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Enhancing Teaching and Supervisory Staff's Creative Problem-Solving Skills

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Abstract

This research analyzed creative problem-solving (CPS) components and examined the perceptions of Thai educational personnel regarding their CPS abilities. The sample consisted of 534 primary school teachers and educational supervisors during the 2024 academic year, selected through multistage random sampling. Data were collected using a questionnaire assessing CPS skills, which were then analyzed using means (*M*), standard deviations (*SD*), and second-order confirmatory factor analysis (CFA). The research revealed that the second-order CFA model for CPS among educational personnel (teachers and supervisors) consists of five key components. Ranked from highest to lowest, these were educators' perceptions of their CPS abilities to solve problems (SOL) ($M = 4.23$, $SD = 0.54$), ability to identify problems (IDE) ($M = 4.17$, $SD = 0.57$), ability to create knowledge (CRE) ($M = 4.17$, $SD = 0.59$), ability to discover concepts (INS) ($M = 4.12$, $SD = 0.58$), and ability to discover methods to solve problems (MET) ($M = 4.11$, $SD = 0.58$). The model strongly aligned with empirical data, indicating that all three models exhibited positive component weights (β) that were statistically significant at the .01 level. This finding underscores the strength of the CPS framework for educational personnel. These findings provide compelling evidence for the effectiveness of the proposed model in assessing and enhancing CPS skills among educational professionals, contributing valuable insights to both practice and future research in this field. This study fills a gap in the literature by providing empirical evidence on the CPS capabilities of educational personnel.

Keywords:

COVID-19;
Creative Problem-Solving Abilities;
Innovation;
Phenomenon-Based Learning;
Pre-Service Teachers;
Second-Order CFA;
Thailand.

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1- Introduction

In such a dynamic world, nurturing and applying creative problem-solving (CPS) skills are important for personal and professional development [1]. CPS skills are needed for solving non-trivial tasks in different areas and managing innovation and flexibility, which are essential for educational purposes. Consequently, it is necessary to incorporate different pedagogical models, including Phenomenon-Based Learning (PhenoBL), because it provides opportunities for students to investigate phenomena in real-world contexts and make cross-curricular connections [2]. PhenoBL orginated from Finland's 2016 National Core Curriculum Reform [3].

The reform calls for a transition from the conventional subject-based forms of learning to the more integrated, learner-centered educational paradigm, which emphasizes real-world applications, teamwork, and critical thinking [4]. PhenoBL allows students to explore complex, real-world problems by integrating knowledge and skills from various disciplines (e.g., science, mathematics, social studies, and the arts) rather than treating subjects as separate learning entities.

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Interdisciplinary learning helps students develop a deeper understanding of complex topics while nurturing 21st-century competencies such as creativity, problem-solving, and collaboration [5, 6].

Combining PhenoBL with CT, the problem-solving strategy that provides students with an analytical and systematic approach to problem-solving methods [7, 8], highly supports students' CPS capabilities. To illustrate, while CT presents analytical and planned models for decomposing and approaching problems systematically, PhenoBL contributes to CPS skills by providing a hands-on exploration and interdisciplinary approaches to the problem, allowing students to think more, considering many aspects of the problem. Educators can foster analytical and creative mindsets by integrating these approaches, equipping students to tackle complex, real-world problems.

Incorporating artificial intelligence (AI) into education has also expanded the avenues for enhancing CPS skills by providing personalized and adaptive learning experiences. AI tools can personalize learning experiences according to individual students' needs and provide real-time feedback and assessment [9]. Incorporating these technologies into education helps teachers improve learning outcomes and facilitates critical 21st-century skills, such as creativity, critical thinking, and productivity [10]. The use of AI and CT in teaching and blended learning using CPS techniques can provide teachers with the necessary technological tools to create a dynamic learning environment for students who think divergently and convergently in preparation for unknown future challenges.

Even though CPS is gaining importance, there is still a strong need for further studies in the literature on developing CPS skills in pre-service teachers (PSTs) in order to advance their ability and expertise in CPS processes. Teachers must be encouraged to develop CPS skills in teacher education, as they must educate the next generation of thinkers and educators who can solve problems [11]. In these situations, today's teachers need to play a different role and become the conveyor of information while acting as role models in problem-solving and guides in helping students think critically and creatively. In addition, daily problem-solving requires teachers to deal with tasks with various complex situations and to use creative solutions to solve these problems [12]. Educational supervisors or academic advisors must ensure teachers know innovative teaching practices by creating an environment that allows them to experiment and encourages others to develop further and expand their innovative behavior [13].

However, research shows that many PSTs find it challenging to construct and/or apply innovative solutions to problems, particularly in classroom teaching and effective use of technology [14, 15]. This is especially true in countries with transitional economies like Kazakhstan, where acquiring CPS skills is critical to education and economic development in a digital age [16]. In Thailand, education personnel must improve CPS to meet the challenges of an ever-changing educational context [17]. Therefore, the lack of research on CPS among educators indicates the need for research that explores the components of CPS and the ways of enhancing them; knowledge that will enrich the scope of studies in CPS with a focus on educational practice.

Creative problem-solving as an organized and structured learning model can help add value to students' capabilities through fun and active involvement activities that fuel motivation and creativity [18, 19]. Moreover, CPS has the potential to find suitable solutions for ill-defined hypothetical tasks where goals, procedures, and evaluations are not predefined. This encourages learners to use divergent and convergent thinking [20].

Divergent thinking or insight (INS) generates multiple, unique answers, whereas convergent thinking is associated with evaluating, analyzing, and choosing workable solutions [21]. A CPS model usually involves multiple stages, which include problem clarification, new idea generation, analyzing and evaluating new ideas, and implementing their solutions [22-24]. A CPS model's use is an approach that supports creativity and prepares learners to think holistically to analyze a problem, troubleshoot it, and take an active role in their learning [25-27].

Therefore, from the analysis of previous research, this study aims to fill the discussion gap by studying the components of CPS of educational personnel in Thailand. The research aims to achieve the following objectives:

RO1: To study the components of creative problem-solving (CPS) of educational personnel.

RO2: To study the opinion level towards CPS by Thai educational personnel.

By fulfilling these objectives, this study aims to provide valuable insights into developing CPS skills among educators, ultimately enhancing teaching practices and better preparing future educators to navigate the challenges of an increasingly complex world. To resolve these questions, in Section 2, the authors review the literature. Section 3 involves the development of the research instrument and its diffusion to educational professionals. It furthermore describes the research design, data collection procedures, and analytical methods employed in the study. Section 4 contains the significant findings, including statistical analyses and interpretations. Section 5 analyses the impact of the results, comparing them to previous research and identifying areas for further inquiry. Finally, in the conclusion, in Section 6, the main findings, contributions, and future research directions are revisited. Through this systematic examination, the study endeavors to advance the understanding of CPS in educational contexts and provide actionable recommendations for cultivating these essential skills among PSTs in Thailand.

2- Literature Review

2-1- Introduction to Creative Problem-Solving (CPS)

Creative problem-solving (CPS) is a critical skill for navigating the complexities of the modern world, particularly in educational contexts [28]. CPS involves identifying problems, generating innovative solutions, and applying knowledge creatively to address real-world challenges [21]. CPS is essential for fostering critical thinking, creativity, and adaptability among students and teachers in education [20]. Research has shown that CPS skills are particularly important for PSTs, who must model effective problem-solving strategies for their students [28]. This section reviews the key components of CPS, its application in educational contexts, and the gaps in the literature that this study aims to address.

2-2- Key Components of CPS

CPS is a multifaceted process that involves several interrelated components. These components include problem identification (IDE) [29], solution generation (SOL) [30], insight and conceptual thinking (INS) [31], methods for problem-solving (MET) [29], and creativity (CRE), with each of these components playing an essential role in the overall CPS process.

2-2-1- Problem Identification (IDE)

Problem identification is the first step of the CPS process, where individuals become aware of and define the problem they are trying to solve. It includes awareness of the root causes of the challenge, asking questions, and clarifying the scope and context of the problem [22, 29]. IDE necessitates analytical thinking and the ability to determine the symptoms from the root causes. For instance, teachers in educational settings must identify challenges such as low student engagement [22] or gaps in learning outcomes before they can design interventions. It has been shown that IDE is associated with the capability to consider the causes of problems and prioritize their causes [24]. For example, Mejía-Villa et al. [23] emphasize the importance of problem clarification in CPS, particularly in educational settings where teachers must address diverse and complex challenges. Therefore, IDE sets the stage for the subsequent steps in the CPS process.

2-2-2- Solution Generation (SOL)

Solution generation involves brainstorming and developing potential solutions to the identified problem. This stage emphasizes insight (INS), where individuals generate ideas without immediate judgment or evaluation [30]. Techniques such as brainstorming, mind mapping, and lateral thinking are often used to encourage creativity and innovation. For instance, teachers might generate multiple strategies to address classroom management issues, such as gamification, restructuring seating arrangements, or using technology-based tools [24]. The goal is to explore diverse possibilities before narrowing to the most viable solutions [18].

2-2-3- Insight and Conceptual Thinking (INS)

Insight and conceptual thinking are the capacity to find novel connections/resources from existing information, to identify potential ideas, and to evaluate the potential of those ideas [21]. It heavily relies on domain-relevant knowledge and the application of divergent and convergent thinking [31]. These elements often serve to discover an idea by uncovering a hidden connection or fixing the problem from different points of view [21]. Insight often occurs by extending current knowledge about a particular domain by combining it with concepts or knowledge from another domain or by looking at the same problem from another standpoint [21]. For example, a teacher may use their knowledge of psychology and technology and decide to combine both fields to create a personalized learning system to cater to individual students' needs [25]. Insight and conceptual thinking are vital in how an abstract idea can translate into a final product to be appropriately applied [21].

2-2-4- Methods for Problem-Solving (MET)

Problem-solving methods refer to choosing, evaluating, and implementing solutions. In this component, individuals assess each solution's feasibility, effectiveness, and potential outcomes and choose the best course of action (32), as evaluation, selection, and justification of methods are essential skills for effective CPS. This component also refers to assessing different methods, selecting the most appropriate one, and justifying the choice (26). In their study, Kanchanachaya and Shinasharkey (25) noted that a methodological approach to CPS, especially in teaching, often presents teachers with unpredictable and multifaceted situations. However, techniques like SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) or decision matrices can be used to compare and prioritize solutions. For example, an educational supervisor may evaluate various teacher professional development (PD) programs based on cost, relevance, and outcomes before selecting one (26). This stage ensures that the chosen solution is viable and effective.

2-2-5 Creativity and Knowledge Creation (CRE)

Creativity is what makes CPS creative [32]. It encourages people to approach things in many new and different ways [27]. Creativity is the ability to use knowledge in new ways, to create novel relationships among objects and phenomena, and to find or formulate ways to solve problems [27]. This component is important in education because teachers need to be ever-changing and adapt to each student's needs while also adapting to the development of new technologies [26]. Examples of this creativity include:

- A creative teacher might think of the lesson plan as a story to tell and the students as an audience;
- A creative teacher might make various scripts for different platforms and devices, such as web pages, digital museum space, social media, etc.;
- A creative teacher might approach the lesson with design thinking, game design/interaction design/virtual space design thinking, and experience/experimental/digital art-centered thinking.

Therefore, these ideas strengthen a teacher's multiple intelligences and mobilize and motivate students' imagination and creativity [26]. In education, creative pedagogical adaptations should fulfill both creative and pedagogical objectives, employing realistic methods based on sound knowledge [26]. Creativity is the founding base of CPS because if you do not think outside of the box, solutions will not be unique, and you will be less prepared to adapt to future changes.

2-3- CPS in Educational Contexts

CPS skills are critical in educational contexts, where teachers and students must navigate complex and often ill-defined problems. Research has shown that CPS fosters critical thinking, creativity, and adaptability among students and teachers [11].

2-3-1- CPS in Teacher Education

Teacher education programs are critical in developing CPS skills among PSTs. Studies have shown that PSTs who develop strong CPS skills are better equipped to model effective problem-solving strategies for their students [11]. However, research also indicates that many PSTs struggle to develop these skills, particularly using technology and innovative teaching methods [14].

2-3-2- Challenges in Developing CPS Skills

Even as awareness of the importance of CPS skills increases, PSTs struggle to develop CPS skills. Wannapiroon & Pimdee [15] found that PSTs found CPS skills challenging to integrate into their teaching practices. Moreover, absolute and relative poverty remain a formidable challenge among PSTs in regions with transitional economies. These difficulties primarily stem from educational systems in transitional economies that are under-resourced and overburdened [16].

2-4- Gaps in the Literature

While a substantial amount of literature has been published on CPS, there are several literature gaps that this study aims to address. First and foremost, there is a lack of research on CPS among educational personnel in transitional economies, including Thailand. Second, our knowledge regarding the components of CPS and how such components can be measured using confirmatory factor analysis (CFA) is limited. Third, research on the level of CPS skills of Thai educational personnel is also lacking, as is research on how CPS skills among Thai educational personnel can be enhanced.

2-5- Theoretical Framework

This study is guided by the theoretical framework of CPS, which emphasizes problem identification, solution generation, insight, methods, and creativity [20, 21]. These components are critical for understanding and enhancing CPS skills among educational personnel. This study aims to comprehensively understand CPS and its application in educational contexts by focusing on these components.

2-6- Research Objectives

The primary objectives of this study are to analyze the components of CPS among educational personnel (RO1) and to study the level of opinions regarding CPS among Thai educational personnel (RO2). This study hopes to contribute timely insights into CPS in education by addressing these objectives.

3- Methodology

This study used a quantitative research design to study the components of creative problem-solving (CPS) among Thai educational personnel. Figure 1 provides a visual overview of the research process.

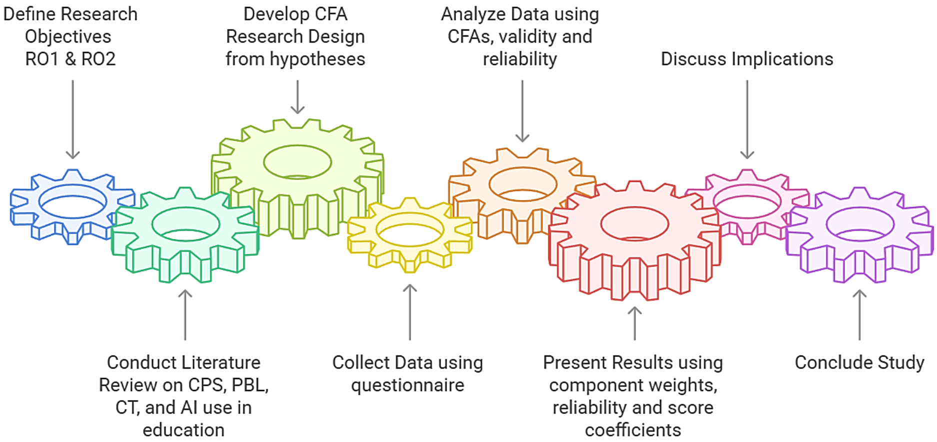

Figure 1. Research Process Flowchart

3-1- Population and Sample

The study focused on educational personnel in Thailand, specifically teachers and educational supervisors in science and technology subjects such as computational science, design and technology, and general science [33]. These individuals were selected from schools under the jurisdiction of the Office of the Basic Education Commission (OBEC), operating under the Ministry of Education [34]. The research population was drawn from five geographical regions, ensuring comprehensive representation during the 2024 academic year. The sample selection process was designed to align with accepted theoretical guidelines and statistical practices.

To ensure sufficient data for analysis, the researchers employed multiple criteria in determining the sample size. The minimum threshold was set at 300 participants, per general recommendations for Structural Equation Modeling (SEM) [35]. Additionally, theoretical considerations emphasized that SEM models with no more than seven latent variables must include at least three observable variables per latent variable to avoid under-identification [36]. Given these considerations, the researchers established a sample size target of 600 participants.

The study used a stratified random sampling method to select schools proportionally from the five regions and the different educational districts [37]. Once the subset of schools had been identified, a simple random sampling method was used to select one teacher from each school, with a lottery drawing procedure being followed to ensure that the selection process was fair. Educational supervisors were also selected by simple random sampling, with one supervisor being selected for each targeted educational district. In this way, a mixed target sample of 400 teachers and 200 educational supervisors was initially selected. However, following the completion of the data collection phase, responses were received from 361 teachers and 173 educational supervisors, giving a total sample size of 534, representing a high response rate of 89% (Table 1).

Table 1. Educator survey process by region

Survey Region	Teachers			Administrators		
	Population	Sample group		Population	Sample group	
		Target	Collected		Target	Collected
Bangkok and Metropolitan Area	443	7	6	78	7	6
Central Region	4,633	70	63	422	36	31
Northern Region	5,526	83	75	581	49	42
Northeastern Region	12,040	181	163	931	79	68
Southern Region	3,958	60	54	357	30	26
Total	**26,600**	**400**	**361**	**2,369**	**200**	**173**

3-2- Research Instruments

The CPS assessment questionnaire was validated through multiple processes. Firstly, five experts in educational psychology and psychometrics viewed its content and holistic consistency using the Index of Item-Objective Congruence (IOC) values between 0.60 and 1.00 as their criteria for acceptance. Next, 50 non-sample Thai educators completed the questionnaire in a pilot test regarding item clarification and differentiation, with discriminatory power values ranging from 0.62 to 0.86. Cronbach's Alpha was then used to assess internal consistency reliability (0.84—0.90). Confirmatory Factor Analysis (CFA) was performed to verify the constructed model of the CPS assessment questionnaire, indicating excellent statistical fit indices. Thus, all these processes confirmed that the instrument was valid and reliable for assessing Thai educational personnel's CPS skills.

3-3- Data Collection

The researchers collected data from OBEC educational personnel (primary school teachers and educational supervisors) across five geographical regions in the academic year 2024 [29]. These participants were selected through random sampling by OBEC staff to participate in a project promoting computational thinking to enhance higher-order thinking skills in October 2024. Data was collected using a Google Form questionnaire with six hundred participants; responses were received from five hundred thirty-four individuals, yielding an overall response rate of 89%.

3-4- Data Analysis

Data analysis was performed using statistical software with the following details:

- The CPS components were analyzed through second-order CFA using LISREL version 9.10 software to interpret the model's validity [38].
- General data analysis utilized descriptive statistics, including percentages, means (*M*), and standard deviations (*SD*) via SPSS for Windows version 21, employing interpretation criteria for *M* scores with '5' indicating a 'very strong' agreement with the item statement [39]. The *M* score criteria were 4.50-5.00. This was followed by a '4' indicating a 'high' level of agreement with the item statement, denoted by a *M* score of 3.50-4.49. The educators did not use levels 3, 2, and 1 for any items.

This structured methodology ensures clarity and logical presentation throughout the research process while adhering to established academic standards for data collection and analysis in educational research contexts.

4- Results

The results of this study provide valuable insights into the creative problem-solving (CPS) abilities of educational personnel, including teachers and supervisors. Below, we present the demographic data, correlation analysis, confirmatory factor analysis (CFA) results, and detailed interpretations of their significance.

4-1- Educator Demographics

The demographic data of the surveyed educators are presented in Table 2. Most respondents were female (63.50%) and worked as classroom teachers (67.60%). Regarding teaching experience, most respondents reported having between 5 to 10 years of experience (36.33%). Regarding educational background, 52.62% held postgraduate qualifications, while 73.97% had degrees in science and technology-related fields.

Table 2. Educator general characteristics

Survey Item	Individuals	%
1. Gender		
- Men	195	36.50
- Women	339	63.50
2. Position		
- Teacher	361	67.60
- Administrator	173	32.40
3. Professional Experience		
- less than 5 years.	162	30.34
- 5-10 years.	194	36.33
- More than 10 years.	178	33.33
4. Highest level of education		
- Bachelor's degree	253	47.38
- Graduate degree	281	52.62
5. Field of study		
- Science and Technology	395	73.97
- Other (e.g., Art, English, Physical Education)	139	26.03

4-2- Correlation Analysis

The relationships between the CPS variables were examined using a Pearson correlation analysis (Table 3), which revealed that all 15 observed variables and their 105 variable pairs showed statistically significant positive correlations (.53 to .81 and $p < .01$). These results indicated strong interrelationships among the CPS components, supporting the cohesive structure of the CPS model. The highest correlations observed were between creativity-related variables (e2, e3) and methods (d2, d3), with values of $r = .81$ and $r = .79$, respectively. These components are closely aligned and may share underlying cognitive processes, such as generating innovative solutions and evaluating problem-solving strategies. Moreover, variables within the same CPS component consistently showed higher correlations. For example, within the solutions (SOL) component, correlations ranged from $r = .66$ to $r = .70$, while within the methods (MET) component, correlations ranged from $r = .73$ to $r = .79$. This indicated that each component represents a distinct yet interrelated aspect of CPS. The skewness and kurtosis values of the variables were also examined, with most values falling within acceptable ranges (skewness: -0.58 to -0.20; kurtosis: -0.39 to 1.55). These results suggest that the data were approximately normally distributed, supporting factor analysis.

Table 3. Correlation, skewness, and kurtosis of observed variables in both groups

VAR	a1	a2	a3	b1	b2	b3	c1	c2	c3	d1	d2	d3	e1	e2	e3
a1	1.00														
a2	.70**	1.00													
a3	.66**	.67**	1.00												
b1	.58**	.59**	.67**	1.00											
b2	.65**	.70**	.70**	.75**	1.00										
b3	.63**	.65**	.63**	.68**	.78**	1.00									
c1	.60**	.60**	.63**	.70**	.69**	.65**	1.00								
c2	.55**	.54**	.63**	.59**	.70**	.67**	.67**	1.00							
c3	.53**	.56**	.58**	.57**	.67**	.61**	.61**	.76**	1.00						
d1	.56**	.60**	.60**	.65**	.68**	.62**	.68**	.70**	.70**	1.00					
d2	.57**	.60**	.63**	.63**	.69**	.65**	.68**	.69**	.67**	.73**	1.00				
d3	.59**	.61**	.61**	.65**	.66**	.63**	.70**	.68**	.64**	.75**	.79**	1.00			
e1	.55**	.59**	.57**	.60**	.65**	.63**	.68**	.65**	.67**	.70**	.75**	.76**	1.00		
e2	.55**	.59**	.61**	.61**	.65**	.66**	.64**	.69**	.65**	.70**	.76**	.79**	.80**	1.00	
e3	.53**	.57**	.57**	.63**	.65**	.62**	.68**	.65**	.65**	.75**	.75**	.77**	.77**	.81**	1.00
Skew.	-0.30	-0.24	-0.20	-0.20	-0.26	-0.27	-0.58	-0.26	-0.22	-0.30	-0.38	-0.40	-0.44	-0.47	-0.51
Kurt.	-0.09	-0.07	-0.23	0.06	-0.03	-0.27	1.55	-0.11	-0.39	0.13	0.56	0.61	0.69	0.82	0.67

** Sig. < 0.01, VAR = observed variable.

4-3- Confirmatory Factor Analysis (CFA)

The second-order CFA demonstrated that the CPS model aligned well with the empirical data across all groups (teachers, supervisors, and the total sample) [29]. The goodness-of-fit (GoF) indices met or exceeded standard thresholds, confirming the validity of the CPS framework for educational personnel (Table 4).

Teachers: The model for teachers showed excellent fit, with a nonsignificant Chi-square value ($\chi^2 = 32.19$, $df = 46$, p = 0.94), RMSEA = 0.00, and CFI = 1.00 [40-42]. These results indicate that the CPS components accurately capture the problem-solving abilities of teachers, who play a critical role in fostering creativity and adaptability in classroom environments.

Supervisors: Similarly, the model for supervisors demonstrated a strong fit, with a nonsignificant Chi-square value ($\chi^2 = 58.20$, df = 62, $p = .61$), RMSEA = 0.00, and CFI = 1.00. This suggests that the CPS model equally applies to leadership-focused roles, highlighting the importance of CPS skills for guiding and evaluating educational processes.

Total Sample: The combined model for both groups also showed excellent fit, with a nonsignificant Chi-square value ($\chi^2 = 45.34$, df = 47, $p = .54$), RMSEA = 0.00, and CFI = 1.00. These findings underscore the broad applicability of the CPS model across different educational roles.

Moreover, according to Khademi et al. [43], the RMSEA, the CFI, and TLI are some of the most common fit indices used to interpret CFA fit results. Furthermore, goodness-of-fit indices such as GFI, AGFI, NFI, CFI, RMR, and SRMR all exceeded their respective benchmarks (≥ 0.90 and ≤ 0.05), indicating excellent model fit [44-47] (Table 4). These findings confirm that the second-order CFA model of creative problem-solving among primary school teachers is statistically valid and can be applied in further analyses. These findings confirm that the second-order CFA model of creative problem-solving among primary school teachers is statistically valid and can be applied in further analyses [48]. Visual representations of the results for each group (teachers, supervisors, and the total sample) are provided in Figures 2 to 4.

Table 4. Goodness-of-fit appraisal criteria, results, and supporting theory.

Criteria Index	Criteria	The values obtained from each group of models			Theory Support
		Teachers	Supervisors	Total	
Chi-square: $\chi 2$	$p \geq .05$	0.94	0.61	0.54	[40-42]
$\chi 2$/df	≤ 2.00	0.70	0.94	0.96	[40-42]
RMSEA	≤ 0.05	0.00	0.00	0.00	[42]
GFI	≥ 0.90	0.99	0.96	0.99	[45]
AGFI	≥ 0.90	0.97	0.92	0.97	[44-47]
RMR	≤ 0.05	0.01	0.02	0.01	[42]
SRMR	≤ 0.05	0.01	0.02	0.01	[42]
NFI	≥ 0.90	1.00	0.99	1.00	[47]
CFI	≥ 0.90	1.00	1.00	1.00	[43]

4-4- Goodness-of-Fit (GoF) Analysis Across Groups

The authors conducted a goodness-of-fit analysis for three second-order CFA models representing primary school teachers' creative problem-solving (CPS) abilities, educational supervisors, and the combined total group. These analyses validate the hypothesized model, comprising five core CPS components: Solutions (SOL), Identification (IDE), Creativity (CRE), Insight (INS), and Methods (MET).

In the model for teachers (Figure 2), the Chi-square value of 32.19 with 46 degrees of freedom (p = .94) indicates an excellent fit, further supported by an RMSEA of 0.00 [42]. These statistics confirm that the observed data aligns closely with the model, reflecting teachers' roles in fostering creativity and adaptability in classroom environments. The Comparative Fit Index (CFI) 1.00 underscores the model's exceptional accuracy in capturing the relationships between the CPS components and their observed variables.

The second-order CFA results indicated that the CPS model of educational personnel (total sample, teachers, and supervisors) fit well with the empirical data. The goodness-of-fit statistics showed that the CPS model of educational personnel satisfied all benchmark fit indices (Figures 2 to 4 and Table 5). The researchers tested the fit of this second-order CFA model of primary school teachers' CPS skills, including 15 observed variables. The fit indices shown in Table 5 indicate that this model fits the data, and our hypothesized structure of CPS became its empirical structure. As all GoF indices exceed the threshold criteria, these results support the assertion that the CPS model is well-suited to the actual data. Consequently, the CPS model was appropriate for further factor analysis and educational application.

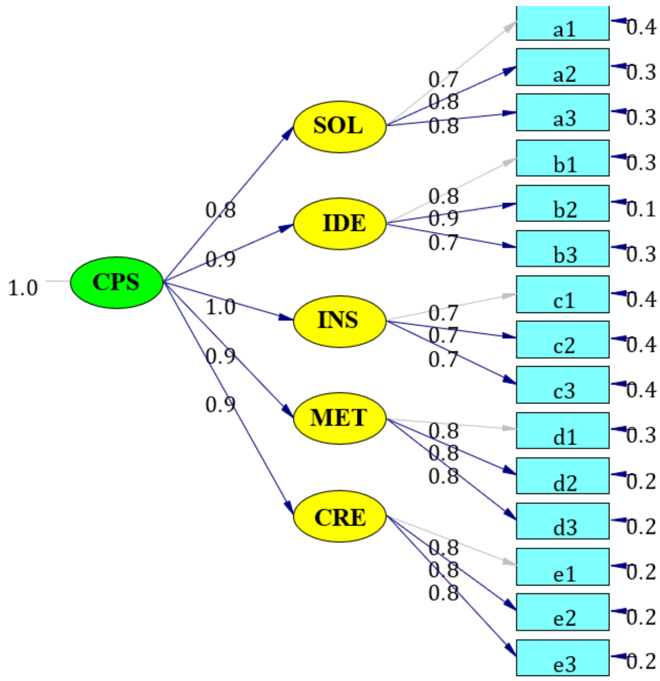

Figure 2. The Final Second-Order CFA for Teacher CPS. Note: Chi-Square=32.19, df=46, *p*-value= .94, RMSEA=0.00, solutions (SOL), identification (IDE), insight (INS), methods (MET), and creativity (CRE), creative problem-solving (CPS)

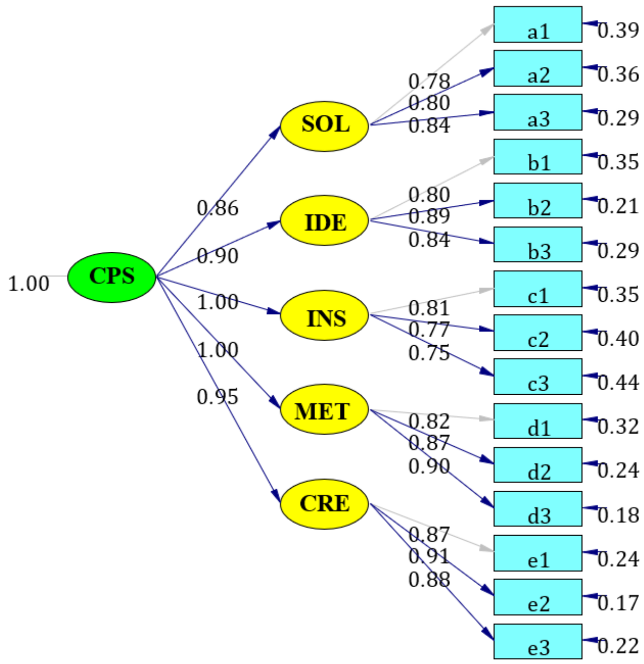

Figure 3. The Final Second-Order CFA for Educational Supervisor CPS. Note: Chi-Square=58.20, df=62, *p*-value = .61, RMSEA=0.00, solutions (SOL), identification (IDE), insight (INS), methods (MET), and creativity (CRE), creative problem-solving (CPS).

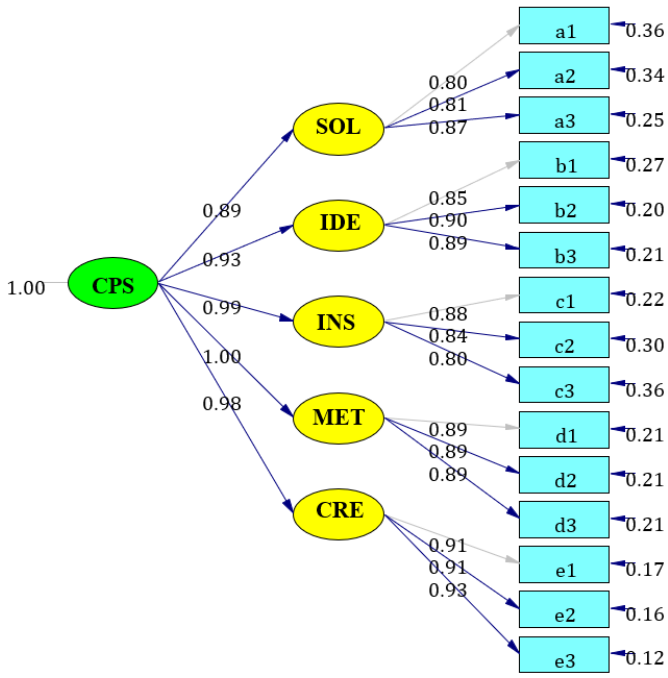

Figure 4. The Final Second-order CFA for both CPS Educational Groups. Note: Chi-Square=45.34, df=47, *p*-value = .54, RMSEA=0.00, solutions (SOL), identification (IDE), insight (INS), methods (MET), and creativity (CRE), creative problem-solving (CPS).

Similarly, the model for supervisors (Figure 3) demonstrates strong goodness-of-fit. The Chi-square value of 58.20 with 62 degrees of freedom (p = .61) and an RMSEA of 0.00 validate the alignment of the data with the proposed structure [42]. Supervisors, pivotal in guiding and evaluating educational processes, showed strong correlations across the five CPS components, suggesting the model's applicability to leadership-focused roles. A CFI of 1.00 further confirms the precision of the model.

The combined model for both groups (Figure 4) also firmly fits the data, as indicated by a Chi-square value of 45.34 with 47 degrees of freedom (p = .54) and an RMSEA of 0.00. This result highlights the model's consistency and adaptability across different educational roles, capturing the universal relevance of CPS components in education. The

CFI of 1.00 reflects the comprehensive nature of the model, successfully encapsulating the interrelationships between variables across both teachers and supervisors.

Across all three models, the statistical indices consistently met or exceeded established thresholds, providing compelling evidence of the CPS model's validity. These findings suggest that the five core components are well-defined and applicable across diverse educational roles, ensuring the model's broader utility for research and practical applications.

Table 5. Component weights (β), reliability of observed variables (t), and component score coefficients (R^2) of the three models

Groups Factors/Variables	Position						Total		
	Teachers			Supervisors					
	β	t	R^2	β	t	R^2	β	t	R^2
Solutions (SOL): Ability to solve problems	**0.87**	**14.11**	**0.76**	**0.89**	**10.93**	**0.79**	**0.86**	**17.67**	**0.75**
a1: I can recognize the problem that needs to be solved.	0.76	↔	0.58	0.80	↔	0.64	0.78	↔	0.61
a2: I can find information related to the problem and fully identify what it requires.	0.81	17.69	0.66	0.81	11.88	0.66	0.80	21.57	0.64
a3: I can link information to the identified problem.	0.82	14.75	0.68	0.87	12.83	0.75	0.84	19.25	0.71
Identification (IDE): Ability to identify problems	**0.90**	**15.38**	**0.81**	**0.93**	**12.47**	**0.86**	**0.90**	**19.12**	**0.82**
b1: I can identify problems or ask questions about problems.	0.81	↔	0.65	0.85	↔	0.73	0.80	↔	0.65
b2: I can consider the causes of problems.	0.91	18.39	0.83	0.90	15.81	0.80	0.89	23.37	0.79
b3: I can prioritize problems.	0.79	15.52	0.63	0.89	15.60	0.79	0.84	20.62	0.71
Insight (INS): Ability to discover concepts	**1.00**	**16.73**	**1.00**	**0.99**	**14.37**	**0.98**	**1.00**	**23.13**	**1.00**
c1: I can use knowledge to solve problems.	0.74	↔	0.54	0.88	↔	0.78	0.81	↔	0.65
c2: I can think of a variety of ways to solve problems.	0.77	15.93	0.59	0.84	15.06	0.70	0.77	21.87	0.60
c3: I can solve problems in a new way that differs from the original idea.	0.75	14.87	0.57	0.80	13.74	0.64	0.75	19.73	0.56
Methods (MET): Ability to discover methods to solve problems	**0.98**	**18.18**	**0.95**	**1.00**	**14.97**	**1.00**	**1.00**	**23.09**	**1.00**
d1: I can evaluate methods to solve problems.	0.83	↔	0.68	0.89	↔	0.79	0.82	↔	0.68
d2: I can choose the most appropriate problem-solving concept or method.	0.86	19.62	0.73	0.89	17.51	0.79	0.87	25.73	0.76
d3: I can state why I chose the most appropriate problem-solving concept or method.	0.87	19.95	0.76	0.89	17.48	0.79	0.92	26.39	0.82
Creativity (CRE): Ability to create knowledge	**0.93**	**17.93**	**0.86**	**0.98**	**14.93**	**0.96**	**0.95**	**23.42**	**0.90**
e1: I can apply knowledge to solve problems.	0.85	↔	0.73	0.91	↔	0.83	0.87	↔	0.76
e2: I can connect knowledge and solve situations in a real-life context.	0.87	20.79	0.77	0.91	26.24	0.84	0.91	30.85	0.83
e3: I can apply methods to solve problems or create new knowledge.	0.87	20.06	0.76	0.93	21.11	0.87	0.88	28.93	0.78

Note. **Sig.< 0.01

5- Discussion

The study's findings provide valuable insights into educational personnel's creative problem-solving (CPS) abilities, including teachers and supervisors [29]. In this section, we compare our results with those of previous studies, analyze their implications, and discuss the unique contributions of our research.

5-1- Creative Problem-Solving (CPS) Framework

Creative Problem-Solving (CPS) has been widely studied as a structured approach to innovation, critical thinking, and effective decision-making [4, 10, 11, 26]. Therefore, this study adopted a multi-component CPS framework comprising five key dimensions. These included solutions (SOL), identification (IDE), creativity (CRE), insight (INS), and methods (MET), which reflect distinct cognitive processes essential for tackling complex educational challenges.

One of the foundational models influencing CPS research is the Osborn-Parnes Creative Problem-Solving Model [49, 50], which consists of divergent and convergent thinking phases, including problem identification, ideation, and solution evaluation. Similarly, Treffinger's Learning Model [51] has been demonstrated using CPS to improve student abilities in observation, communication, grouping, measurement, concluding, and prediction. The present study aligns with these theoretical perspectives by validating a CPS framework specifically tailored for educators and educational supervisors.

The five CPS components examined in this study contribute uniquely to problem-solving:

Solutions (SOL): The ability to recognize and define problems accurately [12, 18, 21-24].

Identification (IDE): Diagnosing the root cause and categorizing problem types [36].

Creativity (CRE): Generating innovative solutions by applying insight (INS) [10, 18-21].

Insight (INS): The capacity to connect different knowledge domains and synthesize new ideas [31].

Methods (MET): Evaluating and selecting appropriate strategies for implementation [26, 29].

This structure enables a comprehensive understanding of how educators apply CPS in real-world teaching and supervisory contexts.

5-2- Educational Theories Supporting CPS

The elements of CPS are not isolated as they interact with and support each other during the problem-solving process. For instance, problem identification supports solution generation by clarifying what needs to be addressed and helping one decide which situation is a problem and which is a solution in progress. Insight and conceptual thinking help connect the ideas generated in the solution generation framework to the context of the implementation framework. Problem-solving methods provide the scaffolding that enables idea development and evaluation styles to be used by more people in more appropriate situations. Creativity allows unique and original ideas to be developed.

Moreover, the role of CPS in teaching and educational leadership is best understood by its harmonious relationship with learning theories. Examples include the Constructivist Learning Theory [52], consistent with social constructivism, which claims that learners can build knowledge through active participation and shared experience [53]. CPS implementations have also shared the ideas used to scaffold the problem-solving process, where teachers can scaffold students' thinking through problem-solving, a hallmark in inquiry-based learning [54]. Finally, Experiential Learning Theory is aligned with experiential learning by immersing teachers and educational leaders in building authentic and real-world problem-solving [55]. Teachers and supervisors gain metacognition competence when they build on learned experience by undergoing a trial-and-error cycle, reflecting on results, and making necessary modifications.

5-3- Computational Thinking (CT) & Problem-Based Learning (PBL) in CPS

Figure 5 illustrates the integration of Computational Thinking (CT), Problem-Based Learning (PBL), and Creative Problem-Solving (CPS) in educational practices. The diagram shows that CT contributes to CPS by fostering algorithmic reasoning and systematic troubleshooting, while PBL enhances CPS through inquiry-driven learning and collaboration. These approaches provide a structured yet flexible framework for addressing complex educational challenges.

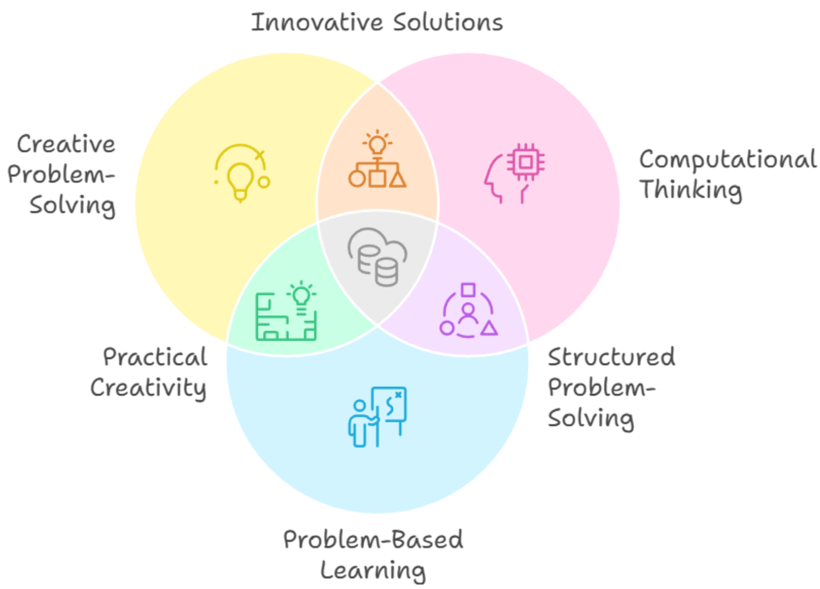

Figure 5. Enhancing Creative Problem-Solving

Problem-based learning (PBL) promotes CPS by immersing learners in authentic, inquiry-based, problem-centered activities [2]. PBL encourages learners to investigate real-world problems, work with peers, and develop creative solutions, a process that closely aligns with the tenets of CPS. Likewise, computational thinking (CT) also supports CPS by encouraging algorithmic thinking, pattern identification, and systematic problem-solving [8]. CT provides a cohesive framework for problem-solving, allowing educators to decompose complex problems into smaller, understandable parts and formulate programs of steps and rules to develop solutions [56].

By integrating PBL and CT-based pedagogies, teachers are given tools to address ill-structured educational problems. PBL, for example, might utilize the design of classroom activities to apply CPS-related skills, and CT can give teachers the analytical skills needed to assess a problem and propose alternative or refined solutions. Such approaches also complement the work of current educational instructional design practitioners and lend themselves to a more holistic approach to problem-solving in educational practice.

Figure 5 shows how integrating CT, PBL, and CPS can be achieved in educational practices. The diagram shows that CT contributes to CPS by fostering algorithmic reasoning and systematic troubleshooting, while PBL enhances CPS through inquiry-driven learning and collaboration. These approaches provide a structured yet flexible framework for addressing complex educational challenges.

5-4- Justification for Applying CPS to Thai Educators

Studies reveal that Thai teachers encounter obstacles when adopting CPS-based methods, technology integration, and classroom creativity and innovation development [17]. The research underscores the following needs in Thailand:

(1) Specially designed professional development programs focusing on CPS skills to enable educators to incorporate CPS into their pedagogy. (2) Teacher training curricula incorporating PBL and CT to equip educators to adapt to complex problems in education. (3) Systemic policy changes around support for innovative, problem-solving-oriented educational environments to integrate CPS into the national curriculum.

This study offers a theoretically grounded, empirically validated CPS framework for the Thai educational context. The strengths and weaknesses identified in this study help curriculum developers, policymakers, and teacher training institutes devise interventions and policies to enhance CPS skills. For example, Thai teachers doing well on insight (INS) and creativity (CRE) skills (as reflected in the high-reliability scores) indicate that Thai teachers are good at innovative thinking and integrating prior knowledge and experience. On the other hand, Thai teachers' marginally lower scores on the methods (MET) components call for possible measures to improve systematic problem-solving skills.

5-5- Practical Application of CPS Components in Educational Contexts

The five key components of Creative Problem-Solving (CPS)—Solutions (SOL), Identification (IDE), Creativity (CRE), Insight (INS), and Methods (MET)—are essential for addressing complex challenges in educational settings. Below, we define each component, differentiate their roles, and explain how they can be applied in practical, day-to-day teaching and supervisory contexts.

5-5-1- Solutions (SOL): Ability to Solve Problems

Definition: The ability to identify problems, collect data, establish facts, and undertake the appropriate solution(s) [25-27].

Teaching Context: If a teacher realizes that a student is struggling to grasp a concept (problem identification), he/she will research alternative teaching strategies (information collection) and attempt the best approach (solution to undertake).

Supervisory Context: An educational supervisor may recognize a shortcoming in teacher training programs (problem recognition), gather feedback from teachers (information gathering), and create an in-service training workshop (solution development).

Differentiation: SOL is geared towards the practical steps needed to solve a problem.

5-5-2- Identification (IDE): Ability to Identify Problems

Definition: IDE involves diagnosing the root cause of a problem and categorizing its type.

Teaching Context: A teacher might observe that students are disengaged during lessons (symptom), identify the root cause (e.g., lack of interactive activities), and categorize the problem as a pedagogical challenge.

Supervisory Context: A supervisor observes low morale in teachers (symptom), looks for a cause (too much work), and defines the problem (organizational).

Differentiation: IDE uses diagnosis to develop an understanding of the problem.

5-5-3- Creativity (CRE): Ability to Create Knowledge

Definition: Producing innovative ways through diverging thinking (lexical knowledge, knowledge of facts, and process knowledge in novel ways).

Teaching Context: The teacher crafts a gamified lesson plan in a creative way to make the lesson more entertaining to learn.

Supervisory Context: A supervisor might create a mentoring program that partners veteran teachers with new teachers to foster and promote collaboration and innovation among teachers.

Differentiation: CRE is distinguished by originality, emphasizing idea generation.

5-5-4- Insight (INS): Ability to Discover Concepts

Definition: Integrating various knowledge domains; synthesizing new knowledge and know-how to improve understanding of the subject matter.

Teaching Instructional Context: A teacher can combine two domains of subject, such as science and art, to create an interdisciplinary project to deepen students' understanding of environmental sustainability.

Supervisory Context: A supervisor may integrate information from psychology and management theory to develop a stress-management program for teachers.

Differentiation: INS classes emphasize synthesizing knowledge and gaining new perspectives; conceptual thinking is key.

5-5-5- Methods (MET): Ability to Discover Methods to Solve Problems

Definition: MET is concerned with evaluating, selecting, and justifying appropriate problem-solving strategies. Practical Application:

Teaching Example: A teacher could evaluate the effectiveness of different assessment methods (e.g., formative versus summative) to select the best method for assessing their students' learning.

Supervisory Context: A supervisor may evaluate different leadership styles (i.e., transformational vs. transactional) and choose the type most appropriate for motivating teachers.

Differentiation: MET emphasizes the systematic evaluation and selection of strategies, emphasizing the decision-making process.

5-5-6- Connectivity Among CPS Components

Each component of CPS has its practical value in everyday situations. However, they demonstrate the greatest power when used in an integrated manner to construct the entire problem-solving process.

Teaching Context: In an example of using CPS problems in a teaching context, IDE could be used by the teacher to identify a learning difficulty faced by a student. INS is then used to discover how multiple disciplines could be used to help solve the problem. CRE could then be used to create an innovative approach to tackle the problem. MET then could be used to test each approach to see if it works for the student. Finally, SOL is used to carry out the plan and improve it for future usage.

Supervisory Context: Using the example of a supervisor helping staff identify a gap in teacher training opportunities and implementing a solution, IDE would involve the supervisor using information from a variety of sources to diagnose the problem, INS would involve investigation into what other schools offer, CRE would involve the development of a teacher-training program unique to that school, MET would involve the assessment of the feasibility of the program, and SOL would incorporate the development and measurement of the implementation plan. Including these elements ensures that educators take a broad view of the problem and address it effectively.

5-6- Cultural and Regional Considerations in CPS Application

The findings of this study provide a validated framework for assessing CPS skills among Thai educators [57]. However, it is important to consider how these skills may vary across regional and cultural contexts. While the sample included educational personnel from multiple geographical regions of Thailand, this study did not conduct a comparative analysis of CPS skill differences between regions. Future research could explore how urban and rural educational environments, local policies, and school resources impact CPS competencies.

5-6-1- Regional Differences in CPS within Thailand

Educational contexts differ dramatically in urban and rural Thailand [58]. In urban Thai schools, for example, teachers often have access to more technology, professional development, and student-centered pedagogical training, which could support some CPS aspects like CRE and INS. Meanwhile, rural Thai teachers are accustomed to working with limited resources and more traditional pedagogical methods and, as a result, may rely more heavily on problem-solving MET that reflects fixed systems. In contrast, CRE and INS may not align with these contexts. These results help policymakers know where to focus their CPS-related professional development programs depending on their educator population.

5-6-2- Adapting the CPS Model to Other Educational Systems

CPS is a universal skill, but cultural norms, educational philosophies, and systemic structures influence its development. Countries prioritizing rote memorization and standardized testing may emphasize Creativity (CRE) and

Insight (INS) less. At the same time, those with progressive, inquiry-based education systems may naturally cultivate Problem Identification (IDE) and Solution Development (SOL). To adapt the CPS framework across different educational systems, policymakers and educators should consider the following:

Curriculum Flexibility: Allowing teachers greater autonomy in lesson planning encourages problem-solving and innovation.

Professional Development: Training should focus on structured problem-solving (MET) vs. more exploratory and creative problem-solving (CRE) as a function of the underlying culture.

Assessment Methods: Countries emphasizing high-stakes testing may need to incorporate alternative assessments (e.g., project-based assessments, critical thinking assessments) to develop CPS skills successfully.

With the realization of Thailand's regional differences and cultural variations across other educational systems, future research and policy implementation can tailor the CPS model for diverse learning environments to ensure that the model can be applied in real-world settings across the globe.

5-7- Confirmatory Factor Analysis (CFA) as a Theoretical Validation Method

To examine the empirical strength of this CPS framework, the study conducted a Second-Order CFA to confirm the associations among the CPS components. CFA is a proven method to validate latent constructs and is especially suited to measuring explanations of complex, multi-dimensional cognitive skills [41]. The justification for the application of CFA is the multidimensionality of CPS: CPS consists of interrelated yet distinct multiple cognitive abilities, and CFA is appropriate for testing the factor structure.

Latent Variable Modeling: CFA enables the identification of unquantifiable constructs, known as latent variables. Examples of latent variables may include creativity or insight - things that cannot be measured directly.

The added value of statistical validation: Ensures the theoretical CPS model fits well with empirical data by examining model fit indices such as Chi-square, RMSEA, CFI, and TLI.

Results of the CFA also supported that all five CPS components had significant factor loadings, supporting the construct validity of our model of educational personnel.

5-8- Model Fit and Reliability

The CPS model exhibited strong fit indices for all groups, with Chi-square values (e.g., $\chi^2 = 32.19$, df = 46, $p = .94$ for teachers) and RMSEA values of 0.00, indicating strong alignment with empirical data. These trends were consistent among supervisors ($\chi^2 = 58.20$, df = 62, $p = .61$) and the total sample ($\chi^2 = 45.34$, df = 47, $p = .54$). The Comparative Fit Index (CFI) exceeded 0.98 across all groups, further validating the model's reliability.

The factor loadings of the CPS components ranged between 0.86 and 1.00 for teachers, 0.89 and 1.00 for supervisors, and 0.87 and 1.00 for the total sample. These findings highlight the universal relevance and reliability of the CPS components. Table 4 supports this, showing consistently high weights (e.g., $\beta \geq 0.86$) and reliability metrics (e.g., $R^2 \geq .75$).

5-9- Component Analysis

The ability to identify problems (IDE) and generate solutions (SOL) emerged as particularly strong components (Table 5). The IDE component was weighted 0.90 for the total sample, emphasizing the critical role of recognizing and articulating challenges. This foundational skill is pivotal, as effective solutions depend on clearly understanding the problem. Table 5 highlights consistent reliability for IDE, with weights ranging from 0.89 to 0.93 and $R^2 \geq 0.79$.

Similarly, SOL demonstrated strong metrics, with weights ranging from 0.86 to 0.89 across groups. This indicates that educators are adept at identifying problems and crafting strategies to address them effectively. Notably, the INS component achieved perfect reliability scores (β=1.00), underscoring educators' capacity for innovative thinking and ability to apply knowledge creatively.

5-10- Mean Score and Educators' Perceptions

The results from Table 6 and Figure 6 show each educator's perceived importance of CPS skills. Mean scores across all components fell within the "high" category (e.g., $M \geq 4.11$). The SOL ($M = 4.23$, $SD = 0.54$) component received the highest score, closely followed by IDE ($M = 4.17$, $SD = 0.57$) and CRE ($M = 4.17$, $SD = 0.59$). These scores underscore educators' recognition of CPS as essential for fostering adaptability and innovation in teaching and leadership contexts [6].

Table 6. Mean (M), standard deviation (SD), and both educator groups' opinions on CPS

Factors/Variables	Teachers (*n*=362)			Supervisors (*n*=173)			Total (*n*=534)		
	M	SD	Level	M	SD	Level	M	SD	Level
Solutions (SOL): Ability to solve problems	**4.20**	**0.53**	**High**	**4.28**	**0.56**	**High**	**4.23**	0.54	**High**
a1: I can recognize the problem that needs to be solved.	4.23	0.60	High	4.28	0.64	High	4.25	0.61	High
a2: I can find information related to the problem and fully identify what it requires.	4.16	0.60	High	4.26	0.63	High	4.19	0.62	High
a3: I can link information to the identified problem.	4.22	0.59	High	4.28	0.62	High	4.24	0.6	High
Identification (IDE): Ability to identify problems	**4.14**	**0.55**	**High**	**4.21**	**0.60**	**High**	**4.17**	0.57	**High**
b1: I can identify problems or ask questions about problems.	4.15	0.59	High	4.23	0.62	High	4.18	0.6	High
b2: I can consider the causes of problems.	4.12	0.62	High	4.17	0.66	High	4.14	0.63	High
b3: I can prioritize problems.	4.16	0.63	High	4.23	0.67	High	4.18	0.64	High
Insight (INS): Ability to discover concepts	**4.11**	**0.56**	**High**	**4.15**	**0.63**	**High**	**4.12**	0.58	**High**
c1: I can use knowledge to solve problems.	4.17	0.62	High	4.25	0.65	High	4.19	0.63	High
c2: I can think of a variety of ways to solve problems.	4.12	0.63	High	4.17	0.67	High	4.13	0.64	High
c3: I can solve problems in a new way that differs from the original idea.	4.04	0.68	High	4.04	0.73	High	4.04	0.69	High
Methods (MET): Ability to discover methods to solve problems	**4.09**	**0.56**	**High**	**4.16**	**0.64**	**High**	**4.11**	0.58	**High**
d1: I can evaluate methods to solve problems.	4.04	0.66	High	4.10	0.66	High	4.06	0.66	High
d2: I can choose the most appropriate problem-solving concept or method.	4.11	0.59	High	4.17	0.71	High	4.13	0.63	High
d3: I can state why I chose the most appropriate problem-solving concept or method.	4.12	0.60	High	4.22	0.68	High	4.15	0.63	High
Creativity (CRE): Ability to create knowledge	**4.16**	**0.55**	**High**	**4.19**	**0.66**	**High**	**4.17**	0.59	**High**
e1: I can apply knowledge to solve problems.	4.20	0.59	High	4.19	0.68	High	4.19	0.62	High
e2: I can connect knowledge and solve situations in a real-life context.	4.15	0.60	High	4.21	0.69	High	4.17	0.63	High
e3: I can apply methods to solve problems or create new knowledge.	4.13	0.64	High	4.16	0.7	High	4.14	0.66	High

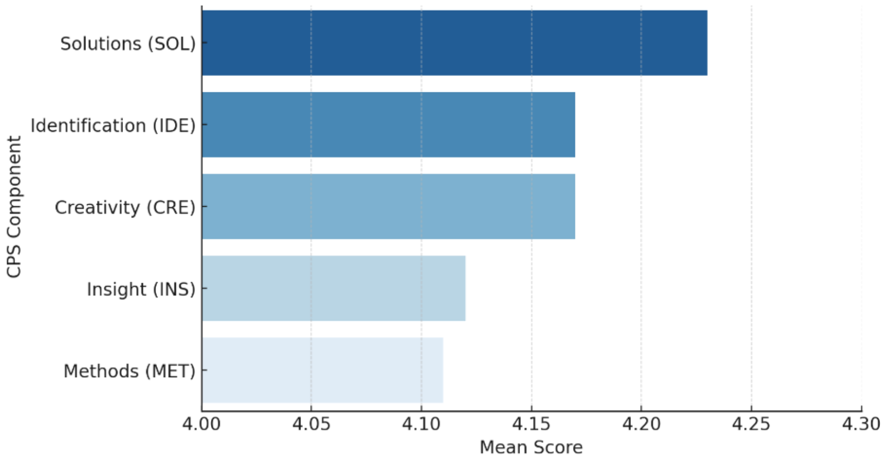

Figure 6. Educator CPS Component Scores

The MET component received slightly lower ratings ($M = 4.11$, $SD = 0.58$), suggesting an area for potential growth. This component's focus on evaluating and selecting appropriate solutions highlights the need for targeted interventions to enhance educators' systematic problem-solving capabilities. Supervisors rated this component higher than teachers, emphasizing structured problem-solving in administrative roles.

While this study measured the CPS skills of educators using self-reports [59], it is necessary to acknowledge potential differences between one's perception of their own CPS skills and their actual demonstrated problem-solving behaviors during teaching. Past research has indicated that self-reported CPS skills are positively associated with actual demonstrated teaching abilities and that CPS skills affect teachers' flexibility when planning for unforeseen natural disasters, alternate teaching strategies, and developing new instructional activities and classroom/student management processes [4, 5, 59]. Therefore, cross-validation of the relation between CPS skills and actual demonstrated CPS would benefit from using multiple sources of information, namely observations, peer assessments, and student test scores, in future studies. A mixed-methods approach may offer a more holistic evaluation of CPS skills demonstrated in real teaching environments and ensure that self-perceived CPS skills can appropriately translate into actual problem-solving behaviors.

5-11-Comparison with Previous Studies

Our results align with and extend the findings of several previous studies on CPS in educational contexts. Below, we compare our findings with key studies in the literature:

Problem Identification (IDE): Our study showed that identifying a problem is an important factor of CPS since there were strong correlations among its observed variables (r = 0.66 to 0.70). This finding aligns with the study by Lee et al. [22], who found that identifying a problem was important, especially in clarifying a problem. Further, our study showed that problem identification may apply regardless of the object of CPS. It showed that teachers and supervisors commonly perceived it despite their different educational roles.

Solution Generation (SOL): The strong correlations between the three solution generation variables (r = 0.66 to 0.70) in the current study echo the conclusion of Sari et al. [24] that interdisciplinary thinking can lead to practical solutions. The current study's strong correlation of solution generation with creativity and methods supports the notion that solution generation should not be treated as an isolated component of CPS but instead in conjunction with creativity and methods.

Insight and Conceptual/Divergent Thinking (INS): Our results show that insight and conceptual thinking have high correlations ranging from r = 0.67 to r = 0.76 with creativity and methods for problem-solving. This result is similar to Chen and Chen [21] and Murwaningsih & Fauziah [60], who showed that insight into divergent and convergent thinking significantly influences CPS. However, our findings extend previous work by showing that insight is a bridge to close the gap between associative idea generation through creativity and idea testing through implementation.

Methods for Problem-Solving (MET): Our results show high correlations among method variables (r = 0.73 to r = 0.79). This result is similar to Sophonhiranrak et al. [26], which showed that creativity, problem-solving through analytical thinking, and task achievement through adherence to methodology significantly influence CPS. However, our findings extend previous work by showing that methods for problem-solving are highly aligned with creativity. Our results indicate that methods for problem-solving are highly aligned with creativity, suggesting that effective problem-solving requires both analytical thinking and creativity.

Creativity (CRE): Our results show high correlations among creativity variables (r = 0.77 to r = 0.81). This finding aligns with Wang [27], who argues that creativity, problem-solving, problem formulation, and solution are the main components of creativity in education. However, our findings extend previous work by showing that creativity is highly aligned with methods for problem-solving and insight.

5-12-Unique Contributions of the Present Study

While the study's findings are consistent with previous studies, they also make several unique contributions to the literature:

Role-Specific Insights: Unlike previous studies focusing primarily on teachers, our study examines CPS abilities across different educational roles (teachers and supervisors). This provides a more comprehensive understanding of CPS in educational contexts and highlights its universal relevance.

Holistic CPS Model: Our study integrates five core CPS components (solutions, identification, insight, methods, and creativity) into a cohesive model. This holistic approach extends previous research, often focusing on isolated individual components.

Empirical Validation: The excellent fit of our second-order CFA model across all groups (teachers, supervisors, and the total sample) provides strong empirical support for the CPS framework. This validation enhances the credibility and applicability of the model for future research and practice.

5-13-Implications of the Findings

The findings of the present study have several significant implications for educational practice and theory:

Practical Implications: Firstly, given the strong intercorrelations among the CPS components, intervention programs designed to enhance one specific CPS component (e.g., creativity) would generate similar improvement in other CPS components (e.g., problem identification or solution generation) as well. This finding has important implications for professional development for pre- and in-service teacher training programs related to developing holistic CPS skills.

Model validity: The satisfactory fit of the second-order CFA model obtained for all groups supports the stability and generalizability of the CPS framework. The model can be usefully applied to assess and develop the CPS skills of educational staff.

Role-specific implications: The consistent fit of the model in teachers and supervisors indicated that CPS skills are considered one of the important skills for the duties of teachers and supervisors. Teachers and supervisors may use them in classroom practices to guide and lead curriculum studies and evaluate curriculum practices.

Moreover, the findings of this study also suggest a necessary next step in developing and reinforcing the five key components of CPS among educational staff. Given the weakness in MET among the teachers in this study, we suggest targeted approaches for developing CPS skills in educational staff. These could include:

- Training on decision-making frameworks and systematic problem-solving techniques.
- Equip educators with structured approaches to develop strategies such as SWOT analysis, decision matrices, and root cause analysis.
- Facilitate collaborative learning opportunities and communities of practice.
- Involve educators in shared learning experiences and discussions to exchange ideas, insights, and strategies for problem-solving.
- Create mentorship and peer support programs. Foster a supportive educational environment where teachers can seek their colleagues' guidance, feedback, and encouragement.

5-14-Implications for Practice and Future Research

The conclusion of this study has some important suggestions for educational practice and future research:

Teacher Training Program: Because there are strong intercorrelations among CPS components, interventions that target one CPS component and skills (e.g., creativity) might increase the acquisition of other CPS skills (e.g., problem identification or solution generation). This study has practical interconnections for teacher training schools and programs, which can focus on CPS skills holistically.

Leadership Development: The relevance of the CPS model to supervisors suggests that CPS skills may be important for educational leadership. Future studies might examine whether/how CPS skills may be incorporated into leadership development programs.

Cross-Cultural Studies: Although our study concentrated on educational personnel in Thailand, subsequent research might explore the relevance of the CPS model for educational personnel from other cultures or in different educational circumstances. Such research could offer valuable clues about the commonality of CPS ability.

6- Conclusion

The findings of this study supported the second-order CFA model of CPS among educational personnel, confirming that solutions (SOL), identification (IDE), creativity (CRE), insight (INS), and methods (MET) were the five main components of CPS. The findings also revealed that educational personnel gave themselves high ratings for their capacity to identify and to solve problems, with SOL (M = 4.23, SD = 0.54) the highest-rated component. However, MET (M = 4.11, SD = 0.58) was rated the lowest, demonstrating that education personnel require more training in employing systematic methods to solve problems.

The strong model fit of the identified model across the teachers and supervisors implies that CPS skills are fundamental competencies applicable across positions in educational organizations. Here, teachers perform CPS mainly in classroom practices with students, whereas supervisors contribute to the organization by applying CPS in curriculum and decision-making processes. The results obtained in the study indicated that an improvement in one CPS skill (e.g., creativity) may lead to an improvement in another CPS skill (e.g., problem identification and solution). This is an important observation for developing teacher training and leadership programs.

Nonetheless, this study has some limitations that can be improved in future research. First, this study relies on self-reported data that may be biased. Second, the study sample is limited to educators from Thailand. Thus, generalizations from the research need to be considered. Future studies should conduct more longitudinal and cross-cultural research to enhance the CPS model. Finally, future studies may conduct an observational assessment or assess CPS skills from the learners' peers.

Finally, the study has produced a psychometrically sound, theoretically grounded assessment instrument that can be used in research and practice related to CPS among teachers. Our findings have important implications for teacher professional development, curriculum development, and educational policy aimed at enhancing creative problem-solving skills among teachers and supervisors.

6-1-Recommendations

Based on the research findings, multiple suggestions can be made for future researchers and practitioners in the field of education. These include the future exploration of the CPS model in diverse educational contexts, including different levels of education and various subject areas. This could provide a more comprehensive understanding of how these components function across different settings. Secondly, conduct longitudinal studies to help assess the development of CPS over time among educational personnel. This would provide insights into how these skills evolve with experience and professional development. Additionally, educational institutions should consider implementing targeted professional development programs that enhance CPS skills among teachers and educational supervisors.

7- Declarations

7-1- Author Contributions

Conceptualization, M.C. and T.K.; methodology, M.C., T.K., and P.P.; software, M.C. and P.P.; validation, M.C. and T.K.; formal analysis, M.C. and P.P.; investigation, M.C., T.K., and K.A.; resources, M.C. and T.K.; data curation, T.K. and P.P.; writing—original draft preparation, M.C. and P.P.; writing—review and editing, P.P., T.K., and K.A.; visualization, M.C. and K.A.; supervision, M.C. and K.A.; project administration, M.C. and T.K.; funding acquisition, M.C. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding

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7-4- Acknowledgements

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7-5- Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of King Mongkut's Institute of Technology Ladkrabang (KMITL) (Certificate No: EC-KMITL_65_076) before consultation with experts relating to the questionnaire's design. A signed informed consent form was also obtained for the study's pilot-survey groups and the main study's respondents. At every step, the anonymity of the participants was considered and ensured, with all interviewees informed that no information concerning their private information would be used. All other survey participants gave informed consent for inclusion before participating in the study.

7-6- Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

7-7- Generative AI Statement

In preparing this manuscript, the authors utilized Scholar GPT to assist in translating the work from Thai to English. Grammarly AI Premium was also used to review grammar and structure refinement. It is important to emphasize that AI detection tools consistently return false positive results (inaccurate results) when applied to translations, as demonstrated by the author's analysis. In addition to using AI tools for translation and language correction, all the content underwent a thorough review and editing by a native English speaker working in collaboration with the authors. Therefore, the authors assert full responsibility for the final manuscript's accuracy, originality, and quality.

7-8- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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Appendix I: Questionnaire

Opinions on creative problem solving of educational personnel: Office of the Basic Education Commission

Section 1: General information of the respondents

1. Gender

- ☐ Male
- ☐ Female

2. Position

- ☐ Teacher
- ☐ Educational Supervisor

3. Teaching experience

- ☐ Less than 5 years
- ☐ Between 5 - 10 years
- ☐ More than 10 years

4. Highest level of education

- ☐ Bachelor's degree
- ☐ Graduate degree (Master's + Doctorate)

5. Field of study

- ☐ Science and technology
- ☐ Other (Art, English, Physical education, etc.)

Section 2: Opinions on creative problem solving of educational personnel

Item	Strongly agree	Agree	Moderately agree	Disagree	Strongly disagree
Solutions (SOL): Ability to solve problems					
a1: I can recognize the problem that needs to be solved.					
a2: I can find information related to the problem and fully identify what it requires.					
a3: I can link information to the identified problem.					
Identification (IDE): Ability to identify problems					
b1: I can identify problems or ask questions about problems.					
b2: I can consider the causes of problems.					
b3: I can prioritize problems.					
Insight (INS): Ability to discover concepts					
c1: I can use knowledge to solve problems.					
c2: I can think of a variety of ways to solve problems.					
c3: I can solve problems in a new way that differs from the original idea.					
Methods (MET): Ability to discover methods to solve problems					
d1: I can evaluate methods to solve problems.					
d2: I can choose the most appropriate problem-solving concept or method.					
d3: I can state why I chose the most appropriate problem-solving concept or method.					
Creativity (CRE): Ability to create knowledge					
e1: I can apply knowledge to solve problems.					
e2: I can connect knowledge and solve situations in a real-life context.					
e3: I can apply methods to solve problems or create new knowledge.					