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Research Article

Examining of Secondary School Students' Integrated Science Process Skills

Oranit CHOKCHAI[1], Paitoon PIMDEE[2]

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Abstract
Integrated science process skills (ISPS) are a fundamental variable in scientific inquiry and scientific literacy. If students are proficient in this skill, they will be ready for living and working in the 21st-century, which requires the application of scientific knowledge and scientific inquiry. For these reasons, the researchers undertook a study to investigate the ISPS of Thai lower secondary school students. From the use of stratified random sampling, 350 Bangkok, Thailand Grade 8 secondary school students were selected. The SPSS statistics software was used for data analysis of the mean and standard deviation. A first-order confirmatory factor analysis (CFA) and a two-way analysis of variance (ANOVA) were also employed. Findings from the research determined that student ISPS consisted of five indicators, including 1) controlling variables 2) hypotheses formulation3) defining variables operationally 4) experimentation, and 5) data interpretation. Findings also revealed that overall, student ISPS were at a level that needed improvement.

Keywords:
21st-century skills, gender, school size, confirmatory factor analysis, ISPS, schools, students, Thailand

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[1]Institute for the Promotion of Teaching Science and Technology (IPST), Bangkok, Thailand. Email: oranit_chokchai@hotmail.com. ORCID No: 0000-0003-1668-2328.
[2]Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. E-mail: paitoon.pi@kmitl.ac.th. ORCID No: 0000-0002-3724-2885.

Introduction

Multiple studies have observed that inquiry-based learning (IBL) is an educational strategy in which methods and practices similar to those of professional scientists to construct knowledge is used by students (Germann, 1991; Germann et al., 1996; Keselman, 2003; Latiet et al., 2012). Also, according to UNESCO (n/d), inquiry refers mainly to asking questions. However, it can also be defined as a responsible research and innovation (RRI) process, whose goals are to acquire scientific knowledge, resolve doubt, or to solve a problem.

Furthermore, for many years, the American Association for the Advancement of Science [AAAS] has published research concerning inquiry-based instruction [IBI] and IBI classrooms (AAAS, 1967, 1993; Minstrell & van Zee, 2000), with three main research methods having been identified, including observation, modeling, and experimentation.

Anderson (2002) also connected inquiry to a learning process in which students are engaged in an active learning process, with student scientific inquiry courses having a positive effect on both their process and thinking skills. Students will acquire skills when they are introduced into the scientific inquiry process and when they learn through inquiry experiences. To reach the inquiry, the students must learn the words hypothesis and inference, with science inquiry skills beginning at an early age (Lind, 1999).

Furthermore, according to the National Research Council [NRC] (NRC, 2000, 2005, 2007), an inquiry is not just about learning the scientific content, but also a set of skills that students need to learn. Moeed (2013) also stated that learning science through investigation is preferred pedagogical approach internationally. Students who develop a scientific inquiry (science investigation) must use cognitive and manipulative skills in scientific explanations (Bilgin, 2006). However, some students remain confused about the variables and controlled experiments (NRC, 1996).

However, Aktamis and Ergin (2008) found that ISPS can increase a student's achievements and scientific creativities. Science learning is also relevant to the predication, the questioning, and the gathering of evidence for testing and interpreting the results.

Furthermore, according to Harlen (1999), the ISPS concept of education originates from a gradual, practice-based approach to understanding concepts related to science use and learning. The development of student scientific attitudes will help in their application of scientific knowledge to solve problems, to live, to work, and seek new knowledge appropriately and creatively (NRC, 2000). Science process skills (SPS) are also categorized as basic SPS and ISPS, with basic SPS being the foundation for learning ISPS, which requires training (Padilla, 1990).

Furthermore, the Programme for International Student Assessment (PISA) is a global study by the Organization for Economic Co-operation and Development

(OECD) to evaluate student literacy (OECD, 2018; Syazali et al., 2019). In earlier Thai PISA assessments, results from the scientific assessment section showed an improvement in student scores in the PISA 2012 over the previous PISA 2009 assessment. However, in the PISA 2015 evaluation, scores fell from the PISA 2012 assessment by 23 points, while also back-tracking to the PISA 2006 level scoring assessment. Furthermore, based on the PISA 2015 assessment, Thai students had an average scientific score of 421, which was significantly below the OECD average of 493 points. Only Indonesia had a lower average scientific score than that of Thai students (OECD, 2013a, 2014, 2016). The average scientific score of Thai students in the PISA assessments from 2000 to 2015 are shown in Figure 1.

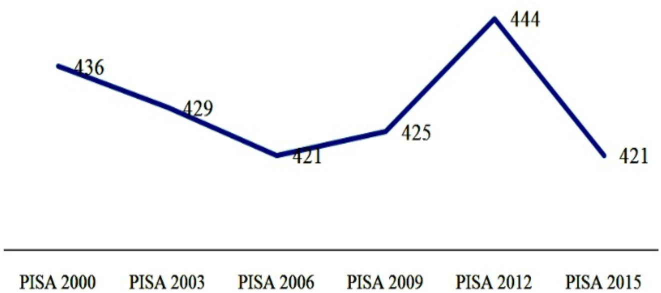

Figure 1.
Average Thai Student PISA Scientific Scores from 2000 to 2015. Source: OECD, 2013a, 2014, 2016.

Also, in the 2015 Trends in International Mathematics and Science Study (TIMSS) assessment, only Thai Grade 8 students participated. These eight graders assessment framework was concerned with both the content domain and cognitive domain, which included 1) knowledge, which includes recall, describe, and illustrate with examples, 2) the application of knowledge, which includes comparison, contrast, and classify, to use a model, to use relate, interpret information, and explain, and 3) the rationales include analyze, synthesize, formulate questions, hypothesize, predict, design investigations, evaluation and draw conclusions (Bell et al., 2010).

Based on recent TIMSS 2015 results, Thai students had an average scientific score of 456, which ranked 26th from the 39 participating countries, indicating a 'low scientific ability'. Furthermore, Figure 2 displays the average scientific score of Thai students in 1999, 2007, 2011 and 2015 (Thailand did not participate in the TIMSS 2003 assessment) (Martinet et al., 2016; Mulliset et al., 2015). Both results from the PISA and TIMSS assessments showed that Thai students had relatively low scientific competencies, which were related to the application of scientific knowledge, inquiry methods, SPS, and other important skills (Martin et al., 2016; Mullis et al., 2015; OECD, 2013a, 2014, 2016, 2018).

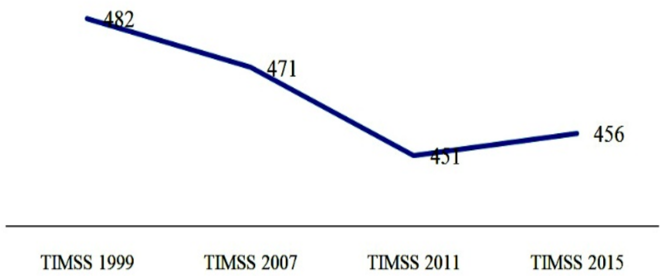

Figure 2.
Average scientific TIMSS Score Trends of Thai Students
Source: Martin et al., 2016; Mullis et al., 2015

Furthermore, it is interesting to note from the PISA 2015 international assessment that male students had a statistically significant higher score than female students (4 points). However, Thai students reversed these results, as female students scored nine points higher than male students (425 for female students, as compared to 416 for male students (OECD, 2016).

Additionally, Jack (2018) researched 720 students in West Africa on the role of gender in the acquisition of SPS and reported that gender had only a minimal effect on students' SPS acquisition. However, other research has revealed that what does affect a student's acquisition of SPS is a student's attitude, laboratory adequacy, and class size (Gultepe, 2016; Jack, 2013).

For these many reasons, the researchers have recognized the crucial importance of ISPS for lower secondary school students. Therefore, the research purpose is to investigate the ISPS models construct validity, and the factor loading values of ISPS indicators, to better understand the elements related to ISPS. Additionally, to find ISPS components, the researchers used a confirmatory factor analysis (CFA)to confirm the model's accuracy. A CFA describes the relationship between latent and manifest variables, while the analysis shows the factor loadings (Bartholomewet et al., 2008; Gagne & Hancock, 2006; Hair et al., 2014; Mulaik, 2009; Tabachnick & Fidell, 2013).

Problem of Study

The study investigated the ISPS measurement model construct validity amongst lower secondary students in Bangkok, Thailand, by use of ISPS score factor loading values. Also, to investigate the ISPS level of the students classified by both their individual indicators and overall, as well as the ISPS level of students by school size, gender, and the interaction effect between school size and gender affecting their ISPS.

Method

Research Model

The population for the study consisted of 19,569 Grade 8 students, who were enrolled in science education programs in the 2016 academic year in schools administered under Bangkok's Secondary Educational Service Area Office 1. The source for this population of 19,569 students can be found at https://www.sesao1.go.th/. From this population, quantitative research was used to examine how two independent variables consisting of school size and student gender affected a student's ISPS. The sample of research section is a sample of 500 obtained by multi-stage random sampling (using random units of school, classroom, and student respectively as random units). School size was divided into four categories, including small schools with less than 500 students, a medium school with 500-1,499 students, a large school having 1,500-2,499 students, and an extra-large school with over 2,500 students. The dependent variable was Grade 8 student ISPS. Additionally, the researchers went to each school and administered the questionnaire. After student completion, the researcher checked each student's test for completeness, after which, the data were analyzed for this study.

Sample of Research

This research has 2 sample sizes;

- The researchers' sample size of the research was 350 students.
- The sample size for CFA analysis in the *Instrument and Procedures* section was drawn from 500 students.

Sample size determination was ascertained from a variety of sources, with primary input coming from the G*Power 3.1.9.2software and power of the test (Power (1-β err prob)) at 0.80 and level of significance at .01 (α =.01) (G*Power 3.1 manual, 2017). The effect size was at 0.25, and to make the power of test most precise, the researcher targeted 350 students. Therefore, data were collected from 350 individuals using a stratified random sampling method.

Table 1.

Criteria and Supporting Theory for the Model's Sampling Procedures

Sample size of research	**350 students**	**ANOVA was used for sample size analysis.**	**Analysis conducted with the use of G*Power 3.1.9.2software program**	**Stratified random sampling was used to obtain the sample.**
The sample size of instrument for CFA analysis.	500 students	The sample size for analysis of construct validity of the ISPS measurement model.	Supporting theory (Bartholomew et al., 2008, Gagne & Hancock, 2006; Mulaik, 2009).	Stratified random sampling was used to obtain the sample.

Instrument and Procedures

The ISPS test for the sample of 350 Grade 8 lower secondary school students contained situation-related questions with four multiple choices, with only one possible correct answer. The study's ISPS final 22-item test was created by the authors after a review of the theory from various papers and research. The conceptual framework included: 1) controlling variables 2) hypotheses formulation 3) defining variables operationally 4) experimentation, and 5) data interpretation (Baird & Borich, 1987; Beaumont-Walters & Soyibo, 2001; Brotherton & Preece, 1995; Dillashaw & Okey, 1980; Karsli & Şahin, 2009; NRC, 1996, 2000; Özgelen, 2012, 2017; Padilla, 1990; Roth & Roychoudhury, 1993; Sermsirikarnjana et al., 2017; Shahali & Halim, 2010; Turiman et al., 2012; Yap & Yeany, 1988; Yeany et al., 1986). The authors then created the ISPS test by using a test blueprint consisting of 32 items. From this blueprint, the 32 item instrument tryout was used to survey a selection of students similar to those in the study's sample. The test was allocated 50 minutes. Afterward, each test was audited for completeness. The quality of the tool was determined by using item objective congruence, confirmatory factor analysis, difficulty, discrimination, and reliability as the following procedures:

Five experts were selected by the researchers to evaluate the content validity which was measured by use of the item objective congruence (IOC) (Hambleton & Rovinelli, 1986; Turner & Carlson, 2003), which the criterion of consistency of 0.5 and above used as a cutoff for the initial 32 items, which had an IOC ranging from 0.8-1.0.

Furthermore, the sample size was determined by Loehlin (1992) who has suggested that when using a CFA model, an investigator's sample is better if it includes at least 200 individuals. Other researchers have also suggested that a study's measurement model by use of a CFA should have at least 400 individuals, with larger sample sizes used to help ensure greater CFA results (Bartholomew et al., 2008; Gagne & Hancock, 2006; Mulaik, 2009; Tabachnick & Fidell, 2013). So, to minimize the errors of the test, data were collected from 500 samples using a stratified random sampling method. In difficulty (p) and discrimination (r), which difficulty selection was 0.20-0.80 andselection of discriminating with a value of 0.20 or higher, from the analysis of the remaining was 22 items. Reliability through Kuder-Richardsonmethod (KR 20) (Zimmerman & Burkheimer, 1968), indicated that values for the ISPS test were 0.79.

Data Analysis

Construct validity and the factor loading values were investigated by analyzing the CFA with the use of SPSS AMOS Version 23 software, with parameter estimation accomplished by the use of the Maximum Likelihood (ML) method and the variance-covariance matrix (Bartholomew et al., 2008). Table 2 shows both the model's goodness of fit criteria and theory, as well as the data derived.

Table 2.
Criteria and Supporting Theory for the Model's Goodness of Fit

Fit index	Acceptable levels	Reference
1) Chi-square statistic: $\chi 2$	*p*-value ≥ 0.05	(Barrett, 2007; Bartholomew et al., 2008; Hair et al., 2014; Hooper et al., 2008; Kenny & McCoach, 2003).
2) $\chi 2$model/df	≤ 2.00	
3) Goodness of Fit Index (GFI)	≥ 0.95	
4) Adjusted Goodness of Fit Index (AGFI)	≥ 0.95	
5) Root Mean Square Residual (RMR)	Values near zero are better.	
6) Root Mean Square Error of Approximation (RMSEA)	≤ 0.05	

Table 3 shows manifest variables/indicators used in the investigation of the construct validity of the student ISPS measurement model.

Table 3.
Latent Variables and Manifest variables and Their Associated Acronyms

Latent variables	Manifestvariables/ Indicator	Acronym
Integrated science process skills (ISPS)	1) controlling variables	ICV
	2) hypotheses formulation	FOH
	3) defining variables operationally	DVO
	4) experimentation	EXP
	5) data interpretation	INT

The mean ($\bar{X}$) and standard deviation (S.D.) were used for the student's ISPS data analysis, both for overall and individual aspects. Additionally, the ISPS data of the students was categorized by school size and gender. The interpretation criteria are shown in Table 4. An analysis of the variance of the sub-population in all groups was analyzed using Lavene's test, and two-way analysis of variance (two-way ANOVA) to examine the interaction effects and main effect (Ning & Kim, 2008).

Table 4.
Criteria Used in the Interpretation of the Student's ISPS.

Statistical average	Interpretation
80.00-100.00	Student skill levels were excellent
70.00-79.99	Student skill levels were very good
60.00-69.99	Student skill levels were good
50.00-59.99	Student skill levels were fair
Less than 50.00	Student skill levels needed improvement

Results

The construct validity testing results of the ISPS measurement model from the first-order CFA and the Pearson Product Moment Correlation (PPMC) analysis between the five indicators indicated that all the variables in the model were correlated and in the same direction (Table 5).Additionally, the Kaiser-Meyer-Olkin (KMO) index analysis indicated that the correlation matrix of the manifest variables was not a unique matrix, with there being enough correlations between variables for analyzing construct validity factors.

Table 5.
Mean, SD., and Correlation Coefficients of the Manifest Variables or Indicators in the ISPS Measurement Model for Students (n=500)

Manifest variables	**Correlation coefficients**					**Latent variables**
	ICV	**FOH**	**DVO**	**EXP**	**INT**	
ICV	1.00					ISPS
FOH	0.388**	1.00				
DVO	0.378**	0.254**	1.00			
EXP	0.415**	0.429**	0.443**	1.00		
INT	0.489**	0.266**	0.526**	0.475**	1.00	
Full score	3	7	2	7	3	22
Mean $\bar{X}$	1.244	4.010	0.670	3.322	0.938	10.184
Std. Deviation	0.931	1.590	0.731	1.628	1.072	4.346
Statistical average	41.467	57.286	33.500	47.457	31.267	46.291

Note. ** $p < .01$, KMO measure of sampling adequacy = 0.783, Chi-Square = 628.039, df = 10, $p = .000$

Construct validity testing results of the ISPS measurement model indicated the model's consistency with the empirical data (Table 6 & Figure 4).

Table 6.
Statistical Analysis of Construct Validity Testing of the Student ISPS Measurement Model (n=500)

Manifest variables	Indicators as factors of the ISPS				
	b_{sc}	S.E.	t	factor score weights(FS)	squared multiple correlations (R^2)
ICV	0.612**	<-->	<->	0.069	0.374
FOH	0.643**	0.084	9.112	0.305	0.413
DVO	0.669**	0.115	11.183	0.130	0.447
EXP	0.646**	0.067	11.855	0.104	0.417
INT	0.774**	0.123	11.839	0.228	0.599

Note. **p<.01, b_{sc}= factor loading values, <--> = fix parameters do not report S.E. and t, Chi-square = 4.330, df = 3, p = 0.228, χ^2/df = 1.443, RMSEA = 0.030, RMR = 0.001, GFI = 0.997, AGFI = 0.983.

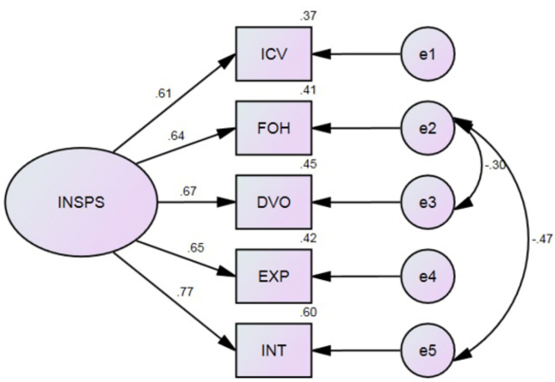

Figure 4.
The ISPS (INSPS) Measurement Model

Note. INSPS = Integrated science process skills, Chi-square=4.330, χ^2/df =1.443, df = 3, *p*-value = 0.228, GFI = 0.997, CFI = 0.998, RMR = 0.001, RMSEA = 0.30.

Table 7 shows the student ISPS study results classified as an indicator and overall. Figure 5 presents the statistical average of individual aspects of student ISPS.

Table 7.

Descriptive Statistic of the Mean, S. D., and the Individual and Overall Aspects of Student ISPS

Indicators as factors of the ISPS	Students (n=350)				ISPS level	Rank
	Full score	$\overline{X}$	S. D.	Statistical average		
Controlling variables (ICV)	3	0.971	0.783	32.367	Improvement needed	3
Hypotheses formulation (FOH)	7	3.577	1.571	51.100	Fair	1
Defining variables operationally (DVO)	2	0.514	0.641	25.700	Improvement needed	4
Experimentation (EXP)	7	2.840	1.423	40.571	Improvement needed	2
Data interpretation (INT)	3	0.660	0.840	22.000	Improvement needed	5
Sum	22	8.563	3.222	38.923	Improvement needed	-

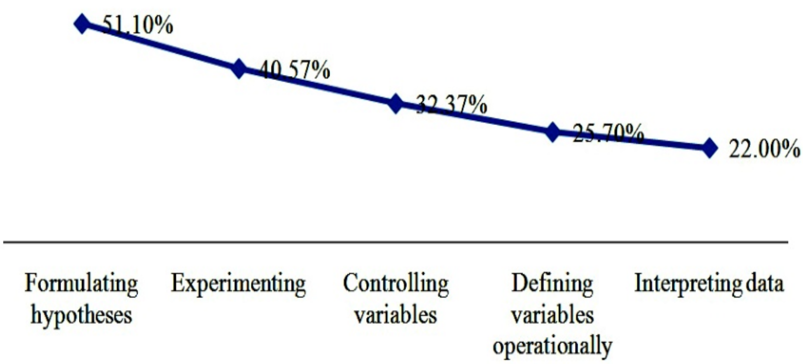

Figure 5.

Statistical Average of Individual Aspects for Student ISPS

Table 8 shows the student ISPS study results classified overall and by individual aspects when categorized by school size. Figure 6 presents the statistical average of student ISPS categorized by school size.

Table 8.
Statistical Analysis of Mean, SD., and Student ISPS Categorized by School Size

School Size		ISPS indicators as factors					Total
		ICV	**FOH**	**DVO**	**EXP**	**INT**	
	Full score	**3**	**7**	**2**	**7**	**3**	**22**
Small (n=72)	$\bar{X}$	0.639	2.694	0.486	1.944	0.667	6.431
	SD.	0.635	1.562	0.531	1.197	0.692	2.466
	Statistical average	21.300	38.486	24.300	27.771	22.233	29.232
	Level	I.N.	I.N.	I.N.	I.N.	I.N.	I.N.
Medium(n=88)	$\bar{X}$	1.159	3.432	0.466	2.773	0.727	8.557
	SD.	0.815	1.522	0.660	1.468	0.867	3.066
	Statistical average	38.633	49.029	23.300	39.614	24.233	38.895
	Level	I.N.	I.N.	I.N.	I.N.	I.N.	I.N.
Large (n=93)	$\bar{X}$	0.989	3.817	0.559	3.075	0.710	9.151
	SD.	0.715	1.375	0.683	1.461	0.829	3.093
	Statistical average	32.967	54.529	27.950	43.929	23.667	41.595
	Level	I.N.	Fair	I.N.	I.N.	I.N.	I.N.
Extra-large(n=97)	$\bar{X}$	1.031	4.134	0.546	3.340	0.546	9.588
	SD.	0.847	1.511	0.662	1.180	0.924	3.281
	Statistical average	34.367	59.057	27.300	47.714	18.200	43.582
	Level	I.N.	Fair	I.N.	I.N.	I.N.	I.N.
Sum(n=350)	$\bar{X}$	0.971	3.577	0.514	2.840	0.660	8.563
	SD.	0.783	1.571	0.641	1.423	0.840	3.222
	Statistical average	32.367	51.100	25.700	40.571	22.000	38.923
	Level	I.N.	Fair	I.N.	I.N.	I.N.	I.N.

Note. I.N. = Improvement Needed

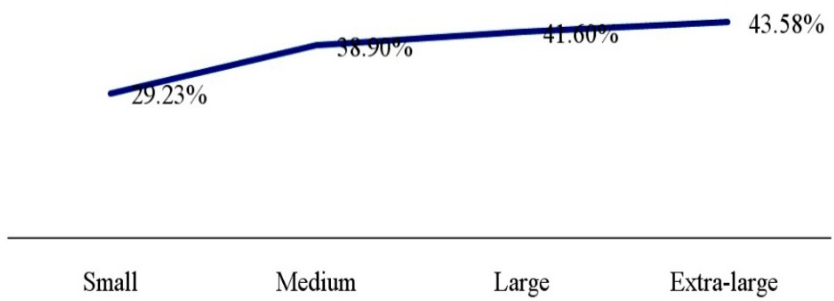

Figure 6.
Statistical Average of Student ISPS Categorized by School Size

Table 9 shows student ISPS results classified by individual aspects when categorized by gender. Figure7 presents the statistical average of student ISPS categorized by gender.

Table 9.
Statistical Analysis of Mean, S.D., and the Statistical Average of student ISPS Categorized by Gender

Gender		**ISPS indicators as factors**					**Sum**
		ICV	**FOH**	**DVO**	**EXP**	**INT**	
	Full score	**3**	**7**	**2**	**7**	**3**	**22**
Male (n=186)	$\bar{X}$	0.962	3.328	0.489	2.823	0.704	8.307
	SD.	0.808	1.544	0.635	1.461	0.866	3.338
	Statistical average	32.067	47.543	24.450	40.329	23.467	37.759
	Level	I.N.	I.N.	I.N.	I.N.	I.N.	I.N.
Female (n=164)	$\bar{X}$	0.982	3.860	0.543	2.860	0.610	8.854
	SD.	0.755	1.558	0.649	1.383	0.810	3.070
	Statistical average	32.733	55.143	27.150	40.857	20.333	40.245
	Level	I.N.	Fair	I.N.	I.N.	I.N.	I.N.
Sum (n=350)	$\bar{X}$	0.971	3.577	0.514	2.840	0.660	8.563
	SD.	0.783	1.571	0.641	1.423	0.840	3.222
	Statistical average	32.367	51.100	25.700	40.571	22.000	38.923
	Level	I.N.	Fair	I.N.	I.N.	I.N.	I.N.

Note. I.N. = Improvement Needed

Figure 7.
Statistical Average for Student ISPS Categorized by Gender

Table 10 indicates that students in medium, large, and extra-large schools had higher ISPS scores than students in small schools, at a statistical significance level of .01.

Table 10.
Statistical Analysis of Two-way ANOVA of Variance for Student ISPS Classified by School Size and Student Gender

Variation Source	Sum of Squares	df	Mean Square	F	Sig.	Comparison
School Size	0.919	3	0.306	16.428**	.000	different
Gender	0.067	1	0.067	3.607	.058	No difference
Interaction effect of school size and student gender	0.098	3	0.033	1.754	.156	No interaction
Error	6.378	342	0.019			
Note. ***p* < .01, Lavene'stest, F = 1.650, *p*-value = .120						

Table 11 shows the multiple comparison test of ISPS students as a statistical average as classified by school size.

Table 11.
Statistical Analysis of the Multiple Comparison Test of Student ISPS Classified by School Size

School Size	Mean, SD	Small	Medium	Large	Extra-large
Small	$\overline{X}$ = 6..431	-	-.0966**	-.1236**	-.1435*
Medium	$\overline{X}$ = 8.557	-	-	-.0270	-.0469
Large	$\overline{X}$ = 9.151	-	-	-	-.0199
Extra-large	$\overline{X}$ = 9.588	-	-	-	-
Sum: $\overline{X}$ =8.563, SD. = 3.222 (Sum score = 22)					
Note. **p < .01					

Discussion

The testing of the ISPS measurement model for Grade 8 lower secondary students in Bangkok, Thailand showed consistency with the empirical data. Ranked in importance, the highest factor loading values among the ISPS indicators was *data interpretation* (INT), followed by *defining variables operationally* (DVO), *experimentation* (EXP), *hypotheses formulation (*FOH), and *controlling variables* (ICV), respectively. (Chabalengula et al., 2012; Germann et al., 1996; Turiman et al., 2017)

Overall, the Thai Grade 8 students' ISPS were determined to need improvement. This is consistent from the PISA 2015 results in which Thai students scored 421, a very significant 23 point drop from the previous 2012 PISA science skills evaluation of 444, and significantly below the OECD average of 493 points (Mala, 2016). Thailand's score represented a ranking of 55th from a total of 70 countries evaluated. This is also in contrast to the average PISA 2015 performance of 15-year-old students in science, which has not changed significantly since 2006. Thai government officials, however, have suggested that a potential reason for the variance in Thai scores was due to which schools participated in the PISA test and those that did not. It was also noted the large difference in scores between rural and urban schools, which is consistent with other reporting from the OECD (2013b). It has also been suggested that Thai rural schools have limited resources; thus, another reason for Thailand's overall drop in scores (Mala, 2018).

However, one small ray of hope from the data showed that the ability to formulate a hypothesis (FOH) was at a fair level, with females being better at these skill then boys. The remaining four aspects from the study all showed levels that 'needed improvement.' This is consistent with the PISA 2015 results in which Thai girls performed better than boys by nine points (OECD, 2015).

This is further confirmed by the PISA 2015 results in which it was reported that within OECD countries, 25% of the boys and 24% of the girls were expected to be employed in a science-related profession by 30 years of age. However, in Hungary, Indonesia, and Thailand, gender differences played a significant role in who would be future scientist, with 25% of Thai girls indicating they expected to work in a science-related field, while only 12% of the boys indicated they would (OECD, 2016). The burning question is 'why?'

Furthermore, similar studies in Turkey showed Turkish students having problems with identifying dependent, independent and controlled variables, which is a crucial experimental process skill (Bolat et al., 2014). However, it has been suggested that a teachers' conceptual understanding of SPS after participating in a training workshop has a significant effect on student ISPS (Kruea-In & Thongperm, 2014).

It another comparative study between New Zealand and Thai students, it was discovered that there were different values used in decision-making processes concerning a nation's development and its relationship to energy. Additionally, Thai students were found to believe that scientific applications were effective tools for solving social problems (Yuenyong et al., 2007).

Furthermore, according to the OECD (2016), motivation is stated to be essential for student engagement, learning, and occupational choice. Furthermore, PISA discusses two forms of science learning motivation, which includes the student's enjoyment in learning science (intrinsic motivation), and the students perception of the learning process usefulness in their future plans (instrumental motivation). This is consistent with Wigfield and Eccles (2000), these two constructs are central in expectancy-value theory and in self-determination theory, which emphasizes the importance of intrinsic motivation (Ryan & Deci, 2009).

In Thailand's case, from the PISA 2015 scientific scores concerning conflicts with the scientific mind, it was reported that Thai students found that the relationship between students' belief in scientific approaches to inquiry and science performance was significantly higher than the OECD average (OECD, 2016). This was also consistent with the TIMSS 2015 study, which found that most Thai students liked to study and appreciate the value of mathematics and science, but have little confidence in their ability to learn in the two subjects.

On the other hand, students in East Asian countries who scored high in Japan (Lestari et al., 2019)., South Korea, Hong Kong, and China-Taipei did not like studying and did not appreciate the two subjects, and there were less confident in both subjects similar to Thai students. Moreover, from the TIMSS 2015 data, it was shown that students in these countries had a higher number of students who do not like science (Martin et al., 2016; Mullis et al., 2015).

Concerning school size, studies have shown that this can be a contributing factor to ISPS development, as availability to resources can play a significant role (Mala, 2018). What remains somewhat unclear, however, does a large school in a rural environment have access to the same resources as the same size school in an urban environment? (Kasayanond et al., 2019). Jack (2018) explored this issue with Nigerian school students who were experiencing difficulty in the acquisition of SPS, and reported that the difficulty was partially due to the school's student-teacher ratios.

It was, however, determined for this study that there was no interaction between school size and student gender, which affected the students' ISPS at a statistically significant level (Sagala et al., 2019). Students in different school sizes were determined to have different ISPS abilities, but once again, these schools were drawn from a single Thai urban environment.

Continuing with the discussion about school size, Lee and Loeb (2000) found that teachers' attitudes influenced student achievement directly and indirectly depending on the school's size. Athuman (2017) also indicated that large class sizes have a significant influence on a student's science process acquisition skills. In addition, Jack (2013) also added that a student's attitude, the school's laboratory adequacy, and the class size influenced a student's SPS acquisition ability. However, gender played no statistically significant role.

This was consistent with studies from Ekon and Eni (2015) and Beaumont-Walters and Soyibo (2001) that indicated that gender did not significantly influence the acquisition of science process skills. However, a science process skills teaching strategy can make a significant difference in achievement in chemistry between boys and girls (Abungu et al., 2014). These findings were also consistent with the PISA 2012 results, in which it was reported that more than 50% of all countries in the project had no difference between science scores from genders.

But in terms of the average science score of Thai students, since the beginning of the PISA testing, female students had higher scores than male students, and the score gap has only grown wider (OECD, 2013a, 2014, 2016). And when analyzing by area, the difference in science scores between male and female students had the widest gap in urban Bangkok and its surrounding metropolitan area (OECD, 2016).

Conclusion and Suggestions

From both this study and other international studies, it has been observed that Thai female science students post higher scores than those of their male counterparts. Additionally, there is a significant difference in a female's desire to participate in a science-related field, as compared to a similar male student. This leads to the question as to 'why?', and the specific identification of what these students perceive as 'science'. Furthermore, Thai science students lack confidence in their ability to learn but are enthusiastic about learning. An investigation into this aspect needs to be undertaken, with solutions proposed. Future investigation also needs to be undertaken as to how science teacher workshops and training seminars affect ISPS outcomes, and how best to implement them.

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Biodata of Authors

Oranit CHOKCHAI is an academic in the Institute for the Promotion of Teaching Science and Technology (IPST), Bangkok, Thailand. She graduated with a B.A. in Engineering (Geotechnology) from Suranaree University of Technology and an M.Sc. in science education from KMITL. Her Ph.D. was obtained from the King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. **E-mail:** oranit_chokchai@hotmail.com. ORCID ID: 0000-0003-1668-2328.

Paitoon PIMDEE serves as an Associate Professor with the Faculty of Industrial Education and Technology and Vice President of Procurement at the King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. He is also the head of his faculty's Ph.D. program. He graduated with a B.Sc. in Chemistry, B.E. in Economics and a M.Sc. in science education. He also holds a Ph.D. in environmental education and specializes in environmental behaviors, conservation behaviors, educational research, and statistics. His google scholar citations are located at https://tinyurl.com/y5fl9r2a. **E-mail:** paitoon.pi@kmitl.ac.th. ORCID 0000-0002-3724-2885.

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