerged to evaluate TDC across various educational contexts (Tzafilkou et al., 2023). Prominent models include the European Digital Competence Framework for Citizens (DigComp 2.1), the European Digital Competence Framework for Educators (DigCompEdu), the ISTE Standards for Educators, and the UNESCO ICT Competence Framework for Teachers, the British Framework for Digital Education, the Spanish Common Framework of Digital Teacher Competence, and Colombia's ICT Competences for Teacher Professional Development. Among these, DigCompEdu has emerged as one of the most widely adopted frameworks for assessing TDC across diverse educational levels.

The Dig Comp Edu framework, developed from the DigComp framework, was designed to enhance the digital competences of educators across Europe (Redecker, 2017). It defines six areas consisting of 22 specific competencies: Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence (Ghomi & Redecker, 2019). As a foundational framework, DigCompEdu informs the development of measurement tools, guides research initiatives, and formulate educational policies, making it an essential tool for promoting self-reflection and professional growth in digital skills among educators. Importantly, DigCompEdu also aligns with scholars advocating for the integration of social and cultural considerations into teachers' digital competencies, particularly concerning technology and education (Engen, 2019). Developed through a comprehensive literature review and synthesis of insights from local and international practitioners, DigCompEdu consolidates existing models into a cohesive framework, making it suitable for diverse educational levels and contexts (Benali et al., 2018; Tzafilkou et al., 2023). Its emphasis lies in the pedagogical integration of digital tools rather than mere technical proficiency.

By identifying essential focus areas for pedagogical and professional development, DigCompEdu provides relevant guidance applicable across disciplines and adaptable to the evolving technological landscape (Lucas et al., 2021). It outlines how educators can merge technological proficiency with subject-specific knowledge to enhance student learning, prioritizing core competencies such as problem-solving, collaboration, and innovation that are vital in today's talent-driven environment. Recognized as a leading framework for fostering digital competence in education Cabero-Almenara et al. (2020), the principles of DigCompEdu framework closely align with China's Competency Standards for Teacher Trainees and the "Digital Literacy of Teachers" initiative issued by the Ministry of Education of China. In this study, the six areas defined by DigCompEdu served as the foundation for conceptualizing and measuring TDC.

Despite its widespread adoption, studies examining TDC reveal significant inconsistencies in TDC levels. Some studies report high levels of digital competence among educators (Antonietti et al., 2022; Wang & Chu, 2023; Zhao et al., 2021), while others, such as Zheng (2019), identify low levels of digital proficiency among Chinese teachers. Several studies also indicate moderate levels of competence (Althubyani, 2024; Çebi & Reisoglu, 2020; Gao, 2022; Jorge-Vázquez et al., 2021; Tzafilkou et al., 2023), and others report moderate to high competence (Cattaneo et al., 2022; Pérez-Calderón et al., 2021). These disparities can likely be attributed to varying research contexts, assessment tools, and participant characteristics, underscoring the need for more robust and standardized assessment instruments. Additionally, these variations emphasize the importance of targeted professional development programs to address digital competence gaps, ensuring the effective integration of technology into teaching practices.

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To facilitate the assessment of TDC, the DigCompEdu CheckIn Self-reflection Tool was developed, offering educators a tool to self-evaluate their competencies and receive personalized feedback for improvement (Ghomi & Redecker, 2019; Redecker, 2017). While this tool has been validated in various educational settings, no studies have employed the Rasch measurement model to evaluate its validity in the Chinese educational system, particularly within higher vocational and technical colleges. This study seeks to advance understanding by adapting and validating the DigCompEdu CheckIn Self-reflection Tool within the Chinese higher vocational education system using Rasch measurement analysis, thus providing insights into its psychometric properties and contributing to a broader understanding of TDC assessment in this unique cultural and educational setting.

Methodology

This study employed a quantitative research design, utilizing a self-administered online questionnaire to gather data. Data collection was conducted via Questionnaire Star, a reputable and widely used online survey platform in China. The choice of an online questionnaire is justified by its cost-effectiveness, time efficiency, and ease of administration, allowing for a broad reach and facilitating data collection from a diverse respondent pool.

Research Instrument

The instrument was developed from the DigCompEdu CheckIn Self-reflection Tool and comprises six dimensions: Professional Engagement, Digital Resource, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence. The initial version includes 30 items: 5 items for Professional Engagement (PE1-PE5), 5 for Digital Resource (DR1-DR5), 7 for Teaching and Learning (TL1-TL7), 3 for Assessment (AS1-AS3), 4 for Empowering Learners (ELN1-ELN4), and 6 for Facilitating Learners' Digital Competence (FLDC1-FLDC6). Each item was adapted according to the definitions and indicators outlined in the DigCompEdu framework. A five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), was employed for responses. To ensure accuracy, the English items were translated into Chinese by a lecturer specializing in English-Chinese translation using back-to-back translation method.

Population, Samples and Sampling

The pilot study was conducted across 21 public higher vocational and technical colleges in Sichuan province, China, targeting an accessible population of 12,250 HVTC teachers. Based on the guidelines established by Krejcie & Morgan (1970), a minimum sample size of 373 teachers was necessary for a significance level of $p = .05$. To mitigate potential challenges such as non-participation, withdrawals, and incomplete responses, a total of 500 samples were selected using a proportional stratified sampling technique. In this approach, the accessible population was divided into 21 strata, each corresponding to one of the public HVTCs in Sichuan Province. The sample size for each stratum was calculated following Johnson & Christensen's (2014) suggestion: the number of respondents to be randomly selected = (Total number of teachers in a sub-population / Total population) × Total required sample size. Consequently, 500 online survey questionnaires were distributed with assistance from the human resources departments of the respective colleges. Ultimately, 447 questionnaires were returned, yielding an impressive response rate of 89.4%.

Data Preparation

Prior to conducting the planned statistical analyses, it was crucial to thoroughly screen and clean the collected data to ensure its quality. Basic descriptive statistics and frequency distributions for each variable were analyzed using SPSS 27.0, effectively identifying any inaccuracies or missing responses. As a result, 447 questionnaires were deemed valid, with no missing values.

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Straight-lining, a phenomenon where a respondent consistently selects the same response for most items (Hair et al., 2017), was assessed using Microsoft Excel 2023. Cases numbered 025, 047, 053, 059, 077, 085, 097, 098, 141, 194, 221, 224, 234, 235, 242, 276, 277, 278, 346, 351, 354, and 405 exhibited straight-lining issues. Consequently, these 22 cases were excluded from the analysis, resulting in a total of 425 cases available for further examination.

Additionally, outliers were identified using boxplot detection methods applied to all independent and dependent variables in SPSS 27.0. Cases numbered 147, 407, 337, 387, 312, 209, 182, and 183 were identified as outliers. After removing these eight outliers, a total of 417 cases remained for subsequent analysis.

Results

This section begins by addressing content and face validity, establishing the foundational appropriateness of the TDC instrument. Following this, a comprehensive validation process was conducted, which included the assessment of item fit, unidimensionality, and local independence. Additionally, reliability and separation index, as well as the item-person map, were analyzed using WINSTEPS 3.74.0 to rigorously validate the effectiveness and precision of the TDC instrument.

Content and Face Validity

Following the development of the instrument, three expert panels from Malaysia and China were chosen to validate its content validity, employing a purposive sampling technique. This panel comprised two professors with over a decade of experience in educational leadership and a lecturer from the Institute of Teacher Education, specializing in the same field. The experts reached a consensus on the overall acceptability of all items, noting that some required rewording for clarity and precision. These findings suggest that the items are well-conceptualized and operationalized, rendering them suitable for the pilot study. Additionally, to assess face validity, two bilingual language experts were selected using purposive sampling, further ensuring the appropriateness of the instrument for the target population.

Construct Validity

Data analysis was performed using the Rasch measurement model implemented in WINSTEPS 3.74.0. The analysis focused on several critical aspects: item fit, item polarity, unidimensionality, local independence, reliability and separation index, as well as the item-person map. These evaluations were conducted to validate the construct of the instrument effectively. The results indicated that the instrument possesses robust construct validity, confirming its effectiveness and reliability in accurately measuring the intended constructs. Subsequent sections provide a comprehensive overview of the data analysis conducted using the Rasch measurement model.

Item Fit and Item Polarity

Item fit analysis is utilized to evaluate how well the items fit with the Rasch measurement model (Miftahuljanah & Mohd Effendi, 2021). According to Linacre (2002), the acceptable range for the mean square standardized infit and outfit (MNSQ) for Likert scale items is between 0.50 and 1.50 logits, with corresponding normalized and standardized infit and outfit (ZSTD) values ranging from -2.0 to +2.0 (Bond & Fox, 2007). ZSTD values can be disregarded if the MNSQ values fall within the acceptable range [38]. Items with MNSQ values higher than 1.50 are classified as underfitting, indicating that they do not behave consistently with other items on the same scale. Such items may confuse respondents, leading to erratic responses from individuals across ability levels, and should therefore be revised or eliminated (Miftahuljanah & Mohd Effendi, 2021). Conversely, items with MNSQ values below 0.50 suggest potential redundancy or overlap with other items on the construct. The MNSQ value, calculated from both infit and outfit statistics, ensures that only items fitting the model are retained for further analysis, while poorly fitting items are identified as weak and excluded from construct evaluation (Miftahuljanah & Mohd Effendi, 2021). Table 1 provides a summary of the item fit statistics.

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Table 1. Fit Statistics of Measurement Items

Items	Raw Score	Total Count	Measure	Model Error	Infit		Outfit		PT-measure	
					MNSQ[1]	ZSTD[2]	MNSQ[1]	ZSTD[2]	Corr.	Exp.
DR3	1538	417	1.24	0.09	1.58	6.8	1.57	6.5	0.71	0.8
AS2	1584	417	0.88	0.09	1.21	2.7	1.4	4.5	0.74	0.78
AS1	1602	417	0.73	0.09	1.06	0.8	1.06	0.8	0.78	0.78
AS3	1614	417	0.63	0.09	0.83	-2.4	0.87	-1.6	0.8	0.78
TL7	1625	417	0.54	0.09	0.93	-1.0	0.92	-0.9	0.79	0.77
DR4	1628	417	0.52	0.09	1.13	1.6	1.13	1.4	0.75	0.77
FLDC1	1631	417	0.49	0.09	1.01	0.2	1.03	0.4	0.76	0.77
ELN3	1642	417	0.40	0.09	1.03	0.4	0.99	-0.1	0.76	0.77
ELN2	1647	417	0.36	0.09	0.88	-1.7	0.86	-1.7	0.78	0.76
FLDC3	1657	417	0.27	0.09	1.22	2.7	1.26	2.7	0.73	0.76
TL6	1663	417	0.22	0.09	0.82	-2.6	0.85	-1.7	0.79	0.76
TL5	1665	417	0.20	0.09	0.84	-2.3	0.78	-2.6	0.79	0.76
ELN1	1672	417	0.14	0.09	0.71	-4.2	0.75	-2.9	0.80	0.76
FLDC2	1673	417	0.13	0.09	0.84	-2.2	0.78	-2.5	0.79	0.75
ELN4	1675	417	0.11	0.09	0.90	-1.3	0.88	-1.2	0.77	0.75
DR2	1687	417	0.01	0.09	1.26	3.2	1.33	3.1	0.70	0.75
PE5	1689	417	-0.01	0.09	1.16	2.0	1.38	3.6	0.71	0.75
TL4	1698	417	-0.09	0.09	0.84	-2.2	0.79	-2.3	0.78	0.74
FLDC4	1707	417	-0.17	0.10	0.84	-2.2	0.81	-1.9	0.77	0.74
FLDC5	1707	417	-0.17	0.10	0.98	-0.2	0.90	-1.0	0.76	0.74
DR1	1717	417	-0.26	0.10	0.88	-1.6	0.81	-1.9	0.76	0.74
FLDC6	1728	417	-0.36	0.10	0.77	-3.3	0.73	-2.7	0.78	0.73
PE1	1734	417	-0.42	0.10	1.12	1.5	1.53	4.2	0.68	0.73
TL3	1750	417	-0.57	0.10	0.87	-1.8	0.79	-1.9	0.74	0.72
TL2	1754	417	-0.60	0.10	0.81	-2.6	0.75	-2.3	0.75	0.72
TL1	1760	417	-0.66	0.10	0.78	-3.1	0.70	-2.7	0.75	0.71
PE2	1762	417	-0.68	0.10	1.13	1.7	1.10	0.9	0.68	0.71
PE3	1770	417	-0.76	0.10	1.09	1.2	1.10	0.8	0.67	0.71
PE4	1785	417	-0.90	0.10	0.92	-1.1	0.87	-1.0	0.72	0.70
DR5	1818	417	-1.23	0.10	1.34	4.2	1.29	1.8	0.62	0.68
Mean	1686.1	417	0.00	0.09	0.99	-0.20	1.00	-0.10		
S.D.	63.4	0.0	0.56	0.00	0.20	2.50	0.25	2.50		

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Note: [1] Mean Square; [2] Z-score Standardized; PE- Professional Engagement; DR- Digital Resources; TL-Teaching and Learning; AS-Assessment; ELN- Empowering Learner; FLDC- Facilitating Learners' Digital Competence.

Table 1 indicates that the infit MNSQ values range from 0.71 to 1.58 logits, while the outfit MNSQ values range from 0.73 to 1.57. Most of these values fall within the acceptable threshold of 0.50 to 1.50 logits, as recommended by Miftahuljanah & Mohd Effendi (2021), suggesting that the majority of items fit the Rasch model appropriately. Notably, the MNSQ values for items DR3 and FLDC6 exceed 1.50, categorizing them as underfitting. These items, which pertain to teachers' competence in creating their own digital resources to suit their teaching needs and encouraging students to use digital technologies to solve problems in the learning process, may reflect varied understanding among higher vocational and technical college educators. Therefore, it is essential to revise or potentially remove these items. Since these two items are adapted from the Professional Engagement dimension and the Facilitating Learners' Digital Competence dimension of the DigCompEdu framework, they represent crucial aspects of digital competence for educators across all levels. Thus, they are revised to better fit with the Rasch measurement model.

In addition to MNSQ values, item fit can also be assessed through item polarity, typically quantified using the PTMEA Corr. value (Bond & Fox, 2015). A positive PTMEA Corr. value greater than 0.30 is considered acceptable (Wu & Adams, 2007), with higher values indicating a greater capacity for the item to differentiate respondents' abilities effectively. Conversely, values of zero or negative indicate misfit items (Linacre, 2005), warranting revision or removal. In this study, all PTMEA Corr. values range between 0.62 and 0.80, surpassing the minimum requirement. This demonstrates that all items are measurable, successfully differentiate among respondents, and contribute positively to the psychometric integrity of the TDC instrument.

Unidimensionality

Unidimensionality is a fundamental assumption of construct validity in Rasch model analysis, ensuring that instruments measure a single underlying construct (Perera et al., 2018). To verify this assumption, a Principal Component Analysis (PCA) of residuals was conducted. This analysis specifically examined the ratio between the raw variance explained by the items and the unexplained variance in the first contrast, along with the eigenvalue of the unexplained variance. A minimum acceptable threshold of 20% for this ratio is recommended (Reckase, 1979). Additionally, the first principal component of the residuals should be constrained to a maximum of 10% (Eakman, 2012; Fisher, 2007), and the variance explained by the items must be at least three times greater than that of the first contrast (Conrad et al., 2012; Embretson & Reise, 2000). Furthermore, the eigenvalue of the unexplained variance should remain below 5; exceeding this threshold poses a potential risk to the unidimensionality assumption (Linacre, 2005). Table 2 presents the results of this analysis, offering a comprehensive view of how well the instrument meets these critical criteria.

Table 2. Principal Component Analysis of Residual Variance (in Eigenvalue Units)

	Empirical		Modeled	
Total raw variance in observations	71.5	100%		100.0%
Raw variance explained by measures	41.5	58.1%		57.9%
Raw variable explained by persons	28.5	39.8%		39.7%
Raw variable explained by items	13.0	18.2%		18.2%
Raw unexplained variance (total)	30.0	41.9%	100%	42.1%
Unexplained variance in 1st contrast	4.2	5.9%	14.1%	
Unexplained variance in 2nd contrast	2.6	3.7%	8.7%	
Unexplained variance in 3rd contrast	2.2	3.1%	7.3%	
Unexplained variance in 4th contrast	1.9	2.6%	6.3%	
Unexplained variance in 5th contrast	1.6	2.3%	5.4%	

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The PCA results indicate that the TDC instrument accounted for 58.1% of the total variance, as shown in Table 2. This percentage not only surpasses the minimum acceptable threshold of 20% (Reckase, 1979), but also closely aligns with the model expectations of 57.9%. Such a finding robustly supports the unidimensionality of the scale. Additionally, the overall noise value is recorded at 5.9%, which is well below the maximum threshold of 10% suggested by Eakman (2012) and Fisher (2007), confirming its acceptability. The ratio of the raw variances explained by the items (18.2%) to the unexplained variance in the first contrast (5.9%) is 3.08, exceeding the recommended minimum ratio of three (Conrad et al., 2012; Embretson & Reise, 2000). Importantly, the eigenvalue for the unexplained variance in the first contrast is 4.2, which, while lower than the maximum allowable value of 5, suggests the absence of a second dimension.

Local dependence

Local independence is a critical assumption in Rasch model analysis, as it evaluates the correlation between items within the same construct (Bond et al., 2020). According to Balsamo et al. (2014), the ideal correlation coefficient should remain below 0.30. Exceeding this threshold may indicate potential redundancy among items, necessitating the retention of the more suitable item while eliminating the other. This decision typically hinges on the MNSQ value, which should approximate the expected value of 1 to ensure a proper model fit (Bond & Fox, 2015; Linacre, 2002). By adhering to these criteria, researchers can ensure that retained items are independent and do not overlap with other items within the construct (Miftahuljanah & Mohd Effendi, 2021). Table 3 provides a comprehensive set of ten residual correlation values, offering insights into the level of independence among the analyzed items.

Table 3. List of local items dependence

Correlation	Item No.-construct	Item No.- Construct
0.55	PE1: Professional Engagement	PE2: Professional Engagement
0.55	FLDC4: Facilitating Learners' Digital Competence	FLDC5: Facilitating Learners' Digital Competence
0.54	TL2: Teaching and Learning	TL3: Teaching and Learning
0.54	DR3: Digital Resources	DR4: Digital Resources
0.51	PE2: Professional Engagement	PE3: Professional Engagement
0.48	TL1: Teaching and Learning	TL3: Teaching and Learning
0.46	TL1: Teaching and Learning	TL2: Teaching and Learning
0.44	FLDC5: Facilitating Learners' Digital Competence	FLDC6: Facilitating Learners' Digital Competence
0.42	ELN1: Empowering Learners	ELN2: Empowering Learners
0.40	FLDC4: Facilitating Learners' Digital Competence	FLDC6: Facilitating Learners' Digital Competence

As shown in Table 3, the residual correlation values range from 0.40 to 0.55, indicating substantial correlations among items within the constructs of Professional Engagement, Digital Resources, Teaching and Learning, Empowering Learners, and Facilitating Learners' Digital Competence. Such correlations necessitated careful consideration regarding which items to retain, revise, or eliminate. For instance, within the Professional Engagement construct, items PE1 and PE2, as well as PE2 and PE3, exhibited correlations exceeding the acceptable threshold. Given that the correlation coefficients remained within the acceptable range of 0.7 (Linacre, 2005), these items were consolidated into a single revised item: "I use different digital channels to communicate with colleagues and students whenever appropriate (e.g., QQ, WeChat, Blogs, TikTok, Apps...)," which aligns with the original item in the DigCompEdu CheckIn Self-reflection Tool stating, "I use different digital channels to communicate with learners and colleagues whenever appropriate." Similarly, in the Digital Resources construct, items DR4 and DR5 demonstrated correlations above the threshold, yet remained within the acceptable range, leading to their merger into the item: "I create my own digital resources and adapt existing digital resources to suit my teaching needs." consistent with the original

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DigCompEdu item. In the Teaching and Learning construct, items TL1, TL2, and TL3 exhibited significant correlations; thus, they were consolidated into a single item: "I carefully consider how, when, and why to use digital technologies with my students in the classroom to enhance teaching and learning," reflecting the DigCompEdu framework's guidance. Furthermore, in the Empowering Learners construct, items ELN1 and ELN2 showed correlations above the acceptable threshold, thus, they were merged into a single item "I consider and address potential digital problems when creating digital assignments for students", aligning with the original item in DigCompEdu CheckIn Self-reflection Tool. Additionally, items FLDC4 and FLDC5, as well as FLDC5 and FLDC6, also showed significant correlations; FLDC4 and FLDC5 were merged into: "I teach students how to use digital technology safely and responsibly," while FLDC6 was retained, aligning with the indicators of the DigCompEdu framework.

Reliability and Separation Index

Table 4 provides an overview of the reliability and separation indices for both respondents and items. The person reliability value is reported as 0.94, which is considered very good, as it falls within the recommended range of 0.91 to 0.94 (Fisher, 2007). This high reliability suggests a strong likelihood that the instrument would yield consistent results when administered to a similar group of respondents (Bond & Fox, 2015). Similarly, the item reliability is noted as 0.97, surpassing the recommended threshold of 0.94 (Fisher, 2007), deemed excellent, further indicating a high level of consistency in item performance across different samples (Bond & Fox, 2015). The separation indices, which measure the capacity of the instrument to distinguish between varying levels of respondent ability and item difficulty, are reported as 3.84 for respondents and 5.66 for items, both well above the minimum recommended value of 2.0 (Fisher, 2007). These separation values suggest that the instrument is highly effective in differentiating between respondents' ability and item difficulty (Bond & Fox, 2015).

Table 4. Reliability index and Separation index

	Reliability Index	Separation Index
Person	0.94	3.84
Item	0.97	5.66

Item-Person Map

The item-person map, depicted in Figure 1, illustrates the distribution of items and respondents' abilities along the logits scale. Respondent abilities are positioned on the left, while item difficulty levels are on the right. Positive logit estimates on the upper left of the scale indicate more capable respondents, while items at the top right are more difficult to yield a "strongly disagree" response. Each "#" on the left side of the map refers to 3 respondents, while each "." represents 1 to 2 respondents (Bond & Fox, 2015). The map shows that respondents' abilities spread over nearly 9 logits, indicating a wide range of responses across the Likert continuum. However, there is an imbalance between the distribution of respondents and items, with two-thirds of respondents targeted by only one item (DR3). This imbalance suggests that the items may not effectively differentiate between respondents with varying abilities. Additionally, items DR5 were perceived as the least challenging, whereas item DR3 is identified as the most difficult for respondents.

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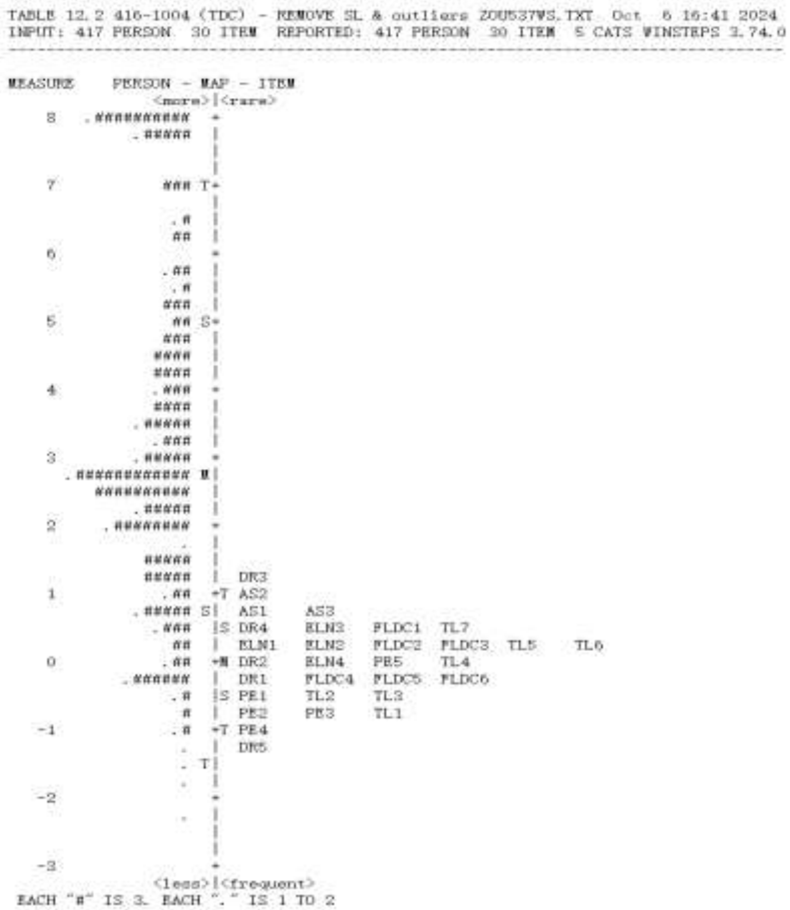

Figure 1. Item–person map for the TDC instrument analysis (Winsteps)

Discussion

This study aimed to validate an instrument for measuring Teachers' Digital Competence (TDC) within the context of Chinese higher vocational and technical colleges, employing the Rasch measurement analysis model. The findings of this study offer valuable insights into the psychometric properties of the instrument and its effectiveness in assessing digital competencies among higher vocational and technical educators.

Expert panel evaluations confirmed the strong content and face validity of the instrument, indicating that the items are well-conceptualized and appropriately aligned with the intended constructs. The revisions suggested by experts, particularly the rewording of certain items, were instrumental in enhancing the clarity and relevance of the instrument. Additionally, bilingual language experts ensured that the items were culturally and linguistically suitable for the target population. This underscores the importance of incorporating diverse expertise during the early stages of instrument development to achieve comprehensive and contextually appropriate content.

The results of the Rasch analysis provided robust evidence for the construct validity of the TDC instrument. Most items fit well within the acceptable range of the Rasch model, indicating that they accurately measure the underlying constructs of the instrument. However, the identification of underfit items (DR3, FLDC6) highlights areas where the instrument could be further refined. These items, although conceptually important, may require rephrasing or additional contextualization to better align with the understanding and practices of principals in higher vocational and technical colleges in China. This finding suggests that while the instrument is generally effective, continuous refinement and context-specific adjustments are

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necessary to maintain its relevance and accuracy. The analysis also verified the unidimensionality of the instrument, with the majority of the variance being explained by the primary construct. The unidimensionality of the measure is supported by an explanation of 58.1% of the raw variance, exceeding the minimum 20% requirement for unidimensionality in the Rasch Analysis Model (Reckase, 1979). The absence of a second dimension is further evidenced by an Eigenvalue of 4.2 for the unexplained variance in the first contrast, accounting for only 5.9% of the variance. To enhance the quality and applicability of the scale, it is recommended to consolidate items PE1 and PE2, merge DR4 and DR5, combine TL1, TL2, and TL3, as well as ELN1 and ELN2, and finally, FLDC4 and FLDC5.

The high person and item reliability index demonstrates that the instrument is capable of consistently distinguishing between respondents with varying levels of digital leadership competence. The strong separation index further proved that the instrument is effective in differentiating between high and low performers, which is essential for its use in both research and practical applications. Additionally, the item-person map indicates that most respondents exhibit a high level of ability, while all items appear relatively easy. To address this, it is necessary to develop more challenging questions akin to DR3, thereby increasing the overall difficulty level of the instrument to better estimate the abilities of higher-performing individuals (Bond & Fox, 2015).

Implications

The validated TDC instrument, with robust psychometric properties, demonstrates that it can be an effective tool for accurately measuring digital competence among educators, particularly within the context of higher vocational and technical colleges. The content and construct validity of the instrument suggests it captures the essential dimensions of TDC, which are aligned with current educational standards such as the DigCompEdu framework. This indicates that the instrument can serve as a reliable assessment tool for identifying educators' strengths and areas needing improvement in digital competence. The findings of this study also underscore the importance of revising specific items to ensure they reflect the nuanced needs of educators in HVTCs. For instance, the underfitting items related to teachers' ability to create digital resources and facilitate students' digital competence suggest that these competences may vary more widely than expected in this educational setting. Revising these items to align better with the Rasch model could provide more accurate insights into these critical aspects of digital competence.

Moreover, the demonstrated unidimensionality of the instrument implies that it measures a single underlying construct, reinforcing its utility for longitudinal studies and comparative assessments across diverse educational contexts. Institutions can use this instrument to systematically track teachers' development in digital competence, guiding professional development programs, and informing policy initiatives aimed at integrating digital technologies in teaching and learning. Finally, these findings have broader implications for the design and implementation of teacher training programs. By identifying the specific dimensions of TDC that require further enhancement, educational leaders can tailor professional development initiatives to better prepare teachers for the demands of digital education. This is particularly critical in the evolving landscape of vocational and technical education, where digital literacy is increasingly seen as a vital skill for both educators and students.

In conclusion, this study contributes valuable insights into the measurement of digital competence, offering a validated instrument that can support educational institutions in their efforts to enhance TDC and, ultimately improve the integration of technology in vocational education settings.

Conclusion and Limitation

This study offers valuable contributions to the assessment of TDC, particularly within HVTCs. The validation of the TDC instrument, utilizing the Rasch measurement model, demonstrates its robust psychometric properties, establishing it as an effective tool for evaluating digital competence among educators. Its alignment with DigCompEdu, underscores its relevance in identifying educators' strengths and areas requiring development. The unidimensional nature of the instrument further supports its applicability in longitudinal and comparative studies, making it a reliable tool for guiding professional development initiatives and policy formulation. Ultimately, this validated instrument provides educational leaders with a means to systematically enhance teachers' digital competence, which is increasingly crucial in the digital age of vocational education.

Despite its contributions, this study has several limitations. First, the sample was limited to educators within HVTCs in the region of Sichuan Province, China, which may restrict the generalizability of the findings to other educational contexts or geographic areas. Future research should expand the sample to diverse educational settings to enhance the applicability of the instrument. Second, this study relied on self-reported data, which may introduce biases; therefore, future work should consider explores principals' perspectives to provide a more comprehensive understanding of TDC. Third, the item-person map analysis indicated that the current items may not effectively differentiate between respondents with high and low ability estimates. Future studies should consider incorporating more challenging items and expanding the sample to include participants from private HVTCs to enhance the discriminatory power of the instrument. Finally, to yield more consistent and robust findings, further research should employ Structural Equation Modeling (SEM) techniques to further validate the construct of the instrument.

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Appendix A: Teachers' Digital Competence Scale

Construct	Items
Professional Engagement (PE)	1. I use different digital channels to communicate with colleagues and students whenever appropriate (e.g. QQ, WeChat, Blogs, TikTok, Apps...). 2. I use digital technologies to work together with colleagues (e.g. Office Automation System, Tencent webinars, Tencent Online collaborative documents, shared calendars, 360 cloud drive, Baidu cloud drive, etc.). 3. I actively develop my digital competence for teaching. 4. I participate in online training opportunities (e.g., online courses, MOOCs, webinars, virtual conferences...).
Digital Resources (DR)	1. I use different websites to find a wide range of digital resources. 2. I use different search strategies to select digital resources. 3. I create my own digital resources and adapt existing digital resources to suit my teaching needs. 4. I effectively protect personal data, e.g. exams, learners' grades, learners' personal information.
Teaching and Learning Leader (TL)	1. I carefully consider how, when and why to use digital technologies with my students in the classroom to enhance teaching and learning. 2. I follow my students' activities in the online collaborative environments. 3. When my students work in groups, they use digital technologies to effectively accomplish course tasks. 4. I use digital technologies to enable students to plan their learning themselves (eg. quizzes for self-assessment, e-portfolios for documentation and showing casting, online diaries/blogs for reflection). 5. I use digital technologies to enable students to document their learning themselves.

Assessment (AS)	1. I use digital assessment tools to monitor students' progress. 2. I analyze all data available to me to timely identify students who need additional support. 3. I use digital technologies to provide effective feedback in teaching and learning.
Empowering Learners (EL)	1. I consider and address potential digital problems when creating digital assignments for students (e.g. equal access to digital devices and resources, lack of digital skills). 2. I use digital technologies to offer students personalized learning opportunities (e.g. I give different learners different digital tasks to address individual learning needs, preferences and interests). 3. I use digital technologies for students to actively engage in class.
Facilitating Learners' Digital Competence (FLDC)	1. I teach students how to assess the reliability of information. 2. I set up assignments which require students to use digital technologies to communicate and collaborate with fellow students. 3. I set up assignments which require students to create digital content. 4. I teach students how to use digital technology safely and responsibly. 5. I encourage students to use digital technologies to solve problems in the learning process.

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