Turkish Journal of Computer and Mathematics Education *Vol.12 No.14(2021), 2737- 2748*

Research Article

Thai Information and Communication Technology (ICT) Student-Teacher Competencies

Jutaporn Chardnarumarn[a], Aukkapong Sukkamart[b],Thiyaporn Kantathanawat[c]

[a]Doctoral student, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand
[b]Associate Professor, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand
[c]Associate Professor, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand

Abstract: The study set out to investigate which factors contributed to a Thai student teacher's competency as viewed from the experiences and expertise of their teachers. The sample group of 214 teaching professionals was collected by the use of multistage random sampling from the Computer Science education departments of 31 Rajabhat Universities (Thai teaching universities) dispersed across four geographical regions in Thailand. LISREL 9.10 software was used to conduct the 2nd order CFA. From the analysis, it was determined that the student-teacher programming skills (PROG) were the most important (1.00). This was followed closely by their educational digital media (MEDIA) skills (0.93), and then their overall ICT knowledge (KNOW) (0.88). The study also determined that hands-on, working knowledge of multimedia applications was judged as the single most important skill that a student-teacher could have. This was closely followed by their project development skills and a good understanding of peripheral software management software, computer operating systems, and educational application software. **A**ll elements were found to be consistent with the empirical data and demonstrated structural integrity, while all 15 observed variables were determined to be at a 'high level' in support of student-teacher ICT competency.

Keywords: Computer science majors, digital media, ICT instructors, information technology competency, preservice teachers, Thailand.

1. Introduction

Teaching is one of the most rewarding professions there is but at the same time also one of the most challenging. One major reason for these challenges is the pace of technological change, both inside and outside the classroom.

Another aspect is students frequently access new technologies far quicker than their teachers. However, new digitally based learning concepts are constantly evolving and teachers are now expected to not only use these new platforms and software but be able to teach them (Matthews, 2021).

Unfortunately, there are a significant number of educators who refuse to embrace these new technologies and are still focused on their comfort level of using traditional 'chalk and talk' methods (Allen, 2020; Dili, 2016; Kenan Foundation Asia, 2021; Mongkhondao, 2015; Vangmeejongmee&Naiyapatana, 2017). Moreover, other studies have revealed that Thai educators are overwhelmed with their assigned tasks which leave them with little time to prepare for their assigned classes and learn new technologies. This problem is very similar to research from Pakistan, in which Pasha et al. (2019) stated that time availability was one of the most prominent challenges faced by teachers.

Fortunately, however, student teachers are part of a new breed of technologically enabled 21st-century educators who can flip a classroom and use a YouTube video with a high degree of confidence and skill (Noonoo, 2012). Therefore, expectations are high for student teachers in many ways and across many aspects of the culture they will be expected to teach in.

In Thailand, various studies have examined both teacher and student-teacher competencies in digital and information communications technology (ICT) teaching and learning environments. Studies also abound that highlight the virtues of digital classroom mediums such as flipped classrooms (Eppard&Rochdi, 2017; Fornons et al., 2021;Noonoo, 2012), blended learning environments (Siripongdee et al., 2021; Wahyudi, 2020), and online classrooms, especially since the COVID 19 global pandemic wreaked havoc and shuttered nearly every campus around the world.

Moreover, these same digitally based learning environments have been proposed as the secret to enhancing a student's higher-order thinking skills (HOTS) and their creative and critical thinking skills (Kruger, 2013).

Governments and their respective education ministries have also written into their five-year economic and educational plans they need for 21st century digitally enabled knowledge workers who have creative and critical thinking skills and who are also motivated to do lifelong learning (Rauch et al., 2021).

Fortunately, anything is possible when access to the right tools is achieved and when the teachers know how to use these tools to teach their students. However, with these new possibilities, there is an increase in demand for teachers as well as the expectation that they will know how to use them better than the students they teach. Also, with the advantage of 24/7 access to learning management system (LMS) based lessons and collaboration, comes the fact that teachers no longer just 'teach' in their classroom at a specific time and place (Eppard&Rochdi, 2017; Shih & Tsai, 2017). In these aspects, difficulties and challenges abound.

Furthermore, under guidelines established in the Thailand 4.0 initiatives, implementation requires a Thai creative society in which innovation is used to enhance new thinking and skills for both teachers and students (Buasuwan, 2018). Once again, under Thailand 4.0, the plan is to use technological innovation and education and robust Internet and wireless access to create a new generation of knowledge workers (Rauch et al., 2021). Thus, the focus and support are now on teaching and learning that helps students with creative thinking, problem-solving skills, and the use of innovation to increase productivity. At the forefront of the numerous and difficult challenges will be Thailand's next generation of student teachers (Boonkua et al., 2019; Office of the National Economic and Social Development Board, 2017).

However, challenges must be met with competent teachers and the measurement of competency is a highly debated field, with many scholars pointing to research by McClelland in the late 1950s as being at the forefront of the discussion on competency (Boyatzis et al., 2017). As a research psychologist, McClelland linked the human ability to perform through job-competency study methods and developments and measured an individual's capability from their motives, self-image, skills, and traits (Kanawapee et al., 2021).

2. Literature Review

2.1. Student-Teacher ICT Knowledge (KNOW)

Khvilon and Patru (2002) have highlighted how imperative it is that teachers are knowledgeable as to the content, teaching methodologies, and standards of their disciplines. Moreover, a combined study from the OECD/UNESCO (2016) on Thailand outlined Thai teacher ICT strategies additionally stating that schools needed to focus on improving Thai teacher ICT classroom skills. It was additionally stated that teacher technology provides tools for analyzing and synthesizing data.

Yuktirat et al. (2018) has also added that digital content can be conveyed through a variety of digital media and formats, while Achwarin (2009) identified nine Thai teacher core competencies (TCCs) including teacher language and technology and their ability to do curriculum development, educational research abilities, and how well they can create educational innovation, use information technology.

2.2. Student-Teacher Programming Skills (PROG)

In Thailand, a study conducted by Kaewta et al. (2020) indicated that programming skills are essential in the creation or development of programs that potentially can evolve into today's most popular smartphone applications. Also, programming skills are needed for the applications and innovations for the Internet of Things (IoT) that require programming skills in building hardware, connectivity, displays, and sensors.

2.3. Student-Teacher Educational Digital Media (MEDIA)

Various scholars have expressed the need and importance for educators to embrace new technologies as technology connects real-world and relevant resources to subject area content (Achwarin, 2009; Jalli, **2020;** Khvilon&Patru, 2002). In Thailand, Phuapan et al. (2015) also stated that in a university environment, evaluation skills were the most essential educator skill for digitally based student learning development. This is consistent with other Thai research in which Watnayoo et al. (2019) noted that in Thailand teachers are expected to teach less but students need to learn more. Therefore, teachers need to modify their teaching focus and instead focus on new teaching designs which rely on their ICT abilities and the use of hardware, software, as well as analyzing media that is effective for student teaching and learning.

However, in a study by Sinlapasakkhajorn and Unaromlert (2015) on obstacles facing 304 teachers in their use of digital media and ICT resources in the rural primary schools in Thailand's northeast province of NakornPathom, the authors discovered significant problems. These included serious problems in out-of-date software, lack of computers, and lack of knowledge of the Internet and Internet applications, and frequent Internet

outages. However, the 'digital divide' is not just a Thai problem but one which exists throughout all of southeast Asia as only three countries (Brunei, Malaysia, and Singapore) have over 80% Internet penetration (Federal Communications Commission, 2014). In Indonesia, out of the country's total population of 268 million, only 56% or 150 million have Internet access. In Thailand, only 57%, in Myanmar only 39%, and finally, in Vietnam, only 38% had Internet access in 2019.

2.4. Student-Teacher ICT Competencies (COMP)

In Thailand, multiple studies have been conducted on teacher competencies. One study from Khunsang and Chaisiri (2020) reported that there were five competency-related aspects involved in teachers majoring in educational technology. These included the teacher's knowledge of ICT, their skills in using ICT, their self-concept, traits, and finally, their attitudes and motivations. Kanawapee et al. (2021) also determined that Thai high school teachers felt their highest competency need was their skill at the curriculum and learning management and the analysis, synthesis, and research for learner development.

In other research concerning Thai and Southeast Asian teacher core competencies (TCC), Vesamavibool et al. (2015) determined 10 TCCs could be measured. These included class preparation, the learning environment's construction, resource development and utilization, student evaluation, and moral and ethics promotion. Teacher competency was also stated to include the creation and development of networks as well as making sure of the welfare of each student. This is also consistent with Wilson and Berne (1999) who investigated TCC and highlighted the great importance, characteristics, and advantages/disadvantages of professional teaching networks. Furthermore in Thailand in 2012, the Office of the Basic Education Commission (OBEC) created a similar list of TCCs. These include curriculum management and learning management, learner development, classroom management, analysis, synthesis, and research to develop learners, teacher leadership, and community relationship building and partnerships for basic learning (Singsungnoen&Jeerungsuwan, 2015).

2.5. Objectives of the Research

To analyses the supporting components of ICT competence for undergraduate student teachers majoring in Computer Science while attending Thai Rajabhat Universities (student-teacher universities)

3. Methodology

The following sections detail the process of questionnaire development, data collection, data analysis, and ensuring reliability and validity of the processes used.

3.1. Population and Sample

The population used in this research was lecturers and professors involved in preparing Thai student teachers for teaching positions in the fields of Computer Science, computer studies technology, or information technology-related fields from one of 31 Thai Rajabhat (teaching) Universities. Furthermore, to obtain a statistically valid sample size we conducted a review of the literature from which it was determined that numerous scholars have determined and used a ratio of 10 questionnaires for each observed variable (Schumacker & Lomax, 2010) in a CFA model. Therefore, as the study was finalized with 15 observed variables, an initial target was set of 150 questionnaires. However, Hair et al. (2016) has reported that samples from 200 – 400 are generally better. Additionally, Loehlin's (1992) Monte Carlo simulations on CFA models have also determined that a sample size ≥ of 200 is best. From these suggestions, we set a goal of 214 teachers and professors.

3.2. Research Tools

The research tool was a questionnaire that was compiled from the related theory concerning educational competency for ICT student teachers. In the design and eventual implementation, two sections were used. In section 1, each respondent was asked to give their input concerning their gender, age, degree level, their current title/position, teaching experience, and which Thai region they were teaching in. In section 2, three parts were consisting of 15 observed variables used a 5-level opinion scale to assess the level of agreement from each respondent. Furthermore, Part 1 in Section 2 had five items related to the importance of each student teacher's knowledge (KNOW) in each ICT area. Part 2 consisted of six items concerning their educational computer system design and programming skills (PRO), and finally, part 3's four items concerning digital educational media. The actual scale and values were 4.50 – 5.00 indicating the '*most agreement*', 3.50 – 4.49 as '*significant agreement*', 2.50 – 3.49 as '*moderate agreement*', 1.50 – 2.49 was '*minimal agreement'*, and finally, 1.00 – 1.49 was a '*strong disagreement*' with the item's statements.

3.3. Pre-Test Questionnaire Reliability and Validity Testing

After the questionnaire's development, seven ICT educational experts reviewed each of the questionnaire's items and gave their assessment of the survey instrument's content quality. Numerous studies suggest that the index of item-objective congruency (IOC) is a useful numerical tool for this purpose (Turner & Carlson, 2003). Normally, items with values of ≤ .50 are deleted or revised. After this process, we were pleased to note that the final questionnaire had IOC values 0.57 – 1.00, and reliability values averaging 0.85.

Finally, to confirm the questionnaire's usability, accuracy, and reliability, we undertook a pre-test in which 35 ICT teachers were asked to evaluate the proposed questionnaire format and research items. Once again, numerical values were assigned to each group of items using Cronbach's α, in which George and Mallery (2010) have also suggested that ≥ .8 is good, and α values ≥ .9 is excellent. Our pre-test returned an Alpha α average value of 0.92.

3.4. Data Collection

The population for the study was teachers and professors teaching in information technology, Computer Science, computer studies, technology, or information technology-related fields within the Faculty of Education at one of 31 Thai Rajabhat (teaching) universities. After this determination, multistage random sampling was used to ensure a consistent and harmonious collection of the empirical data by dividing Rajabhat Universities across Thailand into four geographical regions comprising Thailand's north, central, northeastern, and southern regions. Data collection commenced in September 2020 and was completed by the end of January 2021 which was performed using online questionnaires.

3.5. Data Analysis

The researcher analyzed the data by using a combination of statistical software programs. The details of the analysis are as follows:

- The analysis of each of the variables for the 2nd order CFA model was undertaken using LISREL 9.10 with the interpretation and validation of the model done using the harmonization index criteria as shown in Table 3.
- The analysis of each teaching professional's opinion concerning student-teacher ICT competency used descriptive statistics output from IBM® *SPSS*® for Windows Version 21 program.

4. Results

Research results from the 2nd order CFA student-teacher competency model included the respondents' general information (Table 1), testing of the element weights and R2 (Table 2), a goodness-of-fit (GoF) analysis (Table 3), the final 2nd order CFA model for Thai ICT student-teacher competency (Figure 1), and finally, the descriptive analysis of the variables' mean and standard deviation (S.D.) for Thai teacher s' opinions on their student teachers' ICT competency (n = 211) (Table 4).

4.1. Teachers' Personal Characteristics

Table 1 shows that most of the professional teachers were male, accounting for 52.80%, and between the age of 36 - 45 (44.86%). Moreover, 51.87% of the Thai student teachers' teachers had obtained a Master's degree while another 48.13% had obtained a Ph.D. However, interestingly only 28.97% had risen to the rank of Assistant Professor while 70.56% classified themselves as a 'teacher' only. Finally, 45.33% had 6 – 10 years of teaching experience; another 28.50% had 10 or more years, while the remaining 26.17% had 0 – 5 years of experience.

Table 1. The teachers' general information *(n* = 214)

General Information	Teachers	%
1. Gender		
- Men	113	52.80
- Women	101	47.20
2. Age		
- 25 - 35 years of age	40	18.69
- 36 - 45 years of age	96	44.86
- 46- 55 years of age	47	21.96
- Over 56 years of age	31	14.49
3. Education level		

General Information	Teachers	%
- Master's degree	111	51.87
- Ph.D.	103	48.13
4. Academic position		
- Teacher	151	70.56
- Assistant Professor	62	28.97
- Associate Professor	1	0.47
- Professor	0	0.00
5. Teaching experience		
- Five years or less	56	26.17
- Six to ten years	97	45.33
- More than 10 years	61	28.50
6. University Group		
- Central Group	76	35.51
- Southern Group	21	9.81
- Northern Group	42	19.63
- Northeast Group	75	35.05

4.2. Testing of the Element Weights and R^2

Table 2 also details the LISREL 9.10 analysis results for β (regression coefficient), the SE (standard error), the t-test values, and the R^2 (coefficient of determination). First, Hooper et al. (2008) recommend that R^2 values should be ≤ 0.20. Therefore, we find that from the use of this parameter that the lowest R^2 value for all the variables was 0.33 for D2. Secondly, a t-test was performed in which Hair et al. (2016) have suggested that t-values are significant if the absolute t-value is $|t| \geq 1.96$. Once again, model strength determination was made as the lowest t-value was 12.44 for B5. Moreover, another indication of the mean value's reliability is the use of the SE (standard error), with larger sample sizes usually resulting in smaller SEs. Finally, in Table 2, we note the β values (standardized regression coefficient) which are used for strength comparison effects of each independent variable to the dependent variable (Khaled et al., 2019). The higher the absolute value of the β, the stronger the effect. This is consistent with research on Chinese entrepreneurial education by Mu et al. (2020) who reported that quantitative analysis frequently uses linear regression analysis to accomplish the statistical analysis of data in which β can be used to characterize the correlation between the variables.

Table 2. Variable weights and their R^2 values for student-teacher ICT competency

Elements/Variables	Element weights			R2
	β	SE	t	
I think Computer Science student teachers (CSSTs) should have a good basic knowledge of ICT (KNOW) (5 items).	0.88	0.06	12.79	
I think CSSTs should have a good understanding of how to repair a computer and computing logic (B1).	0.80	-		0.63*
I think CSSTs should be proficient and have a good understanding of peripheral software management software, computer operating systems, and educational application software (B2).	0.85	0.05	14.57	0.72*
I think CSSTs should be proficient in computer networks and their connections, data communications, and the Internet (B3).	0.84	0.05	15.72	0.70*
I think Computer Science student teachers should be proficient in computer equipment maintenance (B4).	0.83	0.05	14.10	0.68*
I think CSSTs should be proficient in ICT legal and copyright issues and be ethical in their installation and use (B5).	0.81	0.06	12.44	0.66*
I think CSSTs should have good educational computer system design and programming skills	1.00	0.07	13.86	

(PROG) (6 items).				
I think CSSTs should have a good working knowledge of computing mathematics (C1).	0.76	-		0.58*
I think CSSTs should be proficient in computer education system design (C2).	0.92	0.06	15.28	0.85*
I think CSSTs should be proficient in computer information systems design (C3).	0.85	0.06	13.18	0.72*
I think CSSTs should be proficient in educational database management software (C4).	0.87	0.05	14.93	0.76*
I think CSSTs should be proficient in their programming skills (C5).	0.85	0.05	14.26	0.71*
I think CSSTs should have good computer studies project development skills (C6).	0.86	0.05	14.68	0.74*
I think CSSTs should have good digital educational media skills (MEDIA) (4 items).	0.93	0.06	14.80	
I think CSSTs should be proficient in educational digital media production (D1).	0.85	-		0.73*
I think CSSTs should be proficient in computer graphic design (D2).	0.88	0.04	18.14	0.33*
I think CSSTs should be proficient in multimedia and animation lesson design (D3).	0.87	0.04	17.78	0.75*
I think CSSTs should be proficient in web design and related programming skills (D4).	0.86	0.04	17.58	0.73*

*$p \leq .01$, β = regression coefficient**,** SE = standard error,t = t-test values**,** R^2= coefficient of determination

4.3. Goodness-of-fit (GoF) testing

The 2nd-oreder CFA model was also found to be consistent with the empirical data as in the GoF analysis in Table 3 the $\chi 2 = 0.99$, $\chi 2/df = 0.95$, RMSEA = 0.00, GFI = 0.95, AGFI = 0.91, RMR = 0.01, SRMR = 0.01, NFI = 0.99, and CFI = 1.00, all indicating that the research model is harmonious with the empirical data.

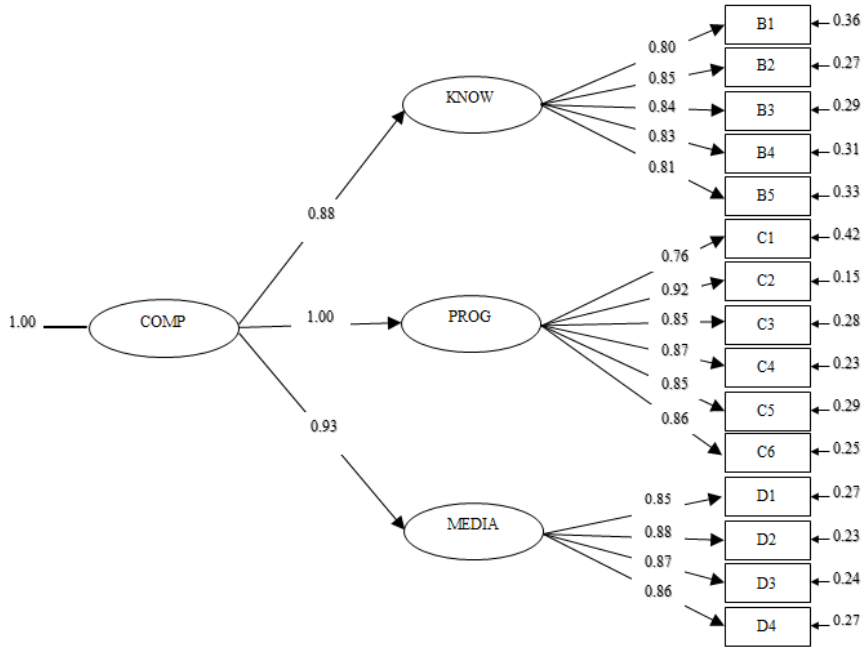
Table 3. Criteria, values, validity, and theory for the GOF appraisal

Criteria Index	Criteria	Value	Validity	Theory Support
Chi-square: $\chi 2$	$p \geq 0.05$	0.99	validated	(Rasch, 1980; Pimdee, 2020, 2021)
Relative Chi-square: $\chi 2/df$	≤ 2.00	0.95	validated	(Byrne et al., 1989; Pimdee, 2020, 2021)
RMSEA	≤ 0.05	0.00	validated	(Hu & Bentler, 1999)
GFI	≥ 0.90	0.95	validated	(Jöreskog &Sörbom, 1996)
AGFI	≥ 0.90	0.91	validated	(Hooper et al., 2008)
RMR	≤ 0.05	0.01	validated	(Hu & Bentler, 1999)
SRMR	≤ 0.05	0.01	validated	(Hu & Bentler, 1999)
NFI	≥ 0.90	0.99	validated	(Schumacker & Lomax, 2010)
CFI	≥ 0.90	1.00	validated	(Schumacker & Lomax, 2010)

4.4. Final 2nd-order CFA model testing results

Figure 1 shows the final 2nd order CFA model for Thai student-teacher ICT competency (COMP), which had a final Chi-Square = 26.75, df = 56, *p*-value = 0.99968, RMSEA = 0.000. Moreover, from the analysis of the 15 observed variables and the three latent variables, it was determined that Thai student-teacher ICT competency (COMP) has significant support from the programming skills (PROG) of each individual, followed by their digital media (MEDIA) skills, and lastly, their knowledge (KNOW), with component weights of 1.00, 0.93 and 0.88, respectively.

Figure 1. The final 2nd-order CFA model for Thai student-teacher ICT competency (COMP).



4.5. Teacher's Opinions on Student-Teacher ICT Competency Importance

Table 4 details the descriptive analysis of each variable's mean and standard deviation (S.D.) for the 211 Thai teachers' opinions on their student teachers' ICT competency importance. Overall, it was determined that each observed variable has a 'high level' (3.50 – 4.49) from each of the teaching professionals surveyed. Moreover, we find that the 15 observed variables had a mean value range of 4.03 - 4.21. Also, it has been suggested that CFA models should have a minimum of three observed variables for each of the latent variables, which was also met in this study. Also, Barclay et al. (1995) has determined that standardized loadings should be statistically significant (≥.50) and appropriately high which is ideally ≥ .707.

Furthermore, from the mean and S.D. analysis, we find that the greatest importance was placed on each student teacher'sworking knowledge of computer graphic design (D2). This was closely followed by each student teacher's good computer studies project development skills (C6) and good working knowledge of computer networks and their connections, data communications, and the Internet (B3). However, the least important aspect was each student teacher's knowledge of computing mathematics (C1).

Table 4. Descriptive analysis of the variables' mean and standard deviation (S.D.)

Indicator	Mean	S.D.
KNOW	4.17	0.72
B1	4.15	0.81
B2	4.19	0.74
B3	4.16	0.75
B4	4.17	0.84
B5	4.17	0.85
PROG	4.11	0.79
C1	4.03	0.90
C2	4.11	0.83
C3	4.13	0.79
C4	4.10	0.85
C5	4.07	0.87
C6	4.20	0.77
MEDIA	4.15	0.71
D1	4.13	0.81
D2	4.21	0.80
D3	4.13	0.79
D4	4.12	0.86

Indicator	Mean	S.D.
Average	4.14	0.80

5. Discussion

The findings from this study's 2nd order CFA are consistent with the learning outcomes detailed in 2019 by Thailand's Ministry of Education's announcement on the standard of qualifications for a four-year bachelor's degree in education for the ICT student teacher program. In this guide, the MOE details that student teachers in ICT programs should know about learning technology, concepts, principles, theories, and be capable of analysing and evaluating the knowledge of ICT use in education. Moreover, each student teacher should be able to apply this knowledge in designing and managing digitally based learning systems (Fornons et al., 2021).

The MOE's guidelines are also consistent with Thailand's ICT framework (ICT2020), in which Thailand envisioned a "Smart Thailand 2020" strategy, with ICT as a key element in improving the Thai economy and life quality. In the third iteration, key objectives were stated to entail broadening ICT access through continuous ICT infrastructure improvement, increased mobile broadband penetration, and increased Thai citizen digital literacy and information literacy (Oranop, 2016). With a change in governments came a change of plans, which today is referred to as the Digital Economy Master Plan (DEMP). Under it, there were five main concepts including the improvement and expansion of hard, soft, and service infrastructures, promotion and innovation, and finally, Thai society and knowledge.

Support for these digital plans can also be found in the *European Framework for the Digital Education Action Plan* which discusses the need for education and training in support of achieving greater use of innovative thinking, digital technology, and digital skills development (European Commission, 2018). Moreover, digital competencies are stated as being critical to the safe use of digital technology in a rapidly evolving digital society. By so doing, educators and their initial training (preservice and student teachers) are highly relevant for achieving the effectiveness of these objectives.

5.1. Programming (PROG)

These principals and plans were also found to be consistent with the overwhelming importance (1.00) of the need for *programming* (PROG) skills determined by the study's 211 Thai professional teachers shown in the study's final model (Figure 1). This result is also consistent with Sengsri (2019) who stated that programming is a compulsory class at the bachelor's Computer Science degree level in Thailand which offers the opportunity to enhance ICT skills and logical thinking and analysis. Programming is also a skill that supports science learning which can also be integrated with many other sciences, including mathematics, computing mathematics, computer studies, data analysis, and related theory (Siriwat et al., 2017).

Luadnakhawok et al. (2017)has also suggested that instructors need to adjusttheir roles from teaching to designing the learning process, as ICT advances have expanded the reach, awareness, and openness of knowledge and the ability to communicate with each other. Moreover, teachers need to learn together with their students and paradoxically reflect on the students' previous learning experiences and new learning experiences based on empirical data and data gathered from ICT resources.

5.2. Educational digital media (MEDIA)

The study next determined that student-teacher knowledge concerning educational digital media was ranked second most important by their teachers (0.93). However, studies have shown that many teachers lack the motivation to use digital resources in class due to their perceived ineffectiveness or benefit awareness (Groff &Mouza, 2008). Therefore, as Matthews (2021) suggests, teachers need to continually develop their digital literacy (DL) skills to ensure that students receive the most recent and highest quality education possible.

In Thailand in many rural schools, resources are lacking including software, computers, and reliable Internet connectivity (Federal Communications Commission, 2014; Sinlapasakkhajorn&Unaromlert, 2015). However, even when resources are readily available, benefits from ICT will not come unless the teacher and their students understand how to implement it (The Office of Educational Technology, 2017).

Therefore, as the results from this study show in response to item D2, "I think Computer Science student teachers should have a good working knowledge of computer graphic design," was determined by the Thai ICT educators as the most important variable in the study (mean = 4.21, S.D. = 0.80). This is interpreted as suggesting that a working, hands-on knowledge of the software is paramount in the perception of a student teacher's classroom competency.

5.3. ICT Knowledge (KNOW)

The study also determined that KNOW was the third most important (0.88) contribution to a Thai student teacher's teaching competency. This is consistent with numerous other studies in which student-teacher knowledge of ICT and its use in a classroom was determined to be crucial. Specifically, studies have pointed to ICT benefits including longer attention spans, increased learning motivation, greater classroom participation and engagement, higher academic achievement, and increased DL (Bester & Brand, 2013; Filer, 2010; Friedman, 2019; Levy, 2018).

5.4. Student-teacher ICT competency (COMP)

A student teacher's ICT competency is a global concern, as in the OECD TALIS 2018 Results (2019) report and the Digital Education at School in Europe report (Eurydice, 2019), both studies highlight the crucial role that educators must play to ensure the proper use of ICT by students. Therefore, student-teacher training must involve learning concerning the appropriate, critical, reflective, and ethical use of ICT.

In Thailand, Khunsang and Chaisiri (2020) added that teacher competence in ICT education emphasis should also be placed on having a role in bringing knowledge and ability to develop learners in achieving effective learning, research development, and integrate various sciences for use in creating coursework, teaching activities, and evaluation processes. Finally, ICT teachers should be able to analyse, synthesize, assess knowledge of technology, be up-to-date, and be able to apply ICT resources to self-development, learners, and teaching-learning management.

Vangmeejongmee and Naiyapatana (2017) also examined Thai teacher competency problems and stated that traditional methods are still quite common in Thai classrooms (chalk and talk), the lack of motivation to teach, and the inability of the teacher to keep pace with the change. The authors also added that there were seven elements involved in developing 'teacher competency'. These were student-centered teaching, assessment and evaluation skills, the instructor's ICT digital literacy competency, their professional ethics and morals, teamwork abilities and professional learning community competencies, their cross-cultural awareness competency, and finally, their coaching and facilitating competency. Finally, Whitty (1996) listed what the author felt constituted professional competency in teachers. From the analysis, it was determined that teacher competency was made up of the knowledge that a teacher had concerning their teaching discipline, knowledge of their students and the methods in which they learn, and their role within their educational system.

6. Conclusion

The study set out to investigate which factors contributed to a Thai student teacher's competency as viewed from the experiences and expertise of their teachers. After an analysis of 214 teaching professionals dispersed across four geographical regions in Thailand, the analysis concluded that student-teacher programming skills were the most important (1.00). This was followed closely by their educational digital media skills (0.93), and then their overall ICT knowledge (0.88). The study also determined that hands-on, working knowledge of multimedia applications was judged as the single most important skill that a student-teacher could have. This was closely followed by their project development skills and a good understanding of peripheral software management software, computer operating systems, and educational application software. Moreover, all elements were found to be consistent with the empirical data and demonstrated structural integrity.

7. Suggestions for future research and study limitations

The authors would like to suggest that further research concerning ICT competency should expand on which ICT competency components are important to other undergraduate disciplines across Thailand. Moreover, it is suggested that ICT competency components should be developed and applied as short courses in undergraduate studies for Computer Science students across all of Thailand's Rajabhat Universities (teaching universities) to enhance student-teacher performance.

Limitations to the study come from the focus on ICT/Computer Science instructors. Future studies might expand the concept of student-teacher competencies across other academic disciplines with the addition of latent variables specific to their field. It would also be interesting to see how the multi-year COVID 19 global pandemic has impacted the perceptions of ICT and digital education media teacher competency skills.

References

Achwarin, N. A. (2009). The study of teacher competence of teachers at schools in the three southern provinces of Thailand.*Scholar: Human Sciences, 1*(1), 1 – 4.

Allen, J. (2020, March 13). How technological innovation in education is taking on COVID-19. *Forbes*, https://tinyurl.com/4cxttkv5

Barclay, D. Higgins, C., & Thompson, R. (1995). The partial least squares (PLS) approach to causal modeling: personal computer adoption and use as an illustration. *Technology Studies, 2*(3), 285 – 309.https://tinyurl.com/uk6m4bh

Bester, G., & Brand, L. (2013).*The effect of technology on learner attention and achievement in the classroom.South African Journal of Education, 33*(2), 1 – 15, https://tinyurl.com/b6k9txab

Boonkua, A. Tantinakorngul, A., &Tungkunanan, P. (2019). Innovative organization of school under the Office of the Basic Education (OBEC): A second-order confirmatory factor analysis. *International Journal of Industrial Education and Technology,1*(1), 67 – 76. https://tinyurl.com/y4x4cwvk

Boyatzis, R. E., & McClelland, David, C. (2017).In *Encyclopedia of Personality and Individual Differences Living Edition*. V. Zeigler-Hill & T. K. Shackelford (Eds.), (pp. 1 -5).https://doi.org/10.1007/978-3-319-28099-8_2230-1

Buasuwan, P. (2018). Rethinking Thai higher education for Thailand 4.0.*Asian Education and Development Studies, 7*(2), 157 – 173, https://doi.org/10.1108/AEDS-07-2017-0072

Byrne, B. M. Shavelson, R. J., &Muthén, B. (1989).Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance.*Psychological Bulletin, 105*(3), 456 – 466, https://doi.org/10.1037//0033-2909.105.3.456

Dili, R., (2016). An assessment of the application of the 2008 Thai English language policy at the basic education level.[M. S. thesis, Thammasat University]. Thailand. https://tinyurl.com/y5f46vep

Eppard J., &Rochdi, A. A. (2017).Framework for flipped learning.In *International Association for Development of the Information Society (IADIS) International Conference on Mobile Learning*.https://tinyurl.com/5m7mb4ma

European Commission.(2018). *Communication from the Commission to the European Parliament, the Council, the European Economic, and Social Committee, and the Committee of the regions on the Digital Education Action Plan.*https://tinyurl.com/vw2phn6

Eurydice. (2019). *Digital education at School in Europe*. European Commission, Publications Office of the European Union.https://tinyurl.com/3vjkrtxe

Federal Communications Commission. (2014, November 17). *Wireline Competition Bureau and Office of Strategic Planning and Policy Analysis, E-rate data update*. https://tinyurl.com/wb4rp52k

Filer, D. (2010). Everyone's answering: Using technology to increase classroom participation. *Nursing Education Perspectives, 31*(4), 247 – 250, https://tinyurl.com/36kjrjde

Friedman, S. (2019, April 15). How teachers use technology in the classroom. *THE Journal*.https://tinyurl.com/cas774re

Fornons, V. Palau, R., & Santiago, R. (2021).Secondary school students' perception according to their learning style of a mathematics Flipped Classroom.*Journal of Technology and Science Education, 11*(2), 227 – 244. https://doi.org/10.3926/jotse.1092

George, D., & Mallery, P. (2010).*SPSS for Windows step by step: A simple guide and reference 17.0 update*.Allyn& Bacon.

Groff, J., &Mouza, C. *A.* (2008).*Framework for Addressing Challenges to Classroom Technology Use. AACE Journal, 16*, 1, 21 – 46. https://eric.ed.gov/?id=EJ805720

Hair, J. F. Hult, G. T. M. Ringle, C., &Sarstedt, M. (2016).*A primer on partial least squares structural equation modelling* (PLS-SEM). Sage.

Hooper, D. Coughlan, J., & Mullen, M. (2008). Structural equation modelling: Guidelines for determining model fit. *Electronic Journal of Business Research Methods, 6*(1), 53 – 60. http://tinyurl.com/zyd6od2

Hu L. T., & Bentler, P. M. (1999).Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1 – 55. http://doi.org/10.1080/10705519909540118

Jalli, N. (2020, March 17). Lack of internet access in Southeast Asia poses challenges for students to study online amid COVID-19 pandemic. *The Conversation*.https://tinyurl.com/ymt3nxbs

Jöreskog K., &Sörbom, D. (1996).*LISREL 8: User's guide*. Scientific Software International Inc.

Kaewta, C. Makdee, S. Inthasaeng, K. Makdee, T., &Wannathong, A. (2020).The development of training courses on the application of IoT platforms to create learners' digital innovations *Journal of Humanities and Social Sciences Surin Rajabhat University,22*(2), 39 – 52.https://tinyurl.com/sukps7xn

Kanawapee, C. Petsangsri, S., & Pimdee, P. (2021). Thai 'Healthy Schools' teacher professional competency needs development analyses.*Elementary Education Online, 20*(1), 1461 – 1471. https://doi.org/10.17051/ilkonline.2021.01.142

Kenan Foundation Asia. (2021, October 18). *Reforming Thailand's education towards 4.0*.https://tinyurl.com/2zrnwvfy

Khaled, W. Lin, J. Han, Z., &Hao, H. (2019). Test for heteroscedasticity in partially linear regression models. *Journal of Systems Science and Complexity*, *32*, 1194 – 1210. https://doi.org/10.1007/s11424-019-7374-2

Khunsang Y., &Chaisiri, K. (2020).Teacher competency in educational technology and communication in accordance with the standard for bachelor's degree, 4-year program.*Ramkhamhaeng University Journal: The Graduate School (Educational Technology)*, *4*(1), 1 – 12, https://tinyurl.com/2bz8ad6p

Khvilon E., &Patru, M. (2002).*Information and communication technologies in teacher education: A planning guide*. UNESCO, https://tinyurl.com/y4hmmqre

Kruger, K. (2013). *Higher-order thinking,* Hidden Sparks, Inc.

Levy, L. A. (2018, July 25). *7 reasons why digital literacy is important for teachers.*https://tinyurl.com/f4sabnnz

Loehlin, J. C. (1992). *Latent variable models.*Lawrence Erlbaum Publishers.

Luadnakhawok, N.Sengsri, S., &Pholthana, P. (2017).ICT: Information Technology to Support Learning for Change. *Journal of Boromarajonani College of Nursing Uttaradit, 9*(1), 70 – 90. https://tinyurl.com/4rdjtdx5

Matthews, B. (2021). Digital Literacy in UK Health Education: What Can Be Learnt from International Research? *Contemporary Educational Technology, 13*(4), ep317. https://doi.org/10.30935/cedtech/11072

Mongkhondao, S. (2015).Critical thinking and teaching impact.[M. S. thesis, ThammasatUniveristy] Thailand.https://tinyurl.com/93a62v53

Mu, K., Shi, Q., Ma, Y., & Tan, J. (2020).Exploration of entrepreneurship education by linear regression and psychological factor analysis.*Frontiers in Psychology,11,* Article 2045,https://doi.org/10.3389/fpsyg.2020.02045

Noonoo, S. (2012, June 20). Flipped learning founders set the record straight. *The Journal.*https://tinyurl.com/tsx4j4y7

OECD/UNESCO. (2016). *Education in Thailand: An OECD-UNESCO perspective, reviews of national policies for education*. OECD Publishing, http://dx.doi.org/10.1787/9789264259119-en

OECD TALIS 2018 Results (2019).*Volume I: Teachers and school leaders as lifelong learners.TALIS.*https://doi.org/10.1787/1d0bc92a-en

Office of the National Economic and Social Development Board. (2017). *The twelfth national economic and social development plan (2017-2021).* Office of the Prime Minister, https://tinyurl.com/4znr2dk8

Oranop, C. (2016). Country case study: Thailand. In *ICT Competency Standards.United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development.*https://tinyurl.com/4swwyvnj

Pasha, A. Pinjani, A. Bijani, A., &Yousuf, N. (2019).Challenges of developing competencies in students in developing contexts.*Literacy Information and Computer Education Journal, 10*(4), 3293 – 3298.https://doi.org/10.20533/licej.2040.2589.2019.0433

Phuapan, P. Viriyavejakul, C., & Pimdee, P. (2015).An Analysis of digital literacy skills among Thai university seniors.*International Journal of Emerging Technologies in Learning, 11*(3), 24 – 31.https://doi.org/10.3991/ijet.v11i03.5301

Pimdee, P. (2020). Antecedents of Thai student teacher sustainable consumption behavior.*Heliyon,* 6, 8, e04676.https://doi.org/10.1016/j.heliyon.2020.e04676

Pimdee, P. (2021). An analysis of the causal relationships in sustainable consumption behaviour (SCB) of Thai student science teachers.*International Journal of Instruction, 14*, 1,000 – 1018. https://doi.org/10.29333/iji.2021.14159a

Rasch, G. (1980). *Probabilistic models for some intelligence and attainment tests.*University of Chicago Press.

Rauch, E. De Marchi, M. Jitngernmadan, P., & Martin, F. M. A. (2021).Descriptive Analysis for Education and Training on Automation 4.0 in Thailand.In P*roceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management*, Singapore, March 7-11.

Shih W.-L., & Tsai, C.-Y.(2017). Students' perception of a flipped-classroom approach to facilitating online project-based learning in marketing research courses.*Australasian Journal of Educational Technology, 33*(5), 32 – 49. https://doi.org/10.14742/ajet.2884

Siripongdee, K. Tuntiwongwanich, S., & Pimdee, P. (2021). Blended Learning Model with IoT-based by smartphone. *International Journal of Interactive Mobile Technologies, 15*(11),166 – 182. https://doi.org/10.3991/ijim.v15i11.22441

Schumacker R. E., & Lomax, R. G. (2010).*A beginner's guide to structural equation modeling*.Routledge.

Sengsri, T. (2019).Error analysis of computer programming for education by self-management group learning.*Journal of Education Naresuan University*, *21*(3), 89 – 101. https://tinyurl.com/2ta8d2yh

Singsungnoen, K., &Jeerungsuwan, N. (2015).The study of competency of instructors toward teaching and learning in the 21stCentury.In *The Twelfth International Conference on eLearning for Knowledge-Based Society,* Thailand, 2015.https://tinyurl.com/y66k54fc

Sinlapasakkhajorn N., &Unaromlert, T. (2015).The study of issues and obstacles facing the use of media and technology for education in primary school the Province NakornPathom.*Veridian E-Journal, Silpakorn University, 8*(2),628 – 638. https://tinyurl.com/nn3rfhkp

Siriwat, N. Jaidumrong, N., &Wannasuthi, N. (2017).The development of mobile web instruction on object-oriented programming for Java programming for undergraduate student.*Education Journal Thaksin University, 17*(2), 24 – 36. https://tinyurl.com/bmeh29j8

The Office of Educational Technology. (2017).*Reimagining the role of technology in education: 2017 National Education Technology Plan Update.*https://tinyurl.com/mbycwnw5

Turner, R. C., & Carlson, L. (2003).Indexes of item-objective congruence for multidimensional items.*International Journal of Testing, 3*(2), 163 – 171.https://doi.org/10.1207/s15327574ijt0302_5

Vangmeejongmee C., &Naiyapatana, O. (2017). Competency of Thai teacher in 21st Century: Wind of change. *Journal of HR Intelligence, 12*(2), 48 – 63. https://tinyurl.com/y4cpfau4

Vesamavibool, S. Urwongse, S. Hanpanich, B. Thongnoum, D., &Watcharin, K. (2015).The comparative study of professional standards for Thai teachers and for Asean Teachers.*Procedia - Social and Behavioral Sciences*, 191, 2, 2280 – 2284. https://doi.org/10.1016/j.sbspro.2015.04.671

Wahyudi, W. (2020).The effectiveness of sharing blended project-based learning (SBPBL) model implementation in operating system course.*International Journal of Emerging Technologies in Learning,15*(5), 202 – 211.https://doi.org/10.3991/ijet.v15i05.11266

Watnayoo, C. Toonthong, S., &Chalaywares.N. (2019).Developing the 21st-century skills on information, media, and technology on computer creativity towards learning for Grade 5 students using coaching.*Thai Journal of Science and Technology*, *10*(1), 1 – 16. https://tinyurl.com/3s5m5zm7

Whitty, G. (1996). Professional competencies and professional characteristics: The Northern Ireland approach to the reform of teacher education. In D. Hustler and D. McIntyre, *Developing Competent teachers; approaches to professional competence in Teacher Education*. David Fulton.

Wilson, S., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of research in Education, 24*, 173 – 209. https://tinyurl.com/y6nanjd6

Yuktirat, C. Sindhuphak, A., &Kiddee, K. (2018). M-learning for the art of drawing: Informal learning for a digital age. *International Journal of Interactive Mobile Technologies, 12*(5), 152 – 168. https://doi.org/10.3991/ijim.v12i5.9207