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High School Student Creativity, Innovation, and Teamwork Skills from Teacher's Perspective: A Second-Order Confirmatory Factor Analysis

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This essay underscores the imperative of cultivating creativity, innovation, and teamwork (CIT) skills in high school students. Employing multi-stage random sampling from August to October 2023, 350 high school technology teachers were asked their opinions concerning what constituted CIT skills in their students. Expert questionnaire validation ensured reliable results. Utilizing descriptive statistics and second-order confirmatory factor (CFA) analysis, the research reveals endorsement of these skills by technology teachers. The model, aligning with the empirical data, highlights innovation's crucial importance, followed by creativity, and teamwork. The research contributes significantly to the literature by providing empirical evidence from technology teachers, offering insights into their perceptions. These results further highlight the educational strategies needed for nurturing a holistic innovative skill set among high school students. The findings, valuable for educators, policymakers, and researchers, fill a gap in enhancing educational practices and curricula to equip students for the 21st-century challenges.

Keywords: creativity, high school students, innovation, teamwork, technology teachers, Thailand

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INTRODUCTION

In the swiftly evolving global landscape, characterized by dynamic changes in social, cultural, economic, and technological spheres, individuals are profoundly impacted. The 21st-century populace faces the dual challenge of adapting to positive transformations and navigating the pitfalls of negative repercussions. This raises a crucial question: How can educational development align itself with the needs of this century, equipping learners with the necessary skills for survival and success? (Care et al., 2018).

The Thai National Scheme of Education B.E. 2560-2579 (2017-2036) (2018) outlines the imperative of nurturing learners with characteristics and learning skills (3Rs8Cs) essential for life in the 21st century. This underscores the importance of strategies that prepare individuals for the ever-shifting realities of the modern world. A critical facet of these skills is creativity and innovation—key determinants of readiness for the complex world of work. As technology advances and societal structures transform, the ability to think creatively, solve intricate problems, and foster innovation becomes paramount.

According to the Organisation for Economic Cooperation and Development (OECD), creativity and innovation skills empower individuals to think beyond conventional boundaries, identify new opportunities, and contribute positively to society. The World Economic Forum (2020) concurs, defining these skills as critical thinking, problem-solving, and the capacity to create anew. These skills are deemed crucial for thriving in the 21st century, necessitating an education system aligned with the realities of contemporary life (Srikan et al., 2021).

While the international community makes strides in shaping education that meets the demands of the 21st century, Thailand faces challenges in adapting its educational landscape rapidly. The deficiency in creativity and innovation skills is starkly reflected in the 2022 PISA assessment by the OECD of 15-year-old Thai children. A decline in scores across mathematics (394), science (409), and reading (379) from PISA 2018 underscores a critical need for educational reforms.

The PISA assessment emphasizes the application of knowledge in real-life scenarios, highlighting a disparity in Thai learners' ability to apply knowledge creatively and innovatively. This deficiency may be attributed to current learning paradigms, which prioritize rote memorization and content delivery, stifling opportunities for creative thinking and problem-solving.

Acknowledging these challenges, this study emphasizes the importance of fostering Creativity, Innovation, and Teamwork (CIT) skills. This emphasis is particularly crucial in addressing a worldwide deficiency in essential skills, elevating the urgency of establishing pathways to engage young individuals in science, engineering, and technology professions. The prominence of creativity and innovation in the skills domain has been highlighted in existing literature.

The Interactionist Model of Creativity emphasizes the role of team interactions in fostering creativity (Amabile & Pratt, 2016). According to this model, team processes, including collaboration, idea exchange, and mutual support, significantly impact creative outcomes. Teamwork provides the necessary conditions for these processes to unfold, ultimately contributing to innovation.

By instilling CIT skills, students can effectively apply knowledge, solve diverse problems, and express innovation, ensuring their preparedness for the challenges of the 21st century (Faud et al., 2022). Joseph (2014) has also suggested that a mentoring and collaborative approach to teaching teamwork, innovation, and entrepreneurship excels in promoting computer and programming students with the professional skills needed as global knowledge workers.

Tajfel and Turner's Social Identity Theory, as outlined by Brown (2020), posits that individuals categorize themselves and others into social groups founded on common attributes. In team dynamics, a unified team identity promotes a harmonious and cooperative atmosphere. This collective identity strengthens communication, trust, and collaboration among team members, thereby stimulating innovation within the group.

The idea that innovation is a social process is supported by various scholars, including Everett Rogers and his Diffusion of Innovations theory. This theory posits that the adoption and diffusion of innovations are influenced by interpersonal relationships and communication (Magsamen-Conrad & Dillon, 2020). Teamwork facilitates the exchange of ideas, diverse perspectives, and knowledge among team members, creating a fertile ground for the generation and diffusion of innovative solutions (Zou et al., 2023).

Theories on team diversity, such as the Information-Decision-Execution (IDE) model by Paulus and Nijstad (2003), suggest that diverse teams, encompassing individuals with varied backgrounds, skills, and perspectives, are more likely to generate creative ideas. Teamwork provides a platform for the integration of diverse viewpoints, leading to innovative and original solutions.

In summary, these theories collectively suggest that teamwork plays a crucial role in innovation by facilitating effective communication, leveraging diverse perspectives, creating psychological safety, and promoting collaborative processes within a group. The synergistic efforts of a well-functioning team can lead to the development and implementation of innovative ideas.

In essence, the interplay of CIT stands as a pillar in shaping the future of Thai high school students (Joseph, 2014; Srikan et al., 2021; Wannapiroon & Pimdee, 2022). As the educational landscape grapples with the challenges of the 21st century, fostering these skills becomes not only a necessity but a cornerstone for the holistic development of individuals capable of thriving in an ever-changing world (Johari et al., 2021).

This study highlights the current state of human resource development within Thailand’s OBEC, focusing on the importance of nurturing creative and innovative skills among high school students. The findings suggest that strategies supporting the development of these skills could better prepare students for an evolving work landscape. The study indicates potential benefits of promoting self-learning and problem-solving skills as part of the learning management model. However, as a descriptive study, these observations are intended to inform further research and discussion rather than prescribe specific interventions. Future studies could explore the effectiveness of various educational strategies in enhancing these essential skills.

Literature Review

The research involved studying the components of high school CIT skills. Data sources include Internet academic publications, textbooks, and related research. The research tools used consist of a document synthesis form. Data collection involves the study of textbooks and related research, followed by the analysis and synthesis of content using a document synthesis form. The data analysis method employed is content analysis.

Table 1 serves as a comprehensive overview of creative, innovation and teamwork skills gathered from various researchers and sources across different cultural contexts. Its location at the beginning of this section provides a clear reference point for the diverse perspectives integrated into the study. The table includes information from prominent researchers and studies in the field, reflecting a multicultural approach to understanding CIT skills. The listed researchers and their respective countries of origin contribute to the richness and diversity of insights incorporated into the research.

Table 1
Literature review of multi-cultural studies for CIT skills

Researcher(s)		Creativity	Teamwork	Innovation
Baruah and Paulus (2019)	USA	✓	✓	✓
Setiawan at al. (2021)	Indonesia			✓
Haryani et al. (2021)	Indonesia	✓	✓	✓
Johari et al. (2021)	Malaysia	✓	✓	✓
Fuad et al. (2022)	Literature review		✓	✓
Dang and Minh (2023)	Vietnam	✓	✓	✓
Tan (2021)	Singapore	✓	✓	✓
Wang et al. (2020)	Taiwan	✓	✓	
Bonkalo et al. (2023)	Russia	✓	✓	
Shahbazloo and Mirzaie (2023)	Iran	✓	✓	✓
Zhang et al. (2024)	China	✓	✓	✓
Faikhamta et al. (2024)	Thailand	✓	✓	✓
Wannapiroon and Pimdee (2022)	Thailand	✓	✓	✓

Research Questions

Creativity

a. How do high school students perceive the development of creative thinking skills in analyzing computer-related problems and proposing detailed solutions? (Paf & Dincer, 2021).

b. To what extent does the initiative to create new and practical ideas impact students' understanding and application of creativity in a technology-driven context? (Pedota & Piscitello, 2022).

c. In what ways do various thinking techniques contribute to the enhancement of students' creative problem-solving abilities? (Saeed & Ramdane, 2022).

Teamwork

a. How does fostering an environment that respects diverse opinions influence students' teamwork skills? (Johari et al., 2021).

b. What is the impact of encouraging an open-minded approach to new ideas on students' collaborative abilities and interpersonal skills? (Joseph, 2014).

c. How does effective idea presentation contribute to students' success in collaborative work and group projects?

Innovation

a. In what ways does systematic planning and execution of innovation development contribute to students' understanding and application of innovative processes?

b. How does the evaluation of the quality of developed innovations influence students' perception and execution of future innovative projects?

c. What is the role of continuous improvement and addressing innovation shortcomings in students' ability to create meaningful and impactful technological solutions?

d. How does the use of digital technology to communicate innovations impact the effectiveness of students' outreach and dissemination?

These research questions aim to explore the impact and significance of CIT skills among high school students based on the provided questionnaire items.

METHOD

In this section, we outline the research methods employed to conduct a CFA and study the components that technology teachers feel are essential for a high school student's CIT skill.

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA)?

First, an Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) have different objectives. An EFA is used when the underlying factor structure is unknown, which then explores the potential structure without predefined hypotheses, identifying possible patterns or groupings of variables. Whereas, a CFA tests a pre-specified factor structure based on theoretical expectations. It requires a priori hypotheses about the number of factors and the loading of observed variables on these factors.

Moreover, a CFA is used when there is a strong theoretical foundation that specifies the expected factor structure. It is more suited for hypothesis testing. On the other hand, an EFA is more appropriate for an initial investigation where the goal is to discover underlying structures without specific hypotheses.

Additionally, a CFA assumes that the researcher has specific hypotheses about the factor structure, including the number of factors and which items load on which factors, which is the case in this study obtained from the extensive literature review. However, an EFA does not require these hypotheses and instead identifies factors based on statistical criteria, which can lead to different models that may not be theory-driven. Finally, a CFA is a confirmatory technique that verifies the factor structure suggested by theory or previous research, whereas an EFA is an exploratory technique that suggests possible structures but does not confirm them.

In summary, CFA is used before SEM to ensure that the measurement model is valid and reliable, thus providing a solid foundation for testing structural relationships. EFA is not typically used in conjunction with CFA because it serves a different purpose—exploratory analysis rather than confirmatory testing. Using CFA after EFA can be beneficial in a sequential approach where EFA identifies potential structures that are then tested with CFA, but in a confirmatory framework, CFA is the primary technique used.

Population and Sample Groups

The population under study comprised technology teachers at the upper secondary level during the academic year 2023, totaling 2,360 individuals (Individual student data collection system, 2023).

These teachers are drawn from 33 schools within the Office of the Basic Education Commission (OBEC) jurisdiction of 62 educational districts (SESAO) (Table 2). For the sample group, 350 individuals were selected, aligning with Costello and Osborne's (2005) recommendation that the sample size should be at least 10-20 times the number of observed variables or parameters in CFA studies. Considering the research framework with 12 observable variables, the sample size was set at nearly 30 times the number of observed variables. Subsequently, a multistage random sampling approach was employed, involving the following steps:

Step 1

Stratified random sampling was conducted by randomly selecting educational districts under the jurisdiction of the Basic Education Commission from four geographical regions. This ensured a representative sample from each region.

Step 2

Simple Random Sampling (First Stage): Simple random sampling was then employed to select educational districts within each geographical region. The selected districts represented no less than 50% of the total number of educational districts offering upper secondary education in that region, forming the primary sample group.

Step 3

Simple Random Sampling (Second Stage): The final stage involved simple random sampling through a lottery system to select 33 schools from the chosen educational districts.

This multistage random sampling approach ensured the selection of a representative sample of technology teachers, facilitating a comprehensive examination of their opinions on CIT skills. The strategic combination of stratified and simple random sampling methods contributed to the robustness and diversity of the sample, aligning with the study's research objectives.

Table 2
Population and sample of technology teachers

Respondents' Regions	Population		Sample	
	SESAOs	Teachers	Schools	Teachers
Southern	9	334	5	54
Northern	15	456	8	68
Northeast	17	933	9	132
Central and Eastern	21	637	11	96
Totals	62	2,360	33	350

Research Tools

The tools used to measure research variables were a questionnaire that assessed construct and indicator appropriateness for high school student CIT skills. There were three components and twelve indicators, evaluated through feedback from seven experts and the assessment of the index of item-objective congruence (IOC) for components and indicators (0.57-1.00). The discriminant power ranged from 0.21 to 0.80, and the reliability was between 0.84 and 0.87.

Index of Item-Objective Congruence (IOC)

The index of item-objective congruence (IOC) is commonly used to assess the content validity of items in a test or questionnaire. One widely recognized formula for calculating the IOC is attributed to Rovinelli and Hambleton (1977), which evaluates how well each test item matches the objectives it is intended to measure, as judged by a panel of experts. The IOC formula is typically calculated as follows:

$$\mathrm{IOC} = \frac{\sum(X_i - c)}{N} \quad (1)$$

where:

Xi represents the score assigned to each item by an expert, usually on a scale from -1 to +1, where -1 indicates the item is not congruent with the objective, 0 indicates uncertainty, and +1 indicates congruence.

c is a constant value, often set to 0, representing the midpoint of the scale.

N is the total number of experts.

This formula results in an IOC index that ranges from -1 to +1, where higher positive values indicate greater agreement among experts about the congruence of the item with the objective (Turner & Carlson, 2003).

Discrimination

As Rönkkö and Cho (2022) have pointed out, the need for discriminant validity assessment in empirical research has led to the introduction of numerous techniques, some of which have been introduced in an ad hoc manner and without rigorous methodological support. However, one of the most commonly used formulas for calculating the discrimination index is based on the point-biserial correlation coefficient (r_pb), which correlates item performance with overall test performance. Formulas for discrimination index (D) are as follows:

$$D = \frac{(P_h - P_l)}{N} \tag{2}$$

where:

P_h is the proportion of high-performing students who answered the item correctly.
P_l is the proportion of low-performing students who answered the item correctly.
N is the total number of students.

Alternatively, the point-biserial correlation can be calculated using the formula:

$$r_{pb} = \frac{M_1 - M_0}{S_t} \times \sqrt{\frac{p \cdot q}{N}} \tag{3}$$

where:

M_1 is the mean score of the test for those who answered the item correctly.
M_0 is the mean score of the test for those who answered the item incorrectly.
S_t is the standard deviation of the total test scores.
p is the proportion of students who answered the item correctly.
q is the proportion of students who answered the item incorrectly (q=1−p).
N is the total number of students.

The point-biserial correlation coefficient provides a more detailed and statistically robust measure of item discrimination.

A discriminant power value of 0.80 indicates a strong ability of the item to discriminate between different levels of the construct, where higher values suggest better discrimination. Discriminant power values from 0.21 to 0.80 are reasonable and align with the common understanding of discriminant power in questionnaire assessments.

Data Collection

Data collection involved technology teachers at the high school level across 33 schools within 62 SESAOs. A Google Form questionnaire was distributed through the network of technology teachers between August and October 2023. A total of 350 responses were received.

CFA Use and Testing

A CFA is essential in theory testing as it allows researchers to test a hypothesized factor structure based on existing theories or prior research. Through CFA, researchers can confirm whether the collected data fits the expected measurement model. This initial step ensures that the constructs and their relationships are aligned with theoretical expectations before delving into more complex models (Schumacker & Lomax, 2016). Once CFA confirms the validity of the measurement model, Structural Equation Modeling (SEM) can be employed to test the relationships among latent variables and observed variables within a more comprehensive hypothesized model that includes both measurement and structural components (Kline, 2015).

CFA plays a critical role in validating the measurement model by confirming that the items (observed variables) load onto the intended latent constructs (factors). This validation is a crucial step as it ensures that the constructs are being measured accurately and reliably (Byrne, 2016). Only after the measurement model is validated through CFA can researchers proceed to SEM to explore the structural model, which examines the relationships between latent variables. This sequential process ensures that the foundational measurement aspects are robust before testing the structural hypotheses (Hair et al., 2014).

One of the significant advantages of CFA is its ability to assess and control for measurement error. CFA allows researchers to evaluate how well each item represents the latent construct, thereby identifying and accounting for measurement errors (Brown, 2015). A validated measurement model achieved through CFA enables SEM to more accurately account for measurement errors when evaluating structural relationships. This enhances the reliability and validity of the conclusions drawn from the structural model (Marsh et al., 2004).

Finally, a CFA aids in specifying the number of factors and their corresponding indicators based on theoretical foundations. This specification provides a clear and organized foundation for SEM. By using CFA, researchers can delineate the measurement model, which SEM then uses to test more complex hypotheses about the relationships among latent constructs (Tabachnick & Fidell, 2013). This process ensures that the measurement model is correctly specified and theoretically grounded before testing the broader structural model.

Data Analysis

The analysis of the data employed descriptive statistics, encompassing means, standard deviations (SD), and percentages, conducted using SPSS for Windows Version 21. A Likert scale with five levels was utilized to gauge agreement concerning each item. The scale levels, corresponding numerical values, and their interpretations were as follows: 5 = strongest agreement (4.50-5.00), 4 = strong agreement (3.50-4.49), 3 = moderate agreement (2.50-3.49), 2 = somewhat agree (1.50-2.49), and 1 = minimal agreement (1.00-1.49). Furthermore, behavioral components, specifically CIT, were examined via a 2nd-order CFA using the LISREL 9.10 program.

FINDINGS AND DISCUSSION

Technology Teacher Characteristics

Respondent characteristics are detailed in Table 3, from which it was determined that the majority of the technology teachers were female (62.00%), were between 30 - 40 years old (44.29%), had had 11 - 15 years of teaching experience (33.71%).

Additionally, 59.43% had a minimum of a BA/BS degree while the remaining had some form of postgraduate degree.

Table 3
Technology teacher characteristics (*n*=350)

Teacher General Information	Teachers	%
Gender		
- man	133	38.00
- woman	217	62.00
Age		
- Under 30 years of age	123	35.14
- 30 - 40 years of age	155	44.29
- 41 years and up	72	20.57
Teaching Experience		
- less than 5 years	53	15.14
- 5 – 10 years	83	23.71
- 11 - 15 years	118	33.71
- Over 15 years of teaching experience	96	27.43
Education Level		
- Bachelor's degree	208	59.43
- Postgraduate degree	142	40.57

CFA Results of High School Students' CIT Skills

Table 4 offers a comprehensive exploration of technology teachers' perspectives on high school students' creativity, teamwork, and innovation skills. The mean and standard deviation results provide valuable insights into the perceived importance assigned by teachers to various components within these skill sets.

Overall Perception

The collective mean for creativity and innovation skills is notably high at 4.46, indicating a strong consensus among technology teachers regarding the paramount importance of these skills. With a standard deviation of 0.60, opinions appear to be relatively consistent among teachers, suggesting a shared viewpoint.

Creativity Component

Creative thinking emerges as the most crucial component, with an average rating of 4.55. This underscores teachers' emphasis on students thinking analytically and proposing detailed solutions to computer-related problems. Items reflecting the initiative in creating new things (A2: 4.86) and utilizing various thinking techniques (A3: 4.39) also receive high evaluations.

Teamwork Component

While teamwork is highly valued (average: 4.43), it ranks slightly lower compared to creativity in terms of average importance. Teachers underscore the significance of respecting others' opinions, being open to new ideas, effective presentation, knowledge exchange, and cooperative work within the teamwork component (Rabgay, 2018; Rumahlatu et. al., (2020).

Innovation Component

Innovation is deemed crucial by teachers, reflected in the mean value of 4.45. Specific aspects such as systematic planning and execution of innovative development (C1: 4.46), continuous improvement, quality assessment (C2: 4.44), and leveraging digital communication technology for innovation dissemination (C4: 4.48) are particularly highlighted.

Comparative Importance

Ranking these components reveals that creativity holds the highest average value (4.55), followed closely by innovation (4.45). Teamwork, while still crucial, ranks slightly lower in terms of average importance (4.43).

Level of Agreement

Across all components, the majority of opinions fall into the category of "strong agreement" or "strongest agreement," indicating a robust consensus among teachers regarding the vital role of creativity and innovation skills. This collective perception emphasizes the high value attributed to these skills in the context of high school education.

Table 4
Mean and SD results for each item concerning CIT skills

Items	CIT skills	Mean	SD	Opinion level
Creativity	Creativity	4.55	0.61	strongest agreement
A1	Thorough analysis of computer-related issues is essential for students to pinpoint their origins and devise comprehensive solutions.	4.39	0.60	strong agreement
A2	Encouraging students to proactively engage in the creation of novel and beneficial innovations fosters a culture of initiative and ingenuity.	4.86	0.50	strongest agreement
A3	It is important for students to employ a diverse array of thinking methodologies to enhance their problem-solving capabilities and foster creativity.	4.39	0.61	strong agreement
Teamwork	Teamwork	4.43	0.60	strong agreement
B1	Valuing diverse perspectives, regardless of their alignment with the context, is vital for nurturing teamwork among students.	4.43	0.61	strong agreement
B2	Encouraging students to remain receptive to fresh viewpoints from their peers is essential.	4.39	0.59	strong agreement
B3	Effective articulation of one's ideas when interacting with others is key for student development.	4.46	0.60	strong agreement
B4	Fostering a culture of knowledge exchange among students is integral to their collective success.	4.42	0.59	strong agreement
B5	Cultivating cooperative working relationships among students is imperative for achieving common goals.	4.43	0.58	strong agreement
Innovation	Innovation	4.45	0.60	strong agreement
C1	It is crucial for students to methodically strategize and implement the advancement of innovations based on a predetermined blueprint.	4.46	0.60	strong agreement
C2	Students should conscientiously assess the caliber of their innovative endeavors.	4.44	0.59	strong agreement
C3	Recognizing and refining weaknesses in innovation is a vital aspect of student learning and progress.	4.42	0.59	strong agreement
C4	Utilizing digital communication technologies to disseminate innovations to society can significantly amplify their impact and reach.	4.48	0.60	strong agreement
Averages		4.46	0.60	0.60

5 = strongest agreement (4.50-5.00), 4 = strong agreement (3.50-4.49)

Correlation Coefficients of Observed Variables

Table 5 presents correlation coefficients among observed variables for the student CIT CFA for high school students (Liu & Wang, 2019). For discriminant validity, construct correlations *should not exceed* 0.85.

Correlation Analysis Overview

The analysis reveals positive relationships among all 12 indicators, indicating a significant association between these variables. A total of 66 pairs of indicators exhibit statistically significant correlations at both the .01 and .05 levels. Correlation coefficients ranged from 0.15 to 0.54, suggesting varying degrees of strength in the relationships.

Preliminary Data Check

The preliminary data examination, before analyzing the components, involved assessing the Kaiser-Meyer Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity. The KMO value of 0.90 surpasses the threshold of 0.50, indicating a high level of sampling adequacy (Patyal & Koilakuntla, 2017). This implies that the data is suitable for further analysis. Bartlett's Test of Sphericity, with an Approx. The chi-Square value of 1050.791, is statistically significant at the .05 level. This signifies a relationship between variables and affirms the data's overall suitability for analysis/

Correlation Coefficients

The correlation coefficients in the table represent the strength and direction of relationships between different pairs of observed variables. Values range from 0.15 to 0.54, indicating positive correlations. The higher the value, the stronger the correlation between the variables. Notable correlations include A2 and A3 (.50**), B1 and B2 (.51**), B4 and B5 (.38**), and C1 and C2 (.45**).

Kaiser-Meyer-Olkin (KMO) Measure and Bartlett's Test

The KMO Measure of Sampling Adequacy, with a value of 0.90, reaffirms the adequacy of the sample for factor analysis. Bartlett's Test of Sphericity, with a significant Approx. Chi-Square value reinforces the presence of relationships among variables.

Overall Significance

The correlation analysis is crucial for understanding the interplay between variables in the creativity and innovation model. Positive correlations suggest that as one variable increases, the other tends to increase, supporting the coherence of the model. Moreover, as no correlation coefficient exceeded 0.8, there was no indication of multicollinearity. In summary, the correlation coefficients highlight significant relationships among observed variables, emphasizing the interconnectedness of the components. The robustness of the preliminary data checks further supports the validity of the subsequent CFA.

Table 5
Correlation coefficients between CIT for high school student innovation

Item	A1	A2	A3	B1	B2	B3	B4	B5	C1	C2	C3	C4
A1	1											
A2	.49**	1										
A3	.35**	.50**	1									
B1	.32**	.51**	.36**	1								
B2	.22**	.35**	.20**	.21**	1							
B3	.28**	.38**	.18**	.27**	.31**	1						
B4	.17**	.38**	.25**	.26**	.24**	.33**	1					
B5	.33**	.40**	.25**	.34**	.30**	.27**	.28**	1				
C1	.20**	.45**	.28**	.36**	.25**	.24**	.24**	.31**	1			
C2	.30**	.40**	.24**	.33**	.26**	.33**	.27**	.33**	.29**	1		
C3	.18**	.50**	.29**	.28**	.15**	.26**	.27**	.22**	.29**	.29**	1	
C4	.35**	.54**	.34**	.31**	.24**	.24**	.25**	.23**	.30**	.29**	.32**	1
KMO Measure of Sampling Adequacy=0.90												
Bartlett's Test of Sphericity =1050.79, df=66, Sig.<.01												

*Sig.<.05, **Sig.<.01

The results of the 2nd-order CFA depicted in Figure 1 demonstrate that the proposed model exhibits strong agreement with the empirical data. Factor loadings for each observed variable on their respective latent constructs (creativity, innovation, and teamwork) were found to be significant, with standardized factor loadings ranging from 0.91 to 1.00. The factor with the highest weight was *innovation* ($\beta = 1.00$, $R^2 = 1.00$), followed closely by *creativity* ($\beta = 0.99$, $R^2 = 0.97$), and *teamwork* ($\beta = 0.91$, $R^2 = 0.83$). Additionally, the model demonstrated a good fit, as indicated by a non-significant chi-square value (40.35, df=42, p-value=0.54) and a low RMSEA (0.00). Other fit indices, such as the Comparative Fit Index (CFI) (Figure 1), further supported the adequacy of the model fit. Overall, these findings substantiate the suitability of the model for investigating the complex interplay of CIT skills among high school students.

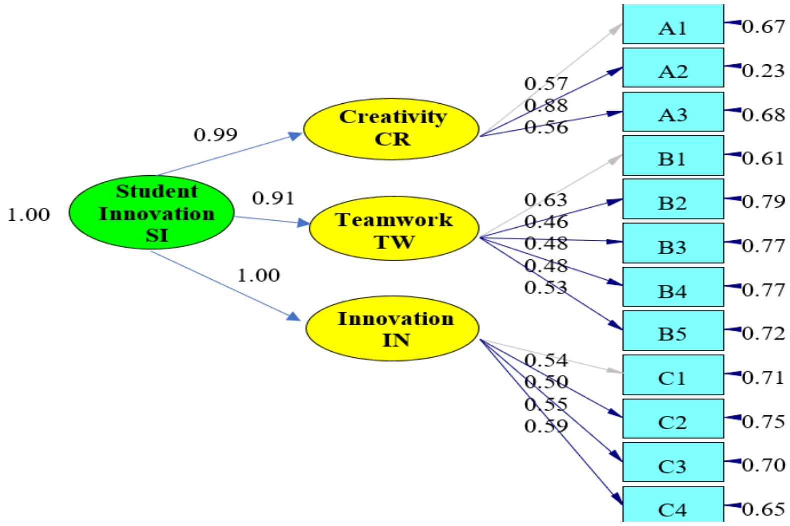

Figure 1
Second-order CFA for high school student creativity, teamwork, and innovation skills
Note: Chi-Square=40.35, df=42, *p*-value=0.54, RMSEA=0.00

Analysis

Table 6 provides a detailed overview of confidence values, including element weight, reliability, and observable variables, for the latent constructs of creativity (CR), teamwork (TW), and innovation (IN). Each latent variable is associated with its respective observable variables, shedding light on the reliability and impact of each item on the overall construct. The most critical information for the reader includes:

Element Weight (α)

Indicates the internal consistency or reliability of the latent variable. In this context, the values for *creativity* (0.84), *teamwork* (0.85), and *innovation* (0.87) reflect the degree to which the items within each construct are interrelated.

Reliability of Observable Variables (b (SE) and t)

The reliability of each observable variable is presented through factor loadings (β), standard errors (SE), and t-values. These values help assess the strength and significance of the relationship between each observable variable and its respective latent construct. For example, in creativity (CR), the observable variable A2 has a β of 0.88 (SE=0.08), indicating a strong and statistically significant relationship with *creativity* (CR).

(R^2) - Variance Explained

R-squared values (R^2) provide insights into the proportion of variance in the latent constructs explained by the observable variables. High R-squared values suggest that the observable variables effectively capture the essence of the latent construct. Notably, in *innovation* (IN), the R-squared value is 1.00, indicating that the observable variables (C1, C2, C3, C4) collectively explain all the variance in innovation.

Interpretation of Specific Observable Variables

Each observable variable is associated with a statement indicating its significance. These statements offer qualitative insights into what aspects of CIT each observable variable aims to measure. For instance, in the *teamwork* (TW) construct, observable variable B5 is related to the importance of working with others cooperatively.

Overall, this table is pivotal for understanding the reliability and contribution of each observable variable to the latent constructs of CIT, providing a detailed perspective on the multidimensional nature of these skills among high school students.

Table 6
Confidence values - element weight, reliability, and observable variables

Latent and Observed Variables		(α)	β (SE)	(t)	(R^2)
Creativity	CR	0.84	0.99(.09)	10.80**	0.97
Thorough analysis of computer-related issues is essential for students to pinpoint their origins and devise comprehensive solutions.	A1		0.57	-	0.33
Encouraging students to proactively engage in the creation of novel and beneficial innovations fosters a culture of initiative and ingenuity.	A2		0.88(.08)	11.30**	0.77
It is important for students to employ a diverse array of thinking methodologies to enhance their problem-solving capabilities and foster creativity.	A3		0.56(.06)	9.02**	0.32
Teamwork	TW	0.85	0.91(.08)	11.75**	0.83
Valuing diverse perspectives, regardless of their alignment with the context, is vital for nurturing teamwork among students.	B1		0.63	-	0.39
Encouraging students to remain receptive to fresh viewpoints from their peers is essential.	B2		0.46(.06)	7.25**	0.21
Effective articulation of one's ideas when interacting with others is key for student development.	B3		0.48(.06)	7.80**	0.23
Fostering a culture of knowledge exchange among students is integral to their collective success.	B4		0.48(.06)	7.91**	0.23
Cultivating cooperative working relationships among students is imperative for achieving common goals.	B5		0.53(.06)	8.56**	0.28
Innovation	IN	0.87	1.00(.90)	10.69**	1.00
It is crucial for students to methodically strategize and implement the advancement of innovations based on a predetermined blueprint.	C1		0.54	-	0.29
Students should conscientiously assess the caliber of their innovative endeavors.	C2		0.50(.06)	7.97**	0.25
Recognizing and refining weaknesses in innovation is a vital aspect of student learning and progress.	C3		0.55(.07)	8.47**	0.30
Utilizing digital communication technologies to disseminate innovations to society can significantly amplify their impact and reach.	C4		0.59(.07)	8.93**	0.35

**Sig.< .01

CFA T-Values Interpretation and Explanation

The CFA's t-value is an essential component in assessing the statistical significance of the factor loadings. Each observable variable in a CFA model is associated with a t-value, which tests whether the corresponding factor loading is significantly different from zero. A high t-value indicates that the factor loading is statistically significant, thus confirming that the observable variable contributes meaningfully to the latent construct it is intended to measure (Kline, 2015).

Table 6 shows the t-values for the observable variables under Creativity, Teamwork, and Innovation, which help establish the reliability and validity of the measurement model. Here's a detailed interpretation:

Creativity (CR):

- Observable variable A2 has a t-value of 11.30, indicating that its factor loading is highly significant (p < .01). This suggests that encouraging students to engage proactively in novel innovations strongly contributes to the Creativity construct.

- A3 shows a t-value of 9.02, also highly significant, reinforcing the importance of employing diverse thinking methodologies in fostering creativity.

2. Teamwork (TW):

- Observable variable B2 has a t-value of 7.25, demonstrating significant contribution to the Teamwork construct (p < .01). This indicates that being receptive to fresh viewpoints is essential for teamwork.

- Variables B3, B4, and B5 have t-values of 7.80, 7.91, and 8.56 respectively, all of which are significant, underscoring their importance in effective articulation, knowledge exchange, and cooperative work.

3. Innovation (IN):

- Observable variable C2 with a t-value of 7.97 and C3 with 8.47, both significant, highlight the importance of assessing and refining innovations.

- C4 has a t-value of 8.93, indicating that utilizing digital communication technologies significantly impacts the dissemination and reach of innovations.

The high t-values across the variables indicate that the model's factor loadings are significantly different from zero, confirming the reliability of the measurement model. This statistical evidence strengthens the argument that the constructs of Creativity, Teamwork, and Innovation are well-defined and measured effectively through their respective indicators (Byrne, 2016).

The study delved into the elements of creativity, innovation, and teamwork skills among Thai high school students, comprising three components and twelve indicators. These components, ranked by weight, reveal that *innovation* holds the highest weight (1.00), demonstrating 100% co-variation. *Creativity* follows closely, with a component weight of 0.99 and 97% co-variation, while *teamwork*, with a component weight of 0.91, displays 83% co-variation.

Johnson (2010) posited that a nation's economic future hinges on its ability to attract and nurture talented entrepreneurs, particularly those adept in creativity and innovation (Glassman & Opengart, 2016). This is consistent with Nakano and Wechsler (2018), who emphasize the importance of creative and innovative skills in creating new things, thinking independently, and embracing flexibility. They also underscored the significance of creativity and innovation in problem-solving, identifying creative individuals as skilled strategists. Recognized globally as vital skills, creativity, and innovation stimulate students' curiosity (Schutte & Malouff, 2020), encouraging them to explore beyond traditional teaching methods.

This study addresses the challenges posed by conventional teaching models and advocates for the development of creative and innovative skills essential for learners in the 21st century. Numerous studies assert that these skills, encompassing critical thinking and problem-solving, are crucial for competitiveness in the contemporary era.

In constructing the model of CIT skills, the study exhibits good construct validity. The synthesized elements from related research align with the findings of previous studies, emphasizing the importance of CIT skills (Baruah & Paulus, 2019; Bonkalo et al., 2023; Dang & Minh, 2023; Faikhamta et al., 2024; Fuad et al., 2022; Johari et al., 2021; Setiawan at al., 2021; Shahbazloo & Mirzaie, 2023; Tan, 2021; Wang et al., 2020; Wannapiroon & Pimdee, 2022; Zhang et al., 2024).

CONCLUSION

This study highlights the current state of human resource development within Thailand's OBEC, with a particular focus on the importance of nurturing creative and innovative skills among high school students. The findings suggest a need to consider strategies that support the development of these skills to better prepare students for an evolving work landscape. The study also indicates potential benefits of promoting self-learning and problem-solving skills as part of the learning management model. However, as a descriptive study, these observations are intended to inform further research and discussion rather than prescribe specific interventions. Future studies could explore the effectiveness of various educational strategies in enhancing these essential skills.

REFERENCES

Amabile, T. M., & Pratt, M. G. (2016). The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Research in organizational behavior*, *36*, 157-183.. https://doi.org/10.1016/j.riob.2016.10.001

Baruah, J., & Paulus, P. B. (2019). Collaborative creativity and innovation in education. In C. A, Muller (Ed.), *Creativity under duress in education? Resistive theories, practices, and actions*, 155-177. https://doi.org/10.1007/978-3-319-90272-2_9

Bonkalo, T., Grebennikova, V., Grebennikov, O., Ignatovich, V., Ignatovich, S., & Shmeleva, S. (2023). Estimation of High School students' creative abilities as a result of joint creative activity. *Revista Conrado*, *19*(94), 270-275. http://tinyurl.com/3s842trw

Brown, R. (2020). The social identity approach: Appraising the Tajfellian legacy. *British Journal of Social Psychology*, *59*(1), 5-25. https://doi.org/10.1111/bjso.12349

Brown, T. A. (2015). *Confirmatory Factor Analysis for Applied Research*. Guilford Publications.

Byrne, B. M. (2016). Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming (3rd ed.). Routledge.

Care, E., Kim, H., Vista, A., Anderson, K. (2018). Education system alignment for 21st Century Skills: Focus on assessment. Center for Universal Education at The Brookings Institution. http://tinyurl.com/2uve2kn4

Costello, A. B., & Osborne, J. (2019). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research, and evaluation*, *10*(1), 7. https://doi.org/10.7275/jyj1-4868

Dang, L. H., & Minh, T. H. (2023, May). STEM-based education to develop high school student's creativity in chemistry classroom–a Vietnamese case study. In *AIP Conference Proceedings* (Vol. 2685, No. 1). AIP Publishing. https://doi.org/10.1063/5.0113214

Faikhamta, C., Srisarakorn, S., & Suknarusaithagul, N. (2024). Design-Based STEM-BCG Learning for Sustainable Development: Design, Practices, and Outcomes. In *Cross-disciplinary STEM Learning for Asian Primary Students* (pp. 84-108). Routledge.

Fuad, D. R. S. M., Musa, K., & Hashim, Z. (2022). Innovation culture in education: A systematic review of the literature. *Management in Education*, *36*(3), 135-149. https://doi.org/10.1177/0892020620959760

Glassman, A. M., & Opengart, R. (2016). Teaching innovation and creativity: Turning theory into practice. *Journal of International Business Education*, *11*, 113. https://commons.erau.edu/publication/696/

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate Data Analysis* (7th ed.). Pearson.

Haryani, E., Coben, W. W., Pleasants, B. A., & Fetters, M. K. (2021). Analysis of teachers' resources for integrating the skills of creativity and innovation, critical thinking and problem solving, collaboration, and communication in science classrooms. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 92-102.

Individual student data collection system. (2023). Data Management Center. (Thailand). http://tinyurl.com/3vwcexuf

Johari, A., Abdul Wahat, N. W., & Zaremohzzabieh, Z. (2021). Innovative work behavior among teachers in Malaysia: The effects of teamwork, principal support, and humor. *Asian Journal of University Education*, *7*(2), 72-84. https://ir.uitm.edu.my/id/eprint/53718/

Johnson, M. W. (2010). The time has come for business model innovation. *Leader to Leader*, *2010, 57,* 6–10. https://doi.org/10.1002/ltl.421

Joseph, A. (2014, June). Teamwork, innovation, and student engagement in technology entrepreneurship – A case Study. In *2014 ASEE Annual Conference & Exposition,* Indianapolis, Indiana. http://doi.org/10.18260/1-2--23110

Kline, R. B. (2015). Principles and Practice of Structural Equation Modeling (4th ed.). Guilford Press.

Liu, H. Y., & Wang, I. T. (2019). Creative teaching behaviors of health care school teachers in Taiwan: mediating and moderating effects. *BMC Medical Education*, *19*, 1-10. https://doi.org/10.1186%2Fs12909-019-1641-8

Magsamen-Conrad, K., & Dillon, J. M. (2020). Mobile technology adoption across the lifespan: A mixed methods investigation to clarify adoption stages, and the influence of diffusion attributes. *Computers in Human Behavior*, *112*, 106456. https://doi.org/10.1016/j.chb.2020.106456

Nakano, T. D. C., & Wechsler, S. M. (2018). Creativity and innovation: Skills for the 21st Century. *Estudos de Psicologia (Campinas)*, *35*, 237-246. https://doi.org/10.1590/1982-02752018000300002

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In Search of Golden Rules: Comment on Hypothesis-Testing Approaches to Setting Cutoff Values for Fit Indexes and Dangers in Overgeneralizing Hu and Bentler's (1999) Findings. *Structural Equation Modeling: A Multidisciplinary Journal*, 11(3), 320-341.

National Scheme of Education B.E. 2560-2579 (2017-2036) (2018). http://tinyurl.com/yy95ncvm

OECD. (2018). *The Future of Education and Skills Education 2030.* Organisation for Economic Cooperation and Development. http://tinyurl.com/4s4j5w5r

Rabgay, T. (2018). The effect of using cooperative learning method on tenth grade students' learning achievement and attitude towards biology. *International Journal of Instruction*, *11*(2), 265-280. https://doi.org/10.12973/iji.2018.11218a

Rönkkö, M., & Cho, E. (2022). An updated guideline for assessing discriminant validity. *Organizational Research Methods*, *25*(1), 6-14. https://doi.org/10.1177/1094428120968614

Rumahlatu, D., Sangur, K., & Liline, S. (2020). The effect of complex instruction team product (CITP) learning model on increase student's skills. *International Journal of Instruction*, *13*(1), 587-606. https://doi.org/10.29333/iji.2020.13138a

Paf, M., & Dincer, B. (2021). A study of the relationship between secondary school students' computational thinking skills and creative problem-solving skills. *Turkish Online Journal of Educational Technology*, *20*(4), 1-15. http://tinyurl.com/yc769jnx

Patyal, V. S., & Koilakuntla, M. (2017). The impact of quality management practices on performance: an empirical study. *Benchmarking: An International Journal*, *24*(2), 511-535. https://doi.org/10.1108/BIJ-11-2015-0109

Paulus, P. B., & Nijstad, B. A. (Eds.). (2003). *Group creativity: Innovation through collaboration.* Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195147308.001.0001

Pedota, M., & Piscitello, L. (2022). A new perspective on technology-driven creativity enhancement in the Fourth Industrial Revolution. *Creativity and Innovation Management*, *31*(1), 109-122. https://doi.org/10.1111/caim.12468

Rovinelli, R. J., & Hambleton, R. K. (1977). On the Use of Content Specialists in the Assessment of Criterion-Referenced Test Item Validity. *Dutch Journal of Educational Research*, *2*(2), 49-60. https://files.eric.ed.gov/fulltext/ED121845.pdf

Saeed, B. A., & Ramdane, T. (2022). The effect of implementation of a creative thinking model on the development of creative thinking skills in high school students: A systematic review. *Review of Education*, *10*(3)/e3379. https://doi.org/10.1002/rev3.3379

Schumacker, R. E., & Lomax, R. G. (2016). *A Beginner's Guide to Structural Equation Modeling* (4th ed.). Routledge.

Schutte, N. S., & Malouff, J. M. (2020). A meta-analysis of the relationship between curiosity and creativity. *The Journal of Creative Behavior*, *54*(4), 940-947.https://doi.org/10.1002/jocb.421

Setiawan, R., Nath, K., Cavaliere, L. P. L., Villalba-Condori, K. O., Arias-Chavez, D., Koti, K., ... & Rajest, S. S. (2021). The impact of teaching innovative strategy on academic performance in high schools. *Productivity Management, 25*(5), 1296-1312. http://tinyurl.com/54zwh4dn

Shahbazloo, F., & Mirzaie, R. A. (2023). Investigating the effect of 5E-based STEM education in solar energy context on creativity and academic achievement of female Junior high School students. *Thinking Skills and Creativity*, *49*, 101336. https://doi.org/10.1016/j.tsc.2023.101336

Srikan, P, Pimdee, P, Leekitchwatana, P, & Narabin, A (2021). Problem-based learning (PBL) and teaching model using a cloud-based constructivist learning environment to enhance Thai undergraduate creative thinking and digital media skills. *International Journal* of *Interactive Mobile Technologies*, 15(22), 68-83. https://doi.org/10.3991/ijim.v15i22.24963

Tabachnick, B. G., & Fidell, L. S. (2013). *Using Multivariate Statistics* (6th ed.). Pearson.

Tan, O. S. (2021). Problem-based learning innovation: Using problems to power learning in the 21st century. Gale Cengage Learning. http://tinyurl.com/2s3pwcch

Turner, R. C., & Carlson, L. A. (2003). Indexes of item-objective congruence for multidimensional items. *International journal of testing*, *3*(2), 163-171. https://doi.org/10.1207/S15327574IJT0302_5

Wang, Y. H., Chang, M. C., & Liou, J. R. (2020). Comparison of the effectiveness of Taiwanese college and high school students participating in creative contests. *Thinking Skills and Creativity, 38*, 100717. https://doi.org/10.1016/j.tsc.2020.100717

Wannapiroon, N, & Pimdee, P (2022) Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment. *Education and Information Technologies*, *27*(4), 5689-5716. https://doi.org/10.1007/s10639-021-10849-w

World Economic Forum (2020, October 20) The future of jobs report 2020. http://tinyurl.com/53m75x6t

Zhang, W., Guan, Y., & Hu, Z. (2024). The efficacy of project-based learning in enhancing computational thinking among students: A meta-analysis of 31 experiments and quasi-experiments. *Education and Information Technologies*, 1-33. https://doi.org/10.1007/s10639-023-12392-2

Zou, M., Liu, P., Wu, X., Zhou, W., Jin, Y., & Xu, M. (2023). Cognitive characteristics of an innovation team and collaborative innovation performance: The mediating role of cooperative behavior and the moderating role of team innovation efficacy. *Sustainability*, *15*(14), 10951. https://doi.org/10.3390/su151410951