A Factor Analysis of Competencies in Information and Communication Technology of Science Teachers Under The Uthaithani Primary Educational Service Area Office

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Abstract
This study aimed to analyse the confirmatory factor structure of information and communication technology (ICT) competency among science teachers under the Uthai Thani Primary Educational Service Area Office. A quantitative research methodology was used. The sample comprised 500 science teachers selected through multistage sampling. The researcher developed a 77-item instrument using a five-point Likert rating scale. The instrument was validated by experts for content validity, and the content validity ratios for individual items ranged from 0.60 to 1.00, with item discrimination indices ranging from 0.44–0.92. The reliability coefficients, calculated using Cronbach's alpha, ranged from 0.97–0.99. Data were analysed using confirmatory factor analysis (CFA) through statistical software, which indicated that the model demonstrated a good fit with the empirical data. The chi-square statistic was 107.331 with 98 degrees of freedom (p = 0.244), indicating good fit. The fit indices also indicated an excellent model fit, with a Tucker-Lewis Index (TLI) of 0.998, a Comparative Fit Index (CFI) of 0.999, a standardised root mean square residual (SRMR) of 0.022, and a Root Mean Square Error of Approximation (RMSEA) of 0.015. Among the factors, the highest factor loading was found in the knowledge component (0.940), followed by the skills component (0.896) and the attitude component (0.708), all of which were statistically significant at the .01 level. Future research should test the model in other contextually diverse regions and across different grade levels and investigate emerging variables relevant to contemporary ICT competencies.
Keywords: Competency, Information and Communication Technology, Science Teachers, Confirmatory Factor Analysis, Primary Education, Thailand Teacher, ICT Skill

Introduction

The Digital Revolution has brought about significant transformations during the Fourth Industrial Revolution, in which Information and Communication Technology (ICT) plays a critical role across all dimensions of the global economy, society, and education. Nations worldwide are facing borderless and liberalised competition, particularly with the emergence of the Internet of Things (IoT), where devices can easily and rapidly connect to the Internet. Consequently, the number of Internet users has been increasing continuously and is expected to rise even further in the future. In response, Thailand has adopted the Thailand 4.0 policy to enhance its citizens' capacity to access information and boundless learning resources and to foster knowledge development and the creation of innovations that address national demands. This policy emphasises flexible and diversified curricula and educational management aligned with 21st-century skills, as outlined in the National Education Plan (2017–2036), which aims to develop learners with 3Rs—Reading, Writing, and Arithmetic

—and 8Cs: Critical Thinking, Creativity, Collaboration, Cross-cultural Understanding, Communication, Computing & ICT Literacy, Career & Learning Skills, and Compassion.

Teachers are key personnel in organising learning experiences that develop learners' essential 21st-century competencies. Primary science teachers play a crucial role in laying the foundation for students' scientific and technological skills through learning processes that emphasis analytical thinking, questioning, experimentation, problem solving, and creative learning (Saxton et al., 2012; Bybee, 2013). Furthermore, science teachers significantly influence learners' motivation and interest in science from an early stage, which contributes to sustained learning at higher levels (Ministry of Education Singapore, 2013). Moreover, primary teachers are required to integrate multiple subject areas, which necessitates appropriate ICT skills to design learning activities that align with student development and enable the effective implementation of Active Learning or STEM Education.

A study by Pheeraphan and Suwathanpornkul (2017) found that 21st-century ICT competency for teachers comprises three main dimensions:

- **Knowledge Competency**: Teachers' understanding of computer fundamentals, information systems, instructional design principles involving ICT, and the application of technology to enhance student development.
- **Skills Competency:** Teachers' ability to use ICT tools effectively for accessing, managing, integrating, evaluating, creating, and communicating information in teaching and learning.
- **Attitude Competency**: Teachers' disposition and willingness to use ICT meaningfully, with positive attitudes and adherence to ethical, legal, and sociocultural norms.

These findings align with previous study of developed ICT competency indicators for 21st-century primary school teachers under the Mukdahan Primary Educational Service Area Office. Her study also identified three major competency domains—knowledge, skills, and attitudes—comprising 55 indicators.

From a synthesis of past research, it can be concluded that ICT competency for 21st-century teachers consists of three key dimensions: knowledge of ICT and instructional design, skills to effectively utilise ICT in teaching, and a positive attitude toward responsible and ethical use of ICT. Given the important role of primary science teachers in using ICT to enhance students' scientific and technological capabilities, it is essential to study and analyse the components of their ICT competency. This analysis provides data for planning targeted teacher development based on actual capacity and training needs.

However, a review of related literature and research indicates that many science teachers still face limitations in using ICT due to a lack of readiness in terms of personnel, equipment, software and application skills, as well as confidence and attitude toward using technology effectively in the classroom.

In the Uthai Thani Primary Educational Service Area Office, science teachers are considered vital for raising the quality of student learning at the primary level. Understanding the components of their ICT competencies is essential for planning effective teacher development that responds to priority needs and enables the design of appropriate professional training workshops. It will also support the Ministry of Education's policy on "Developing Teachers and Educational Personnel to Be Professionals in the Digital Era" and contribute to achieving Sustainable Development Goal 4: Quality Education.

Although prior studies have proposed ICT competency indicators for teachers, three critical gaps persist. First, there is limited CFA-based validation tailored specifically to primary science teachers in provincial Thai contexts, where resources and teaching conditions differ from those in metropolitan settings. Second, cross-group comparability has rarely been examined; evidence of measurement invariance across regions and grade levels is scarce, constraining the use of a single model for equitable benchmarking. Third, existing frameworks seldom reflect emerging ICT practices, such as AI-integrated pedagogy, data literacy, and cybersecurity, which are now salient to classroom practice. Addressing these gaps will yield a context-

sensitive, psychometrically robust model that can guide targeted professional development. Therefore, the researcher is interested in studying the analysis of ICT competency components of science teachers under the Uthai Thani Primary Educational Service Area Office using Confirmatory Factor Analysis (CFA) to examine the structural components of ICT competencies and validate the construct of the competency model. The results of this study will be valuable for planning the professional development of primary science teachers and for designing training programs that effectively promote 21st-century science and technology skills.

Research Objectives

- To analyse the confirmatory factors of information and communication technology (ICT) competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area.
- To verify the model fit of the ICT competency components of science teachers against empirical data.

Research Hypothesis

The model of information and communication technology (ICT) competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area is consistent with the empirical data.

Literature Reviews

Science teachers are also very important in terms of their competency with regards to Information and Communication Technology (ICT) in the context of educational innovation and practices of pedagogy. The digital competencies in teaching have been explored by different studies, with the most important skill identified as digital literacy as a crucial skill of modern teachers. An overview of the ICT use in education revealed that one of the research areas is the digital teaching competencies, which is important to implement policies of sustainability, training differentiation, and ethical digital literacy that would assume generational diversity as a strategic resource in pedagogical innovation and professional development (Romero-Carazas et al., 2025).

Guided by the models like UNESCO ICT Competency Framework of Teachers, studies indicate that science teachers are characterized by moderate digital skill with the confidence levels engaged in the lack of basic up to advanced digital skills. Tiered teacher training programs that allow developing the basic skills gradually with the development of the advanced ones and taking into account such demographic characteristics as age and gender are suggested in such studies (Bitegeko et al., 2024). The fine line between age and ICT competency challenges the gap between digital natives and digital immigrants and instead, studies indicate that there exist no significant differences in ICT competence across age groups among the pre-service teachers implying that there exist diverse digital competencies that need to be taken into consideration in professional development (Guo et al., 2008).

The introduction of ICT in science education, in particular, requires the type of professional development program that targets not only skill acquisition but also pedagogical changes. The literature sheds light on the fact that most of the current professional development initiatives are characterized by poor change approaches that require reforms that can incorporate digital technologies into the process of curricular renewal and cognitive learning (Fernandes et al., 2018). Those who teach with extensive use of ICT in science are more confident and have more lifelong learning oriented pedagogies, which explain the relationship between ICT competence and professional engaged teaching (Voogt, 2010).

The obstacles to ICT integration in teacher education are inadequate knowledge of technological justifications, inadequate resources, excessive workload and time that interfere with efforts by teacher educators and student teachers to integrate ICT in its full application. Therefore, it is crucial to include ICT-based pedagogical skills in teacher education, not only through certain courses but also through the modeling of the teaching practice (Ngao et al., 2022).

Additional systematic reviews, such as those that concentrate on particular contexts, such as English as a Foreign Language and Islamic studies, are

revealing notable gaps in the concurring frameworks of measuring the digital competencies or report challenges of infrastructure constraints and uneven attitudes of the teachers. These highlight the fact that there is an urgent requirement of professional development, institutional support, and quality infrastructure to close digital competencies gaps in various learning environments (Nurjanah et al., 2025; Qazi et al., 2021; Sabiri, 2019).

The literature is generally a complex conceptualization of ICT competencies with science teachers, which supports extensive training that is responsive to the needs of teachers and real-life contexts, thus increasing the effectiveness of teaching science by involving the use of technology (Fernandez-Batanero et al., 2020).

Research Methodology

The research on studying the Factor Analysis of Competencies in Information and Communication Technology of Science Teachers under the Uthai Thani Primary Educational Service Area Office employed confirmatory factor analysis (CFA) rather than exploratory factor analysis (EFA) because the constructs and items were derived from established theory and clearly articulated prior research. The existing conceptual framework delineates teachers' ICT competence into three primary dimensions: knowledge, skills, and attitudes. The objective of the present study was to test, rather than discover, this structure. The findings support the hypothesized model. This study was designed by the researcher according to the following research methodology:

Population and Sample Group

The population for this study comprised 880 primary school science teachers under the administration of the Uthai Thani Primary Educational Service Area in the 2022 academic year.

The sample comprised 500 primary school science teachers from the Uthai Thani Primary Educational Service Area in the 2022 academic year. A multistage sampling technique was employed as follows.

Determination of Sample Size

Following Vanichbuncha (2006) guideline of

selecting at least 15 cases per variable, and given 29 variables in this study, the minimum required sample size was 435 teachers. To enhance the reliability of the findings, the researcher increased the sample size to 500.

Multistage Sampling Steps
Stratification by School Size

All primary schools in the service area were grouped into four strata based on total enrolment.
- Small schools: fewer than 120 students
- Medium schools: 121–600 students
- Large schools: 601–1,500 students
- Extra-large schools: 1,501 students or more

Stage 1 – School Selection

Within each stratum, 50 percent of schools were randomly selected as the primary sampling units.

Stage 2 – Teacher Selection

From each selected school, 50 percent of the science teachers were randomly sampled, yielding a total of 500 participants.

Variables

The variable is the information and communication technology (ICT) competency of science teachers under the Uthai Thani Primary Educational Service Area Office, comprising three domains: knowledge, skills, and attitudes.

Research Design

This study employed a quantitative research design using confirmatory factor analysis (CFA) to examine the factor structure of science teachers' information and communication technology (ICT) competencies. The target population consisted of 880 science teachers in the Uthai Thani Primary Educational Service Area Office during the 2022 academic year. A total of 500 participants were selected using multistage sampling.

The research instrument was a 77-item questionnaire utilising a five-point Likert scale developed by the researcher. The instrument was validated for content validity by experts, with item-objective congruence (IOC) values ranging from 0.60–1.00. The discrimination indices ranged

from 0.44 to 0.92, and the reliability coefficients, calculated using Cronbach's alpha, ranged from 0.97–0.99.

The data were analysed using confirmatory factor analysis (CFA) with statistical software to verify the construct validity of the model and assess its consistency with empirical data.

Research Instruments

The instrument used to collect data in this research was the ICT competency test, which is divided into two parts as follows:

- **Part 1**: Basic information questionnaire for science teachers, including gender, age, school, and teaching experience in science subjects. The questionnaire was in the form of a checklist and a fill-in-the-blank format, with four items.
- **Part 2**: ICT competency components questionnaire, which is a 5-level rating scale, consisting of 3 components: 1) knowledge, 2) skills, and 3) attitude, with 77 items.

Content validity was checked by five experts with the following qualifications: 1. Three people with a master's or doctorate degree in educational measurement and evaluation or a related field. 2. Two people with a master's or doctorate degree in educational information technology or a related field. The experts considered the consistency of the questions with the defined variables and characteristics. Questions have an IOC value between 0.6 and 1.0

The questionnaire had a discrimination power between 0.44 and 0.92, with 77 questions.

The reliability of each aspect of the questionnaire is knowledge aspect has a value of 0.971, skills aspect has a value of 0.989, attitude aspect has a value of 0.972.

Data Collection Procedure

The researcher collected data by sending questionnaires using Google Forms. The steps for data collection are as follows:

The researcher wrote a letter requesting permission to collect research data from the Graduate School, Nakhon Sawan Rajabhat University, to educational institutions in Uthai Thani Province, namely, under the Office of the Uthai Thani Primary Educational Service Areas 1 and 2, to request cooperation in collecting data from teachers who were the sample group.

The researcher sent the questionnaires created by Google Form to educational institutions under the Office of the Uthai Thani Primary Educational Service Area that were authorised to request cooperation from science teachers in answering the questionnaires.

The researcher collected 465 questionnaires that received responses.

The researcher checked the completeness of the questionnaires that received responses and found that 450 out of 500 questionnaires, or 90.00 percent, were complete and could be analysed.

Complete data were entered into the statistical data analysis process.

Data Analysis

The researcher analysed the obtained data and used various statistical values in the following order:

Basic statistical values were analysed to identify the characteristics of the sample and the distribution characteristics of each variable used in the study, and percentages were analysed for nominal variables. The basic statistics used in the analysis were percentages and means of the data.

The second-order confirmatory components of the Information and Communication Technology Competency Test for Science Teachers under the Office of the Uthai Thani Primary Educational Service Area were analysed to examine the consistency between the structural model of the components of Information and Communication Technology Competency and the empirical data using the Mplus program.

Result of Data Analysis
Section 1: Results of the Analysis of the Sample Group's Basic Information

The basic information of the sample group included data on gender, age, and teaching experience in science. The analysis results of the Sample Group's Basic Information show that most science teachers under the Office of Uthai Thani Primary Educational Service Area are female, accounting for 87.33 percent, while male teachers account for

12.67 percent. Most of the teachers are aged between 20 and 30 years (33.78 percent), followed by those aged 31–40 years (32.89 percent). Most of them have less than 6 years of teaching experience in science subjects, accounting for 40.44 percent, followed by those with 6–10 years of experience at 30.89 percent.

Section 2: Results of the First-Order Confirmatory Factor Analysis of ICT Competencies of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

In this section of the data analysis, the researcher examined the subcomponents of ICT competencies, which consist of three main components: knowledge (seven subcomponents), skills (14 subcomponents), and attitudes (eight subcomponents), totalling 29 subcomponents. Pearson correlation coefficients were calculated and used for the first-order confirmatory factor analysis. The results are presented in Table 1.

Table 1 First-Order Factor Analysis of the ICT Competency Model of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

Variable	b	SE	t	R^2
First-Order Factor Analysis				
Knowledge (k)				
k1	0.709	0.027	26.023**	0.503
k2	0.801	0.045	17.845**	0.641
k3	0.903	0.016	56.494**	0.815
k4	0.943	0.012	76.076**	0.890
k5	0.842	0.016	51.185**	0.709
k6	0.847	0.023	36.865**	0.717
k7	0.857	0.022	38.817**	0.735
Skill (s)				
s1	0.817	0.017	49.530**	0.668
s2	0.888	0.011	78.992**	0.788
s3	0.699	0.025	28.144**	0.488
s4	0.938	0.008	123.165**	0.880
s5	0.856	0.014	61.121**	0.733
s6	0.895	0.010	86.071**	0.801
s7	0.902	0.014	65.239**	0.814
s8	0.935	0.008	122.014**	0.874
S9	0.917	0.008	111.503**	0.842
s10	0.897	0.010	86.360**	0.804
s11	0.791	0.020	40.075**	0.626
s12	0.897	0.011	79.845**	0.804
s13	0.892	0.013	66.203**	0.795
s14	0.869	0.013	67.622**	0.755
Attitude(a)				
a1	0.824	0.019	43.102**	0.680
a2	0.788	0.021	36.654**	0.621
a3	0.905	0.022	41.467**	0.820
a4	0.918	0.015	62.006***	0.842
a5	0.645	0.029	22.256**	0.417
a6	0.798	0.026	30.454**	0.637
a7	0.780	0.037	21.143**	0.608
a8	0.850	0.036	23.474**	0.722

Note * $P < .05$ ** $P < .01$

From Table1, when considering each component, it was found that the knowledge component consisted of seven observed variables, with factor loadings ranging from 0.709 to 0.943. The variable with the highest factor loading was "having knowledge of digital information and applying digital information in teaching" (k4), with a factor loading of 0.943.

Section 3: Results of the Second-Order Confirmatory Factor Analysis of ICT Competencies of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

In this stage of the analysis, the researcher used the subcomponent scores to test the model's consistency with the empirical data by conducting a second-order confirmatory factor analysis. The results are presented in Table 2

Table 2 Goodness-of-Fit Indices of the Confirmatory Factor Analysis Model for the ICT Competencies of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

	Fit Indices
Chi-Square Statistic (X^2)	107.331
Probability Value for Hypothesis Testing (P-value)	0.2439
Degrees of Freedom (df)	98
Relative Chi-Square (X^2/df)	1.095
Comparative Fit Index (CFI)	0.999

Non-Normed Fit Index (TLI)	0.998
Standardized Root Mean Square Residual (SRMR)	0.022
Root Mean Square Error of Approximation (RMSEA)	0.015

The results of the second-order confirmatory factor analysis using Mplus software revealed that the model demonstrated a good fit with the empirical data. This was evident from the chi-square value of 107.331, with a probability level of 0.2439, indicating that the chi-square value was not significantly different from zero. The relative chi-square was 1.095, which is less than 2.00, suggesting that the structural model has a satisfactory fit with the empirical data. In addition, the Comparative Fit Index (CFI) was 0.999, and the Tucker-Lewis index (TLI) was 0.998, both of which indicate an excellent model fit with the empirical data.

Table 3 Factor Loadings and Model Fit Results of the ICT Competency Model of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

Variable	b	SE	t	R^2	Factor Score Coefficient
Second-Order Factor Analysis					
Knowledge(k)	0.940	0.018	52.278**	0.883	-
Skill (s)	0.896	0.019	47.431**	0.803	-
Attitude (a)	0.708	0.029	24.809**	0.504	-
Goodness-of-Fit IndexChi-sqaure = 107.331 df = 98 P = 0.2439 CFI = 0.999 TLI = 0.998 SRMR = 0.022 RMSEA = 0.015					

Note * P < .05 ** P < .01

As shown in Table 3,the factor loading for the knowledge component (k) was 0.940, for the skills component (s) was 0.896, and for the attitude component (a) was 0.708. The standard errors (SE) ranged from 0.018 to 0.029. The statistical significance (t-values) of the factor loadings ranged from 24.809 to 52.278, all of which were statistically significant at the P <.01 level. The reliability of the data (R^2) showed that the predictive coefficient for the knowledge, skills component was 0.803, and attitude components were 0.883, 0.803, and 0.504, respectively.

The ICT competency model of science teachers under the Office of Uthai Thani Primary Educational Service Area consists of three components and is consistent with empirical data. The model fit indices were: df = 98, p = 0.2439, RMSEA = 0.015, CFI = 0.999, TLI = 0.998, SRMR = 0.022, and Chi-square = 107.331. Considering the factor loadings, the most significant component was the knowledge component (0.940), followed by the skills (0.896) and attitude (0.708) components.

To provide a clearer understanding of the ICT competency model of science teachers under the Office of Uthai Thani Primary Educational Service Area, the researcher presents the confirmatory factor analysis model of ICT competencies, as illustrated in Figure 1.
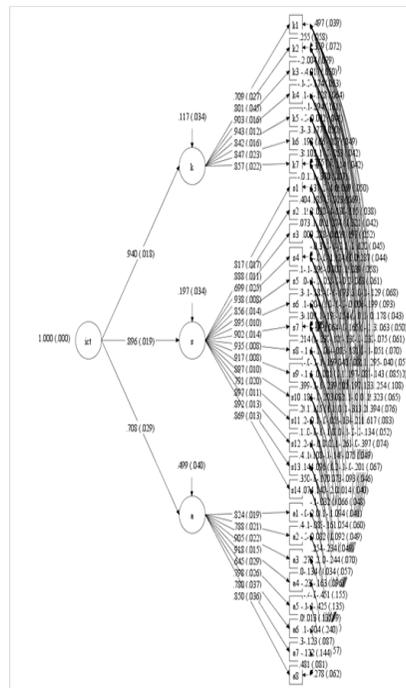

Figure 1 ICT Competency Model of Science Teachers under the Office of Uthai Thani Primary Educational Service Area

Figure 1 shows that the ICT competency model of science teachers under the Office of Uthai Thani Primary Educational Service Area consists of the following components: knowledge (k), skills (s), and attitudes (a), with factor loadings ranging from 0.708 to 0.940.

Research Results

The research on the components of information and communication technology (ICT) competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area can be summarized as follows:

The results of the first-order confirmatory factor analysis revealed that all 29 subcomponents of ICT competencies were significant elements of the ICT competency assessment model. When examining each subcomponent, it was found that the variables under the knowledge component had factor loadings ranging from 0.709–0.943. The variable with the highest factor loading was "having knowledge of digital information and applying digital information in teaching" (k4), with a factor loading of 0.943.

The variables under the skills component had factor loadings ranging from -0.699 to 0.918. The variable with the highest factor loading was "ability to use basic programs and various office software applications" (s4), with a factor loading of 0.938.

The variables under the attitude component had factor loadings ranging from 0.645–0.918. The variable with the highest factor loading was "acceptance and ethical compliance with regulations on technology use" (a4), with a factor loading of 0.897.

The results of the second-order confirmatory factor analysis, conducted to examine the consistency between the structural model of ICT competency components and the empirical data, showed that the model had a good fit with empirical data. The Chi-square value was 107.331 with a probability level of 0.2439, indicating that the chi-square value was not significantly different from zero. The relative chi-square was 1.095, which is less than 2.00, suggesting that the structural model is satisfactorily consistent with the empirical data. Additionally, the Comparative Fit Index (CFI) was 0.999, and the Tucker-Lewis Index (TLI) was 0.998, indicating a strong model fit. The Standardised Root Mean Square Residual (SRMR) was 0.022, and the Root Mean Square Error of Approximation (RMSEA) was 0.015, both of which were low and close to zero. These indices indicate that the confirmatory factor analysis model of the ICT competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area, comprising three components—knowledge, skills, and attitudes—is consistent with the empirical data.

In the second-order factor analysis, the factor loadings of the ICT competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area were ranked from highest to lowest as follows: knowledge (k) (b = 0.940), skills (s) (b = 0.896), and attitude (a) (b = 0.708).

Discussions

The research on the components of information and communication technology (ICT) competencies of science teachers under the Office of Uthai Thani Primary Educational Service Area presents the following key points for discussion:

The results of the first-order confirmatory factor analysis revealed that the knowledge component had the highest factor loading. The top three observed variables that best represented this component were: Knowledge of digital information and the ability to apply it in teaching; Knowledge of basic computer operations and peripheral devices, including basic troubleshooting and maintenance; and Knowledge of using various office software applications. This finding may be due to the fact that digital literacy is considered a crucial factor in effective classroom instruction. Teachers with foundational knowledge of technology are better equipped to handle classroom situations, such as configuring devices and addressing basic technical problems. This result is consistent with Kittipadung (1998), who stated that users must possess various types of knowledge, including strong proficiency in both English and Thai for communication and knowledge acquisition, an understanding of computer languages, and the ability to apply computer knowledge to tasks. Users should also understand how to use software to facilitate work, possess knowledge of various types of software applications, and be familiar with

computer maintenance, hardware and software selection, adjustments, and applications. In addition, the findings align with the previous research of a model for developing ICT competencies among primary school teachers in Northeastern Thailand. The study found that knowledge competencies consisted of basic ICT knowledge and knowledge of using ICT to support professional tasks.

Following the knowledge component, the skills component ranked second in terms of the factor loading. The top three observed variables that best represented this component were: ability to use basic programs and various office software applications, ability to design and develop information and communication technology (ICT) tools for instructional purposes, and ability to use ICT in assessing the teaching and learning process and utilising the evaluation results to improve and design instructional activities. This finding may be explained by the growing recognition that technological skills are essential for teachers in the 21st century, as they play a vital role in enhancing instructional effectiveness and preparing students to thrive in a technology-driven environment. These skills also encompass the ability to conduct ICT-related research, integrate ICT into instructional practices, share knowledge, and collaborate with others. This result is consistent with the statement by the study that teachers must be proficient in using tools, materials, and various technologies that are necessary and appropriate for instruction in the digital age. It is also supported by the research of the study of a competency development model for ICT among primary school teachers in Northeastern Thailand. Her study indicated that ICT skills consist of basic ICT skills, skills in using ICT for instructional management, and skills in applying ICT for administrative and professional tasks.

Finally, the attitude component showed the lowest factor loading among the three components. The top three observed variables that best described this component were: Acceptance and ethical compliance with regulations regarding technology use, Understanding and willingness to adhere to rules governing technology use, and Teachers' continual self-directed learning in information and communication technology (ICT). This finding may

be explained by the fact that teachers' integration of ICT into instructional practice is fundamentally influenced by their acceptance of technology. Such acceptance plays a key role in promoting the effective integration of technology into teaching and ultimately enhancing student learning outcomes. These findings are consistent with Kittipadung (1998), who asserted that users' success depends on their positive attitude toward computers. Users who are confident in using computers and communication devices, eager to learn, satisfied with working with technology, and consistently follow technological advancements tend to be more effective in their use. Furthermore, users must be committed to integrating ICT into teaching and learning, self-disciplined, respectful of rules and regulations, and persistent in solving problems that arise when using computers and communication tools. They should also demonstrate a desire for continuous self-improvement, an interest in creating digital media, and a sense of responsibility for the information they use. This is also aligned with study of developed components of ICT teaching competency for lower-secondary school teachers. Her study emphasised that teachers should possess a positive attitude toward computers, a positive attitude toward the Internet, and a readiness to embrace change.

The second-order confirmatory factor analysis indicated that science teachers' ICT competency comprised three main components: Knowledge, Skills, and Attitude. Each component demonstrated the following standardised factor loadings: the Knowledge component had the highest factor loading ($\beta = 0.940$, $R^2 = 0.883$), reflecting that foundational knowledge in ICT is the core requirement for teachers. This includes understanding fundamental concepts, data management, software use, and application principles in the teaching and learning context. This finding aligns with the UNESCO framework, which emphasises that knowledge is the foundation for all other competencies. Teachers are expected to possess knowledge in three interrelated dimensions—content, technology, and pedagogy—which ultimately fosters the development of appropriate skills and attitudes for effective 21st-century learning. Similarly, Harinvon et al. (2014) affirmed that basic ICT knowledge forms the core

of teacher competency frameworks across all levels. The Skills component followed (b = 0.896, R² = 0.803) and served as a practical mechanism, reflecting the ability to use technology efficiently, such as selecting appropriate tools, creating media, operating equipment, and troubleshooting technical issues. This finding is consistent with Hakkarainen et al. (2001), who noted that ICT skills are the next most important aspect after knowledge acquisition. Teachers with strong ICT skills are more confident and effective in integrating technology into their classrooms. The Attitude component had the lowest factor loading (b = 0.708, R² = 0.504), but it remained important in a qualitative sense. Attitude functions as a psychological reinforcement that promotes sustainable ICT use. This component encompasses teachers' confidence, willingness to adopt technology, and intrinsic motivation for continuous learning. These findings are supported by Tondeur et al. (2016), who found that teachers' attitudes have a greater impact on the integration of technology than technical factors.

Recommendations
Recommendations for Utilization The Research Results

Based on a study of the components of information and communication technology (ICT) competence among science teachers under the Uthai Thani Primary Educational Service Area Office, the knowledge component carries the highest weight—specifically, knowledge of information in digital form and the use of digital information in instruction. Accordingly, school administrators in this jurisdiction can use the findings as a guideline to develop teachers' capacity in ICT knowledge and AI-aware digital pedagogy by organising academic and hands-on training on topics such as AI fundamentals for teachers, digital media production and creation, data literacy, and designing integrated and blended lessons. These activities enhance teachers' knowledge and understanding of current technologies.

Based on a study of the components of ICT competence among science teachers under the Uthai Thani Primary Educational Service Area Office, the attitude component carried the lowest weight,

specifically respect for and compliance with ICT-related laws. Accordingly, school administrators can use these results to organise workshops that concretely strengthen teachers' understanding, awareness, respect for, and compliance with relevant laws, thereby supporting the safe, correct, and sustainable integration of technology into teaching and learning. Workshop content should also be updated for AI and emerging technologies, including personal data protection, copyright/fair use and open licencing, cybersecurity hygiene, AI ethics and responsible use, and digital citizenship training.

Recommendations for Future Research

A study and analysis of the components of information and communication technology competency of teachers in other organisations, such as the Secondary Education Area Office or local government organisations, should be conducted, and the resulting evidence should be used to adapt and present practical guidelines for promoting and developing ICT competencies expanded to encompass AI, digital pedagogy, and emerging technologies thatare implementable now and aligned with future needs.

It is recommended to conduct an exploratory factor analysis (EFA) of science teachers' ICT competency to identify new or emerging components that reflect the latest developments and trends, including AI, digital pedagogy, and emerging technologies.

Future research should examine the ICT competencies expected to emerge in response to technological changes, such as artificial intelligence (AI), by considering a broad spectrum of competencies that accommodate diverse forms of learning and emphasise integrated, blended approaches. This agenda should be expanded to encompass digital pedagogy and emerging technologies (e.g. data science, extended reality (XR), and cybersecurity).

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