TPM Vol. 32, No. 3, 2025
ISSN: 1972-6325
https://www.tpmap.org/

A CONFIRMATORY FACTOR ANALYSIS OF DIGITAL COMPETENCY FOR TEACHERS

PHUMIPHAT RADUN
KHON KAEN UNIVERSITY, THAILAND

PRAKITTIYA TUKSINO
KHON KAEN UNIVERSITY, THAILAND

ABSTRACT:
This study forms part of a broader investigation on the development of digital comp etency frameworks for teachers. The primary objective was to examine the structural validity and model fit of the digital competency components for educators using empirical data. A total of 400 in-service teachers were selected through multi-stage random sampling. The instrument utilized was a five-point Likert-type rating scale developed based on operational definitions of digital competency. Content validity was verified by five domain experts, yielding item-objective congruence indices ranging from .80 to 1.00. The internal consistency reliability, calculated using Cronbach's alpha, was found to be .991. Data analysis involved both descriptive statistics and second-order confirmatory factor analysis (CFA). The findings revealed that digital competency for teachers comprises six core components—professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and enabling learners' digital competence—with a total of 22 observed indicators. The model demonstrated good fit with the empirical data: χ^2 = 75.092 (df = 58, p = .065), CFI = .993, GFI = .986, AGFI = .978, RMSEA = .026, and SRMR = .024. Standardized factor loadings for the six components ranged from .494 to .740, and the loadings for individual indicators ranged from .874 to .974.
Keywords: digital competency, teachers, confirmatory factor analysis

INTRODUCTION:

Contemporary society has transitioned into a knowledge-based era, where individuals are expected to function as knowledge workers—those who are capable of continuous learning and adaptation. In the context of 21st-century competencies, digital literacy and information and communication technology (ICT) skills have become essential. To align with global technological trends, the Thai government has embraced the Thailand 4.0 vision, emphasizing the development of national telecommunications infrastructure and the expansion of nationwide internet accessibility as key drivers of innovation-led economic and social development (Suvit Maesincee, 2016).

As digital technologies and online communication networks rapidly evolve, they have significantly influenced how individuals interact with, create, and disseminate information. The ease with which digital content can be copied, modified, and shared—whether from home, school, workplace, or public space—demands a level of ethical and legal awareness among users. Yet, many continue to engage with digital content without fully understanding the implications or potential misuse. Given the transformative power of digital media in shaping knowledge, learning, and socio-economic systems, individuals must possess the skills to access, evaluate, manage, and responsibly engage with digital content. This includes managing one's emotional expression in virtual communities (Pornchanit Leenaraj, 2017).

Technology plays a pivotal role in national development and in enhancing educational quality (Viberg et al., 2020). The Ministry of Education's Digital Education Action Plan (2020–2022) underscores the benefits of digital technologies at both student and teacher levels. For students, digital tools promote faster and more diverse learning experiences, enabling flexible access to content anytime, anywhere. For teachers, these tools support varied instructional approaches, simplify lesson delivery, and foster more engaging learning environments. As a result, educators today must be equipped with digital competencies—defined as the knowledge, skills, and attitudes required to use digital tools effectively, ethically, and creatively in ways that promote responsible citizenship and meaningful student learning in an ever-changing world. As noted by Krumsvik (2011), digitally competent teachers are better positioned to facilitate learning in digital environments.

A review of both local and international literature, including sources from reputable organizations and digital education experts (e.g., Institute of Professional Qualifications, 2014; Office of the Higher Education Commission, 2018; Digital Economy Promotion Agency, 2019; Calvani et al., 2009; DQ Institute, 2017; Krumsvik, 2008), highlights six core components of teacher digital competency: (1) professional engagement, (2) use of digital resources, (3) teaching and learning, (4) assessment, (5) learner empowerment,

and (6) enabling learners' digital competence. These components require further validation through empirical investigation using confirmatory factor analysis (CFA).

Given the critical role of digital competency in education, especially under the current trend of online and blended learning models, this study addresses the need for a valid and up-to-date framework for assessing teachers' digital skills. While previous studies have explored similar themes, the rapid pace of digital transformation necessitates ongoing research to ensure the relevance and applicability of digital competency indicators. Therefore, this study aims to analyze and validate a structural model of digital competency for teachers, contributing to a more robust understanding of how educators can be supported in developing the digital skills necessary for effective teaching in the 21st century.

RESEARCH OBJECTIVE

The primary objective of this study was to examine the construct validity and model fit of a proposed digital competency framework for teachers by comparing the structural model with empirical data.

Expected Benefits

1. **Theoretical and Practical Foundations**

The study provides foundational insights into the components and indicators of digital competency assessment for teachers. These findings can serve as a valuable resource for stakeholders involved in teacher development, enabling the design of targeted training programs and evidence-based policies. Furthermore, self-assessment results from teachers can inform strategic educational planning and contribute to national initiatives aimed at enhancing digital teaching capacities.

2. **Methodological Contributions**

The study contributes to the methodological field by developing a validated instrument for assessing teachers' digital competencies using a Likert-type rating scale. Additionally, it offers insights into the structure and design of digital competency evaluations, which may guide future research and application in educational settings.

METHODOLOGY

Population and Sample

The target population in this study comprised in-service teachers working in basic education schools under the jurisdiction of the Office of the Basic Education Commission (OBEC), Ministry of Education, Thailand, duringthe 2024 academic year. According to official records, the total number of teachers was 370,708.

A total of 400 teachers were selected as the sample through multi-stage random sampling, with 100 participants drawn from each of Thailand's four geographic regions to ensure representation across diverse educational contexts.

Sample Size Determination

Hair et al. (2010) recommend a minimum sample size of 10 respondents per estimated parameter when conducting confirmatory factor analysis (CFA). Similarly, Bentler and Chou (1987) suggest a ratio of 5 to 20 participants per parameter. Gagne and Hancock (2006) further emphasize the importance of having at least 400 participants to ensure the stability of second-order CFA results.

In this study, the structural model included 22 parameters requiring estimation. Based on the recommendations above, the minimum sample size should fall between 396 (using a 5:1 ratio) and 820 (using a 20:1 ratio). Accordingly, the researchers determined a sample size of 400 participants, accounting for potential non-responses and ensuring sufficient statistical power for model testing.

RESEARCH INSTRUMENT

The instrument used in this study was a digital competency assessment scale specifically developed for teachers. Its development was grounded in a review and synthesis of relevant literature and frameworks from both domestic and international sources, and refined through expert validation. The instrument was designed as a five-point Likert-type rating scale, measuring six core components across 22 indicators, with a total of 53 items.

1. **Content Validity**

The initial version of the instrument was submitted to five experts in the field for content validation. The experts evaluated the alignment between each item and the corresponding operational definitions. The index of item-objective congruence (IOC) ranged from .80 to 1.00, indicating strong content validity, as all items exceeded the acceptable threshold of 0.50.

2. **Item Discrimination Analysis**

A pilot test was conducted with a group of 40 teachers possessing similar characteristics to the study sample. Item-total correlation analysis was performed using standard statistical software. The item-total correlation coefficients (rit) ranged from .504 to .633, which are above the recommended cut-off point of .40, demonstrating adequate item discrimination.

3. **Internal Consistency Reliability**

Cronbach's alpha coefficient was used to assess the internal consistency of the scale. The pilot group (n = 40) yielded an overall reliability coefficient of .758, with subscale reliabilities ranging from .504 to .683. When applied to the full research sample (n = 400), the overall reliability increased to .973, and subscale reliabilities ranged from .681 to .835—indicating a high level of reliability across all components (see Table 1).

Table 1

Cronbach's Alpha Coefficients for the Digital Competency Scale by Component

Overall Digital Competency Scale	No. of Items	Pilot Group (n = 40)	Main Sample (n = 400)
1. Professional Engagement	10	.889	.959
2. Use of Digital Resources	5	.905	.967
3. Teaching and Learning	14	.945	.976
4. Assessment	8	.890	.967
5. Learner Empowerment	6	.935	.973
6. Enabling Learners' Digital Competence	10	.927	.945
	53	**.915**	**.964**

Data Collection

The data collection process was conducted using the finalized version of the digital competency scale. The researchers distributed the questionnaires to the selected sample of 400 teachers. All participants completed and returned the instruments, resulting in a 100% response rate.

An initial analysis of demographic data revealed that the majority of respondents held the professional teaching rank of "Skilled Teacher" (24.75%). Most participants were female (80.11%) and held a bachelor's degree or its equivalent (55.25%). The age group most represented was 30–40 years (30.50%), and the largest proportion of respondents had between 5 and 10 years of teaching experience (33.75%).

Data Analysis

The data obtained from the 400 completed questionnaires were analyzed using both descriptive and inferential statistics. To examine the structural validity of the digital competency model, second-order confirmatory factor analysis (CFA) was employed. Parameter estimation was conducted using the maximum likelihood (ML) method, which computed all parameters within the model and converted them into variance–covariance matrices of observed variables.

The model's goodness-of-fit with the empirical data was assessed using the following indices: Chi-square (χ^2), relative chi-square (χ^2/df), Comparative Fit Index (CFI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The criteria used to determine acceptable model fit are presented in Table 2.

Table 2 Model Fit Criteria for Confirmatory Factor Analysis

Fit Index	Criteria for Acceptable Fit
Chi-square (χ^2)	Non-significant ($p > .05$)
Relative chi-square (χ^2/df)	< 2.00 (indicating a good fit)
Comparative Fit Index (CFI)	≥ 0.99 (excellent fit)
Goodness-of-Fit Index (GFI)	≥ 0.95 (excellent fit)
Adjusted Goodness-of-Fit Index (AGFI)	≥ 0.95 (excellent fit)
Root Mean Square Error of Approximation (RMSEA)	< 0.02 (excellent fit)
Standardized Root Mean Square Residual (SRMR)	< 0.02 (excellent fit)

RESEARCH FINDINGS

The structural validity of the proposed digital competency model for teachers was evaluated using second-order confirmatory factor analysis (CFA). The key findings are presented as follows:

1. Descriptive Statistics of Digital Competency Variables by Component

The overall mean score of digital competency among teachers was at a high level (M = 3.724, SD = .875), with a coefficient of variation (CV) of 23.508, indicating moderate dispersion. The skewness (Sk) was negative and the kurtosis (Ku) was positive, suggesting that the majority of participants scored above the mean and the distribution was more peaked than normal.

When examined by component, all six components had mean scores at a high level. The highest mean was found in Component 3 (Teaching and Learning), followed by Component 4 (Assessment), Component 2 (Use of Digital Resources), Component 5 (Learner Empowerment), Component 6 (Enabling Learners' Digital Competence), and Component 1 (Professional Engagement), respectively. The standard deviations ranged from .847 to .959, and coefficients of variation from 23.138 to 25.779, indicating moderate variability across components. The component with the greatest variation was Component 5, while Component 1 showed the least variation. All components exhibited negatively skewed and positively kurtotic distributions, reflecting a concentration of high competency scores (see Table 3).

Table 3 Descriptive Statistics of Digital Competence Variables by Component

Variable/ Component	*n*	*M*	*SD*	C.V.	Min	Max	Sk	Ku
Digital Competence	400	3.724	.875	23.508	1.000	5.000	-.826	.427
Professional Engagement	400	3.659	.847	23.138	1.000	5.000	-.682	.291
Digital Resources	400	3.694	.896	24.242	1.000	5.000	-.698	.309
Teaching and Learning	400	3.812	.939	24.640	1.000	5.000	-.870	.436
Assessment	400	3.791	.959	25.302	1.000	5.000	-.838	.252
Empowering Learners	400	3.662	.944	25.779	1.000	5.000	-.614	.122
Information and Media Literacy	400	3.810	.933	24.634	1.000	5.000	-.698	.309

2. Correlation Analysis among Indicators in the Digital Competency Model

The proposed digital competency model consisted of six latent variables (components):

1. Professional Engagement (4 indicators),
2. Use of Digital Resources (3 indicators),
3. Teaching and Learning (4 indicators),
4. Assessment (3 indicators),
5. Learner Empowerment (3 indicators), and
6. Enabling Learners' Digital Competence (5 indicators),

making a total of 22 observed variables.

The correlation matrix of these 22 indicators was analyzed. The results revealed that all pairs of observed variables were significantly correlated at the .05 level ($p < .001$), with Pearson correlation coefficients ranging from .541 to .719. These values indicate moderate to moderately high inter-variable relationships. The coefficients of determination (R^2) ranged from 29.27% to 51.70%, suggesting that the variables shared a substantial proportion of variance.

Bartlett's Test of Sphericity was conducted to verify whether the correlation matrix significantly differed from an identity matrix. The results yielded $\chi^2 = 22{,}722.698$ ($df = 105$, $p < .001$), indicating statistical significance. Additionally, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .974, which is close to 1.00, confirming that the data were suitable for factor analysis. These results support the appropriateness of conducting confirmatory factor analysis to test the structural validity of the proposed digital competency model for teachers.

3. Results of Second-Order Confirmatory Factor Analysis

The second-order confirmatory factor analysis (CFA) confirmed that the proposed digital competency model for teachers consists of six components:

(1) Professional Engagement,
(2) Use of Digital Resources,
(3) Teaching and Learning,
(4) Assessment,
(5) Learner Empowerment, and
(6) Enabling Learners' Digital Competence.

The overall model demonstrated a good fit with the empirical data. The evaluation was based on seven widely accepted fit indices: $\chi^2 = 75.092$ ($df = 58$, $p = .070$), $\chi^2/df = 1.295$, CFI = .993, GFI = .986, AGFI = .978, RMSEA = .026, and SRMR = .024. All values met or exceeded the established thresholds, indicating that the hypothesized model was well aligned with the observed data (see Table 4).

Table 4 Goodness-of-Fit Indices for the Digital Competency Model for Teachers

Fit Index	Value	Threshold	Interpretation
Chi-square (χ^2)	75.092	$p > .05$	Acceptable
Relative chi-square (χ^2/df)	1.295	< 2.00	Good fit
Comparative Fit Index (CFI)	.993	≥ .90	Excellent fit
Goodness-of-Fit Index (GFI)	.986	≥ .90	Excellent fit
Adjusted Goodness-of-Fit Index (AGFI)	.978	≥ .90	Excellent fit
RMSEA	.026	< .05	Good fit
SRMR	.024	< .05	Good fit

Standardized Factor Loadings and R^2 Values for Each Component and Indicator

The standardized factor loadings (λ) of the observed variables (indicators) for each latent construct (component) were examined. All loadings were statistically significant at the .01 level ($p < .001$), and the coefficients of determination (R^2) ranged from moderate to high levels across the six components, as detailed below:

Component 1: Professional Engagement

This component included four indicators with standardized loadings ranging from .546 to .703. The indicator with the highest loading was continuous professional development in digital technology (λ = .703), followed by reflective practice (λ = .671), inter-organizational communication (λ = .603), and professional collaboration (λ = .546). The R^2 values ranged from .299 to .494.

Component 2: Use of Digital Resources

This component consisted of three indicators with loadings between .649 and .738. The strongest indicator was the creation and adaptation of digital resources (λ = .738), followed by selection of digital resources (λ = .693), and management, protection, and sharing of digital content (λ = .649). The R^2 values ranged from .421 to .545.

Component 3: Teaching and Learning

The four indicators for this component yielded loadings ranging from .494 to .697. The most influential indicator was instructional design (λ = .697), followed by collaborative learning (λ = .667), guidance and counseling (λ = .646), and self-regulated learning facilitation (λ = .494). R^2 values ranged from .244 to .486.

Component 4: Assessment

This component contained three indicators with loadings between .637 and .690. The highest loading was feedback and planning (λ = .690), followed by assessment strategies (λ = .656), and evidence analysis (λ = .637). R^2 values ranged from .406 to .477.

Component 5: Learner Empowerment

Three indicators were included, with loadings ranging from .581 to .684. The most influential indicator was active engagement with learners (λ = .684), followed by access and inclusion (λ = .621), and personalization and differentiation (λ = .581). R^2 values ranged from .337 to .467.

Component 6: Enabling Learners' Digital Competence

This component comprised five indicators with standardized loadings ranging from .613 to .740. The strongest indicator was digital communication and collaboration (λ = .740), followed by digital content creation (λ = .662), media and information literacy (λ = .645), responsible digital use (λ = .637), and digital problem-solving (λ = .613).

R^2 values ranged from .376 to .547.

Model Diagram

The final structural model of digital competency for teachers is illustrated in Figure 1. This model was validated through second-order confirmatory factor analysis and consists of six latent constructs and 22 observed indicators. The model demonstrated excellent goodness-of-fit with the empirical data, as indicated by the following statistics:

$\chi^2 = 75.092$, df = 58, $p = .065$
$\chi^2/df = 1.295$
RMSEA = .026
SRMR = .024
CFI = .993
TLI = .988

These indices provide strong evidence that the hypothesized model closely aligns with the observed data.

DISCUSSION

The findings of this study confirmed that the digital competency of teachers can be represented through a multidimensional structure comprising six interrelated components and 22 specific indicators. These components are: (1) professional engagement, (2) use of digital resources, (3) teaching and learning, (4) assessment,
(5) learner empowerment, and (6) enabling learners' digital competence. This structural model was initially developed based on theoretical synthesis and was refined through expert validation before empirical confirmation via CFA.

The model's strong goodness-of-fit indices indicate that it provides a reliable and theoretically sound framework for assessing digital competency in the teaching profession. Experts in the field agreed with the proposed structure and suggested minor revisions to indicator wording to enhance clarity and scope. The empirical analysis confirmed that each indicator loaded significantly onto its respective latent factor, further validating the internal consistency and theoretical alignment of the instrument.

When compared with previous studies, the present model aligns closely with the work of Kanittha Sirisak (2016), who identified similar components through qualitative synthesis and expert interviews. Moreover, the present findings are consistent with global frameworks such as those proposed by Calvani et al. (2009), the Office of the Higher Education Commission (2018), and the DQ Institute (2017), which highlight the integration of technical, cognitive, ethical, and pedagogical dimensions in digital competence.

Particularly noteworthy is the high factor loading of the "Teaching and Learning" component, which suggests that this domain is central to teachers' digital competency in the context of 21st-century education. This may reflect the increased reliance on digital tools during the COVID-19 pandemic, which prompted widespread use of online teaching platforms and communication technologies in both instructional and collaborative contexts (World Health Organization, 2021).

Suggestions for Future Research

This study primarily focused on the identification of components and the development of an assessment instrument for evaluating teachers' digital competency. However, it did not explore the underlying causal factors influencing digital competency, nor did it examine the potential outcomes of such competencies on other educational variables.

Future research should build upon these findings by investigating causal relationships between digital competency and other relevant constructs such as instructional effectiveness, student engagement, or digital citizenship. Employing structural equation modeling (SEM) or mixed-methods approaches could yield deeper insights into how various factors contribute to or result from digital competency.

Moreover, subsequent studies may consider using qualitative research designs to explore the lived experiences, challenges, and contextual factors that influence teachers' digital practices in diverse educational settings. Case studies, in-depth interviews, or ethnographic approaches could enrich the understanding of how digital competencies are developed and applied in real-world teaching environments.

Finally, it is recommended that future studies test this validated model across different educational levels and regions—such as higher education institutions or early childhood education—in order to assess its generalizability and adaptability. Longitudinal research could also track the development of digital competencies over time, particularly in response to evolving technological demands in education.

REFERENCES

- Bentler, P. M., & Chou, C. P. (1987). Practical issues in structural modeling. *Sociological Methods & Research, 16*(1), 78–117.
- Calvani, A., Cartelli, A., Fini, A., & Ranieri, M. (2009). Models and instruments for assessing digital competence at school. *Journal of E-Learning and Knowledge Society, 4*(3), 183–193.
- DQ Institute. (2017). *Digital intelligence (DQ): A conceptual framework & methodology for teaching and measuring digital citizenship*. DQ Institute.
- Gagné, P., & Hancock, G. R. (2006). Measurement model quality, sample size, and solution propriety in confirmatory factor analysis. *Multivariate Behavioral Research, 41*(1), 65–83. https://doi.org/10.1207/s15327906mbr4101_5
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Pearson Prentice Hall.
- Krumsvik, R. J. (2008). Situated learning and teachers' digital competence. *Education and Information Technologies, 13*(4), 279–290. https://doi.org/10.1007/s10639-008-9079-5
- Sirisak, K. (2016). *A study on digital competency development guidelines for teachers based on professional curriculum research* [Doctoral dissertation, Chulalongkorn University].Chulalongkorn University Intellectual Repository (CUIR). http://cuir.chula.ac.th/handle/123456789/55685
- Viberg, O., Hatakka, M., Bälter, O., & Mavroudi, A. (2020). The current landscape of learning analytics in higher education. *Computers in Human Behavior, 89*, 98–110. https://doi.org/10.1016/j.chb.2018.07.027

- World Health Organization. (2021). *Rolling updates on coronavirus disease (COVID-19)*. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen
- Institute of Professional Qualifications. (2014). *Core competency standards for digital skills and information technology* [in Thai]. http://tpqi-net.tpqi.go.th/qualifications/735
- Office of the Higher Education Commission. (2018). *Guidelines for implementing the national qualifications framework regarding digital competency for undergraduate programs* [in Thai]. https://www.egd.cmu.ac.th
- Office of the National Digital Economy and Society Commission. (2019). *25 elements of digital competency* [in Thai]. https://www.dlbaseline.org/digital-competency
- Pornchanit, L. (2017). Digital literacy skills for enhancing quality learning. *Journal of Library, 61*(2), 76–92. [in Thai]
- Promote, T., Cheevasuksakul, A., & Angsuchoti, S. (2019). A confirmatory factor analysis of digital competence among Thai professional nurses. *Royal Thai Army Nursing Journal, 20*(3), 276–285. [in Thai]
- Supamas, A., Somthawin, W., & Ratchaneekorn, P. (2011). *Statistical analysis for search in social and behavioral sciences: Techniques for using LISREL* (3rd ed.) [in Thai]. Charoendee Mankong Publishing.
- Suvit, M. (2016). Concept of Thailand 4.0. [in Thai].
- http://planning2.mju.ac.th/government/20111119104835_planning/Doc25590823143652358135.pdf