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Thai information and communication technology student teacher complex problem-solving skills

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Abstract

From the study's qualitative analysis, 5 latent variables and 21 observed variables concerning complex problem-solving (CPS) skills were identified and subsequently used in a questionnaire on a sample of 214 Thai education professionals teaching information and communication technology (ICT)-related student teachers in one of 31 Thai Rajabhat (teaching) Universities. Goodness-of-fit and descriptive statistical analysis (mean and standard deviation) were analysed by using IBM® Statistical Package for the Social Sciences® for Windows version 21, while the second-order confirmatory factor analysis used LISREL 9.10. The results revealed that the educators perceived *information literacy* (1.00), *analytical thinking* (0.96), *self-control* (0.93), *knowledge application* (0.90) and *planning ability* (0.85) as the most important for the student teachers' CPS skills. Moreover, the results revealed that each teacher's opinion on CPS skill indicators was at a 'high agreement' level. Therefore, it suggested that the results can be used by Thailand's Ministry of Education and other ICT-related education agencies in developing CPS skill programmes for Thai student teachers.

Keywords: CPS, ICT, Information literacy, preservice teachers, Thailand

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1. Introduction

Success in the 21st century requires a multitude of competencies. These include creativity, critical thinking (CT), lifelong learning and collaboration skills (Griffin & Care, 2015). However, other scholars for over four decades have pointed out the central importance at being able to *solve complex problems* (Funke, 2010; Mainzer, 2009), with the Nobel Prize winning author Simon being an earlier discussant of the need for humans to conceptualise and solve complex problems (Mintrom, 2015). Moreover, delegates of the World Economic Forum (2015) have also concluded that *complex problem-solving* (CPS) is one of the most important competencies required for the future of humanity.

In Germany, Dorner and Funke (2017) have also added that individual psychological processes that occur within individual persons and deal with ill-defined complex problems come under the authors' definition as 'CPS'. Eichmann et al. (2019) has also added that CPS is a highly transversal competence needed for vocational and educational environments as well as everyday life.

Furthermore, the early 1970s research on CPS has influenced large-scale educational testing including the OECD's Programme for International Student Assessment (PISA) for student evaluation and testing (OECD, 2014). In the earlier 2012 PISA student evaluations, minimal complex systems (MCSs) were introduced which included exercises dealing with simple dynamic situations that required controlled interactions such as the exploration and control of simple ticketing machines, mobile phone use and MP3 players (Dorner & Funke, 2017).

Technologically today, all these ideas and processes have advanced to a new generation of devices where simple ticketing machines have become common ticketing systems across vast metropolitan areas (Kaewwongwattana et al., 2015). The use of a mobile phone has expanded outside the limited realm of cellular person-to-person communications into a device attaching to social media platforms consisting of billions of nodes and users around the world, and the MP3 player of yesteryears is now YouTube or a similar device connected to the Internet of Things (Siripongdee et al., 2021).

Therefore, MCSs have evolved into highly complex systems and *solving the problems* these systems create is now squarely on the shoulders of information and communication technology (ICT) professionals. However, as studies from even the United Kingdom suggests, ICT standards for teaching and learning reveals significant shortcomings (van Weert & Munro, 2017) even though students between 14 and 16 years old at the GCSE level are taught development knowledge, skills and processes associated with analysing, designing and implementing ICT-based systems. Moreover, in these courses, there is a 60% weighted assessment focusing on ICT *problem-solving* through the use of ICT, and according to Hubwieser and Friedrich (1997), *problem-solving* is at the heart of all other UK informatics courses.

In Thailand, similar difficulties exist, although the Thai government's goals and educational expectations for ICT professionals are very high (Sinlapasakkhajorn & Unaromlert, 2015). Fortunately, student teachers have been stated to be 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).

Recently, the Thai governments and their respective educational ministries and agencies have also written into their 5-year economic and educational plans the need for 21st-century digitally enabled knowledge workers (Rauch et al., 2021). 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 *problem-solving skills* for both students and teachers (Buasuwan, 2018). Once again,

under Thailand 4.0, the plan is to use technological innovation and education and robust and complex Internet and wireless systems to access and create a new generation of knowledge workers (International Labour Organisation, 2019; 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 (Office of the National Economic and Social Development Board, 2017). At the forefront of numerous and difficult challenges will be Thailand's next generation of student teachers (Boonkua et al., 2019). Therefore, expectations are high for Thai student teachers in many ways and across many aspects within the environments they will be expected to teach in.

However, the International Labour Organisation (ILO, 2019) released a report in which ICT skills shortages was discussed for Thailand. In the ILO report, it was highlighted that in Thailand there were only 386,000 ICT specialists, or an amazingly low 1% of the country's entire labour force, who specialise in ICT. Furthermore, in 2017, Thailand only graduated 34,283 individuals in the fields of ICT, science and mathematics, or the equivalent of 10% of the total number of Thai graduates. Fortunately, these limited ICT ranks are filled with 33% of women, like in India and Indonesia. Also, although there are sufficient ICT graduates in Thailand, there is a lack of training access and up-skilling, with very limited numbers of higher level education institutions that provide advanced ICT training. Finally, of the 10 softskills Thai managers identified that mid-level ICT staff needed, *problem-solving skills* was listed as seventh on the list as most important.

1.1. Conceptual framework

Multiple studies have identified the need for ICT student teachers to have *CPS skills* and advanced processes which allow them the ability to integrate multiple disciplines together in order to achieve the desired results (Eichmann et al., 2019; Funke, 2010; Greiff et al., 2012). Also, according to Lotz et al. (2016), CPS and intelligence are substantially correlated in their study on 496 German students, while Wustenberg et al. (2012) indicated that teachers can use CPS to measure important aspects of academic performance.

Therefore, we can see that CPS skills involve a variety of methods and elements. Thus, we isolated these aspects and proposed five primary components for investigation on Thai ICT student teachers' CPS as perceived by their teachers and professors. These five aspects are explained below.

Information literacy (IL) and its development through the use of ICT has been a topic of numerous studies in recent years, with social media platforms and their use in teaching IL becoming more and more investigated by researchers (Juliantari et al., 2020). In hot and humid climates, such as Southeast Asia, in past years libraries were difficult to build and costly to maintain and IL was challenging to teach.

However, today with the advent of smartphones and the Internet, the methods and platforms in which IL is taught has radically shifted. Moreover, the conversation concerning IL student development has morphed into a simultaneous discussion concerning the added requirement to teach *digital literacy* (DL) at the same time (Moto et al., 2018; Surmelioglu & Seferoglu, 2019). Although IL and DL are not exactly the same, they are connected at the hip through ICT.

Moreover, UNESCO has reported that 21st-century citizen and worker effectiveness requires creativity and evaluation skills that effectively utilise IL, media literacy (ML), technology and ICT literacy (Scott, 2015). In Turkey, Kozikoglu and Onur (2019) added that an essential element of a student teacher's lifelong learning was IL.

Analytical thinking (AT) skills has almost become synonymous with CT skills. Moreover, according to website postings from Radford University (2021), when a potential employer states they are looking for staff that has CPS skills, they are saying they want employees who possess AT and CT skills. Thus, an individual's AT skill is the ability to break down problems into smaller parts to find solutions.

Also, AT is an integral component of ML, which entails the ability to access, analyse, evaluate and create messages in a variety of forms (Aufderheide,1993; Christ & Potter, 1998), which together constitute a skills-based approach to ML (Livingston, 2004).

Self-control (SC) is a person's self-determination of their own thoughts, emotions and feelings when faced with stressful situations, problems, obstacles or a state of self-conflict (Funke, 2010; Greiff et al., 2012).

Knowledge application (KA) has been stated to entail using the knowledge that is available to make decisions and perform tasks through direction and routines (Becerra-Fernandez & Sabherwal, 2010). In an ICT sense, content management systems or learning management systems can be thought of in this context as both can optimise KA on an organisation-wide or student/campus-wide basis (Dalki, 2011).

Also, within the long-term medical care sector, Berta et al. (2010) added that KA in itself is highly complex. In turn, KA is reliant upon a facility's KA capacity or absorptive capacity to effect change through learning, as KA capacity underpins the emergence of the application process and the advancement of knowledge through it.

Planning ability (PA) according to Forcheri et al. (2000) involves an individual's learning objectives construction and pursuit, how one structures their goals according to one's own time and resources and the evaluation of how much effort it takes to reach them. Also, PA is the purpose of one's work, which has a goal to create a strategy to achieve the goal to support future events in the short term and long term (Eichmann et al., 2019; Funke, 2010).

1.2. Purpose of the study

This research will first set out to confirm the variables selected by the authors concerning student teachers' CPS do in fact fit well with the model. Secondly, we will use a second-order confirmatory factor analysis (CFA) model to measure the behaviour of the indicators that contribute to ICT/computer programme studies student teachers' CPS skills. It is also a goal to establish which CPS indicators are most important and contribute to the effectiveness of ICT careers in order to reduce the shortage of personnel in this field in the future.

2. Method and materials

2.1. Population and sample

The population for the study is 248 teaching professionals who are student teacher instructors in one of the 31 Rajabhat Universities (Thai teaching universities), which has a student teacher education programme in an ICT-related field or computer studies. Moreover, various scholars have suggested that to obtain a statistically valid sample size, a ratio of 10 questionnaires for each observed variable in a CFA model is sufficient (Moto et al., 2018). However, Hair et al. (2020) have suggested that sample sizes from 200 to 400 are stronger depending on the model's complexity and the number of variables. Additionally, Loehlin's (2004) Monte Carlo simulation results for CFA models suggested that a sample size of ≥200 individuals is appropriate. From these suggestions, we set a goal of 214 teaching professionals based on 21 indicators using a multiple of 10.

2.2. Participant ethics consideration

The Human Ethics Committee from our research university was notified and consulted before the meeting with experts concerning the questionnaire's design and the questionnaire's pre-test. Along with the committee's approval, we obtained an informed consent form from each survey participant which stated that each participant's anonymity was ensured (Pimdee, 2020).

2.3. Research instrument

The research tool was a questionnaire that was compiled from the related theory concerning CPS. In the design and eventual distribution, three parts were used. In part 1, each respondent was asked to give their input concerning their gender, age, degree, their position, teaching experience and which Thai region they were student teachers in Table 2. In part 2, there were 5 sections consisting of 21 observed variables which made use of a 5-level Likert-type opinion scale to assess the level of agreement from each respondent. Furthermore, section 1 in part 2 had five items related to the importance of each student teacher's PA. Section 2 consisted of four items related to SC importance. Section 3 was concerned with items related to IL. Section 4 was related to the importance of AT skills, and finally, Section 5 had five items relating to KA skills. The interpretation of each individual's opinions for each item used a scale where 4.51–5.00 indicated 'strongly agree', 3.51–4.50 indicated 'high agreement', 2.51–3.50 indicated 'moderate agreement', 1.51–2.50 indicated 'little agreement' and 1.00–1.50 indicated 'minimal agreement' (Chuenban et al., 2021). Finally, Section 3 allowed for the input of suggestions and recommendations.

2.4. Research instrument validity and reliability assessment

The research tool was a questionnaire that was compiled from the related theory concerning CPS. In the design and eventual distribution, three parts were used. In part 1, each respondent was asked to give their input concerning their gender, age, degree, their position, teaching experience and which Thai region they were teaching in Table 2. In part 2, there were 5 sections consisting of 21 observed variables which made use of a 5-level Likert-type opinion scale to assess the level of agreement from each respondent. Furthermore, section 1 in part 2 had five items related to the importance of each student teacher's PA. Section 2 consisted of four items related to SC importance. Section 3 was concerned with items related to IL. Section 4 was related to the importance of AT skills, and finally, Section 5 had five items relating to KA skills. The interpretation of each individual's opinions for each item used a scale where 4.51–5.00 indicated 'strongly agree', 3.51–4.50 indicated 'high agreement', 2.51–3.50 indicated 'moderate agreement', 1.51–2.50 indicated 'little agreement' and 1.00–1.50 indicated 'minimal agreement' (Chuenban et al., 2021). Finally, Section 3 allowed for the input of suggestions and recommendations.

2.5. Data collection and analysis

Multistage random sampling was used to ensure a consistent and harmonious collection of the empirical data by dividing 31 Rajabhat Universities across Thailand into four geographical regions comprising Thailand's north, central, north-eastern and southern regions (Table 1).

Table 1. Sampling process by regional Rajabhat Universities

Rajabhat Universities by region	Universities	Obtained
Northern Thailand	6	42
Central and Metropolitan Thailand	11	76
North-eastern (Isan) Thailand	11	75
Southern Thailand	3	21
Totals	31	214

Thereafter, we identified student teacher programmes in computer studies, ICT and/or related fields. The researcher analysed the data by using a combination of statistical software programmes. The details of the analysis are as follows:

(1) The analysis of each of the variables for the second-order CFA model used LISREL 9.10 with the interpretation and validation of the model being carried out with the use of IBM® Statistical Package for the Social Sciences (SPSS®) for Windows version 21 for the goodness-of-fit (GoF) harmonisation index criteria.

(2) The analysis of each teaching professional's opinion concerning student teachers' ICT competency also used descriptive statistics [mean and standard deviation (SD)], output from the IBM® SPSS® for Windows version 21 programme.

3. Results

3.1. Student survey general information

In part 1 of each educator's questionnaire, there was a section concerning their general information. In Table 2 we find that 52.80% of the teachers were male. Also, the majority or 44.86% were 36–45 years of age, with an almost equal distribution of master's degrees (51.87%) to Ph.Ds (48.13%). However, in spite of their attainment of advanced degrees, 70.56% still were classified as 'teachers' only, with 28.97% assistant professors and only 1 individual indicting they had obtained the rank of associate professor. There was also a nice bell curve in their teaching experience as the majority (45.33%) had been teaching for 6–10 years. Finally, most of the respondents were concentrated in schools in Thailand's central region which includes the capital Bangkok (35.51%), while another large group of 35.05% was in Thailand's north-east or Isan region.

Table 2. Thai ICT student teacher general information (n=214)

Respondent's General Information	**Number**	**%**
Gender		
- Male	113	52.80
- Female	101	47.20
Age		
- 25–35	40	18.69
- 36–45	96	44.86
- 46–55	47	21.96
- Over 55	31	14.49
Education		
- Master's degree	111	51.87
- Ph.D.	103	48.13
Academic position		
- Associate professor	1	0.47

Respondent's General Information	**Number**	**%**
- Assistant professor	62	28.97
- Teacher	151	70.56
Teaching experience		
- 1–5 years	56	26.17
- 6–10 years	97	45.33
- More than 10 years	61	28.50
Region		
- Central	76	35.51
- South	21	9.81
- North	42	19.63
- North-east	75	35.05

3.2. Alpha, element weights, R^2, mean and SD test values

In Table 3, the first data column is Cronbach's α values from the study's initial 30-student pilot test, with alpha value reliability cut-offs frequently cited as $\alpha \geq 0.70$. As such, from the values for each of the study's five primary elements, we find good reliability as each element was $\alpha = 0.87$.

Also, testing for the *β* (standardised regression coefficient) was carried out to compare the strength of each independent variable to the dependent variable (Khaled et al., 2019). It is also suggested that as the absolute value of *β* increases, the stronger the relationship effect.

This is consistent with research on multiple linear regression analysis in STEM education research in which Theobald and Freeman (2014) stated that the use of *β* is to accomplish the data analysis in which *β* can be used to characterise the correlation between the variables. Thus, we find moderate to very strong variable correlations with *β* = 0.52–1.00.

Moreover, in Table 3, we find another indicator of the mean value's reliability from the use of the value of standard error (SE), which is usually interpreted with smaller SE values indicating that the sample mean is a more accurate reflection of the actual population mean. Additionally, the theory suggests that bigger sample sizes normally result in a smaller SE, with SD normally not directly affected by a sample's size.

Next, we find the *t*-test values, from which Hair et al. (2020) 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 7.90** for E5.

Furthermore, Chicco et al. (2021) stated that that the coefficient of determination (R^2) testing can be a strong tool when used in regression analysis evaluations. Thus, in the final column in Table 3 we find R^2 values were from a low of 0.26 (weak) to a high of 0.82 (significant).

Thus, according to Hair et al. (2020), we find the range of R^2 values are substantial ≥0.75 to weak ≥0.25, which is the evaluation in human behaviour and their opinions are quite normal and acceptable for wide ranges.

Finally, in the final two columns in Table 3, we find the results from the descriptive statistical analysis of the mean ($\bar{x}$) and SD using IBM® SPSS® for Windows version 21. From the results, we note that the student teachers perceived that their ability to *apply previous knowledge when solving complex problems* (E1) ($\bar{x}$ = 4.24, SD = 0.75) was most important.

This was closely followed by their ability to *combine prior knowledge with new knowledge in solving complex problems* (C1) ($\bar{x}$ = 4.21, SD = 0.74). However, their ability to *monitor and control CPS operations* (A5) ($\bar{x}$ = 4.05, SD = 0.81) was least important.

Also, the analysis showed that each Thai Rajabhat University ICT student teacher had a '*high agreement*' level ($\bar{x}$ = 3.51–4.50) with each of the study's indicators concerning their CPS skills.

Table 3. Mean, SD, element weights and R^2 values of Thai ICT student teachers' CPS skills

Elements and indicators of CPS skills	α	element weight			R^2	$\bar{x}$	SD
		β	SE	*t*-value			
PA-Thai student teachers should be able to…	**0.87**	**0.85**	**0.07**	**10.95****	**0.64**	**4.15**	**0.67**
See the big picture of complex problems (A1).		0.76	-	-	0.57	4.08	0.77
Assign tasks to solve complex problems (A2).		0.75	0.05	14.61**	0.56	4.10	0.85
Set success goals in solving complex problems (A3).		0.77	0.05	13.87**	0.60	4.21	0.80
Apply techniques during CPS operations (A4).		0.81	0.06	12.44**	0.66	4.11	0.82
Monitor and control CPS operations (A5)		0.90	0.06	13.90**	0.82	4.05	0.81
SC-Thai student teachers should be able to…	**0.87**	**0.93**	**0.06**	**13.41****	**0.69**	**4.15**	**0.69**
Remain focused during CPS operations (B1).		0.82	-	-	0.68	4.15	0.70
Carefully consider all aspects during solving complex problems (B2).		0.84	0.05	15.09**	0.72	4.15	0.82
Make step by step decisions in solving complex problems (B3).		0.79	0.05	14.03**	0.65	4.15	0.83
Control demands within the scope of CPS (B4).		0.85	0.05	15.20**	0.72	4.14	0.79
IL-Thai student teachers should be able to…	**0.87**	**1.00**	**0.07**	**14.43****	**0.59**	**4.19**	**0.68**
Combine prior knowledge with new knowledge in solving complex problems (C1).		0.82	-	-	0.67	4.21	0.74
Distinguish features of complex problems (C2).		0.74	0.06	12.46**	0.55	4.17	0.79
Select useful information in solving complex problems (C3).		0.75	0.05	12.70**	0.57	4.20	0.79
AT-Thai student teachers should be able to…	**0.87**	0.96	0.07	13.86**	0.58	**4.15**	**0.66**
Distinguish key components of complex problems (D1).		0.82	-	-	0.68	4.18	0.80
Rationally interpret complex problems (D2).		0.70	0.06	11.49**	0.50	4.10	0.84
Relate the relationship of facts within CPS (D3).		0.80	0.05	13.65**	0.64	4.14	0.83
Summarise principles from common opinions (D4).		0.72	0.06	12.07**	0.52	4.19	0.72
KA-Thai student teachers should be able to…	**0.87**	**0.90**	**0.06**	**13.48***	**0.57**	**4.19**	**0.61**
Apply previous knowledge when solving complex problems (E1).		0.85	-	-	0.74	4.24	0.75
Acquire new knowledge when solving complex problems (E2).		0.84	0.06	12.86**	0.70	4.15	0.78
Synthesise prior knowledge and new knowledge when solving complex problems (E3).		0.80	0.05	14.33**	0.66	4.19	0.74
Relate all knowledge relationships when solving complex problems (E4).		0.70	0.06	11.58**	0.49	4.19	0.76
Evaluate after applying knowledge when solving complex problems (E5).		0.52	0.06	7.90**	0.26	4.17	0.78

** *p*-value ≤ .01

3.3. Second-order CFA GoF analysis

Numerous studies use a GoF analysis to assess the second-order CFA model's validity. Therefore, nine additional validity indices plus the values were used for this purpose and were all found to be consistent with the empirical data and thus appropriate for the study's final model analysis shown in Figure 1. We can also conclude that the second-order CFA model for Thai ICT student teachers' CPS skills found all five components consistent with the empirical data, as the values for χ^2 were not statistically significant at 0.078 (p = 0.05), χ^2/df = 1.17 (χ^2/df ≤ 2.00), root mean square error of approximation = 0.02 (RMSEA ≤ 0.05), goodness-of-fit index = 0.93 (GFI ≥ 0.90), adjusted goodness-of-fit index = 0.90 (AGFI ≥ 0.90), normed fit index = 0.98 (NFI ≥ 0.90), comparative fit index = 0.99 (CFI ≥ 0.90), root mean square residual = 0.03 (RMR ≤ 0.05) and standardized root mean squared residual = 0.03 (SRMR ≤ 0.05).

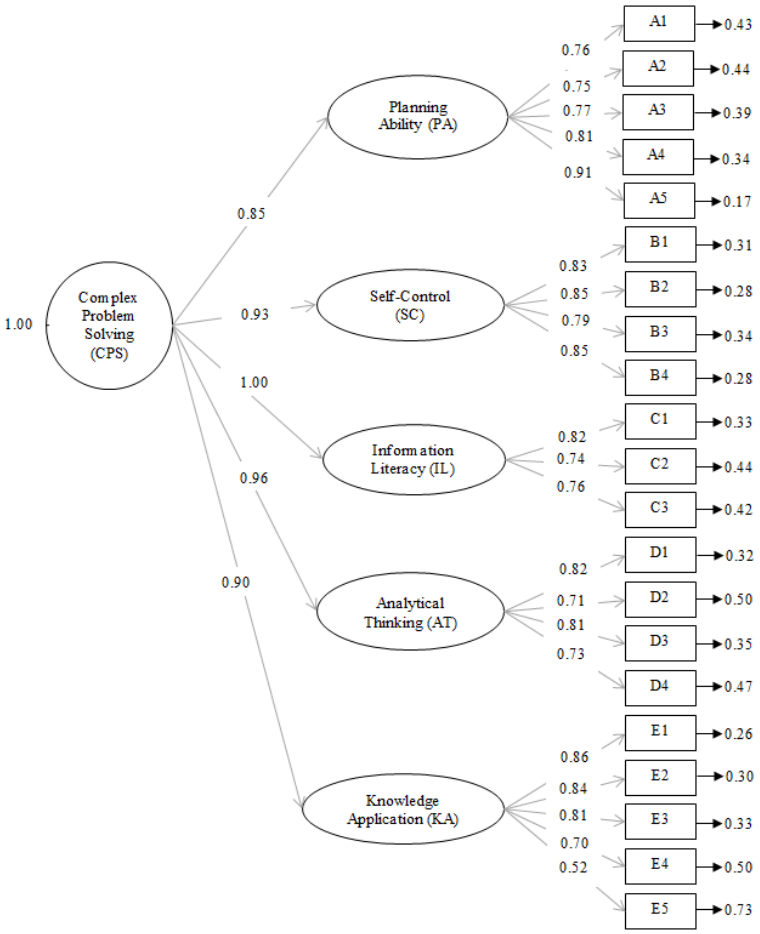

Figure 1. Second-order CFA final model for Thai ICT student teachers' CPS skills
χ^2 = 166.46, df = 142, p-value = 0.07860, RMSEA = 0.028

4. Discussion

4.1. Information literacy

The study's results concerning IL indicated IP's significant and greatest importance in each student's CPS skills (β = 1.00, R^2 = 0.59). The study's results are also consistent with Godbey and Derma (2018) who surprising found that their student teachers were unfamiliar with the concept of 'IL', but once explained, saw it as important to their own and future students' success. Also, Greiff et al. (2012) revealed that from their study on student dynamic problem-solving, information retrieval was an important element.

Moreover, IL skills are the ability to *combine* ($\bar{x}$ = 4.21, SD = 0.74), *select* ($\bar{x}$ = 4.20, SD = 0.79) and *distinguish* ($\bar{x}$ = 4.17, SD = 0.79) useful information. These elements are also in agreement with the American Library Association (1989) which sees IL as a process in which students come to recognise their need for information, its identification, search and evaluation strategies, information organisation skills and, finally, its legal and ethical use. Yet again, ICT literacy skills according to Moto et al. (2018) are essential for research and evaluating information, which further promotes effective learning and working.

4.2. Analytical thinking

The teachers' next ranked AT as the most important for their student teachers' AT abilities (β = 0.96, R^2 = 0.58), which is consistent with participants from a World Economic Forum (2015), after which CT, problem-solving and AT skills were included in the list of the 10 most important items needed for employment. In Spain, Vintere (2019) also added that these same aspects were the cornerstones of sustainability for the process of mathematics education.

4.3. Self-control

Third in importance was each student teacher's SC in their CPS skills (β = 0.93, R^2 = 0.69). This is consistent with the earlier German studies by Dorner et al. (1983) in which the authors contended that it was not IQ intelligence tests that predicts performance, but instead having the CPS ability to stay calm in the face of a challenging situation while also having the ability to switch easily between processing analytically and a more holistic one.

However, as multiple studies have noted, CPS is not only a cognitive process but an emotional one as well that is strongly dependent on an individual's levels of motivation (Barth & Funke, 2010; Spering et al., 2005). This is consistent with Funke (2012) who stated the importance of emotional regulation during CPS; the study was also suggested that CPS situations with negative results feedback lead to higher information retrieval and better performance.

4.4. Knowledge application

Fourth in importance was each student teacher's KA in their CPS skills (β = 0.90, R^2 = 0.57). This is consistent with Engelhart et al.'s (2017) study which noted in a discussion on CPS that only after specific feedback can performance in a complex environment be increased.

4.5. Planning ability

Finally, fifth in importance was each student teacher's PA in their CPS skills (β = 0.85, R^2 = 0.64). This is consistent with Eichmann et al.'s (2019) study which determined that early planning was beneficial

in CPS activities. However, this was dependent on the task and as the level of complexity increased, planning was best suited as short intervals throughout the task.

5. Conclusion

From the study's initial qualitative analysis, five latent variables and 21 observed variables concerning CPS skills were identified and subsequently used in a questionnaire on a sample of 214 Thai education professionals teaching ICT-related student teachers in one of 31 Thai Rajabhat Universities. The CPS skills considered most important to Thai ICT student teachers were their *IL* (1.00), *AL* (0.96), *SC* (0.93), *KA* (0.90) and, finally, *PA* (0.85). Moreover, the results revealed that each teacher's opinion on CPS skill indicators was at a 'high agreement' level. Therefore, it is suggested that this study's results can be used by Thailand's Ministry of Education and other ICT-related education agencies in developing CPS skill programmes for Thai student teachers.

6. Recommendations

It is suggested that similar future studies investigate how CPS skills can be developed in other faculties and universities across Thailand. Moreover, as there are close similarities between creative thinking, critical thinking, and analytical thinking, exploring CPS skills lower in the educational system (elementary through high school) is also suggested. These results can then be applied leading to the development of quality worker skills and a more sustainable future.

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