An integrated science process skills needs assessment analysis for Thai vocational students and teachers

Pongsuwat SERMSIRIKARNJANA, Krissana KIDDEE and Phadungchai PUPAT

King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, THAILAND

E-mail: sermsirikarnjana@gmail.com

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Abstract

In Thailand, 318,500 students were enrolled in vocational courses in 2015. Under the new 20-year educational plan, the ratio of vocational to general students is projected to increase from 38:62 to 60:40, which is required to meet the goals of Thailand's new digitally enabled, knowledge based, economic model under Thailand 4.0. Additionally, nearly 60% of students enrolled in vocational programs are focused on science and technology tracks, but testing scores remain abysmally low. Therefore, an integrated science process skills needs assessment was conducted from the survey's questionnaire results for the sample group of 345 which was drawn from 2,343 vocational science teachers and students by use of a multi-stage sampling technique. Descriptive statistics were used which included mean ($\bar{X}$) and standard deviation (SD). Also, one-way ANOVA, matrix analysis, and the modified priority needs index ($PNI_{Modified}$) were used. The findings revealed that authentic performance of integrated science process skills was at a medium level, while the expected performance was relatively high. The skills needed to be improved were experimenting, formulating hypotheses, interpreting, making inferences, identifying, and controlling variables and defining operationally, respectively.

Keywords: 21st Century workforce, Fourth Industrial Revolution (4IR), Industry 4.0, Thailand 4.0, vocational certificate students

Introduction

Thailand 4.0 is an economic model based on creativity, innovation, new technology, and high-level services (Baxter, 2017). To develop a country within this global context, it must be driven by innovation and creativity, along with the skills necessary for workers within a 21st Century environment (Reeve, 2014, 2016; Trilling & Fadel, 2009). Transforming however to the challenges of the 21st century dynamics is therefore based on high quality education, which meets the goals of Thailand's 12th National Economic and Social Development Plan (2017-2021), while focusing on the development of critical thinking skills, as well as creativity (Baxter, 2017; Office of the Prime Minister, 2016).

To meet these challenges, Thailand in 2015 enrolled 318,500 vocational education students, which was an 86,052-student increase compared to the same period in 2014 (Mala, 2015). In 2017, Thailand will graduate 400,000 bachelor's degree students, along with 140,000 vocational education graduates, who will be entering Thailand's workforce (Board of Investment, 2017).

In Thailand, the Office of the Vocational Education Commission (Ovec) is responsible for student vocational education policies, and the implementation of what is referred to as a 'dual' or 'double-track' system, which is a collaboration between entrepreneurs, vocational institutions, and academic schools, allowing students to graduate with both academic and vocational qualifications, which in some countries might be referred to as 'work/study' program. Furthermore, in the

Thai vocational system, there are two main levels of certification available, which are the Vocational Certificate level and the High (Upper) Vocational Certificate level.

Having completed lower secondary education, students may choose to follow a vocational upper secondary specialization. Students take the same compulsory subjects as those in the academic stream, with specialization in one of five major fields including agriculture, home economics, business studies, arts and crafts, and engineering. The Certificate in Vocational Education (Bor Wor Saw) and the Certificate in Dual Vocational Education (DVT) both require three years of study, while the DVT program requires a significant amount of practical, on-the-job training in partnership with an industry participant (Fadul, 2011).

The importance of the vocational education system for Thailand cannot be understated as Thailand advances into the Fourth Industrial Revolution (4IR) which Thai policy makers have labeled as Thailand 4.0 (Jones & Pimdee, 2017). In this vision for a digitally enabled, knowledge based workforce, vocational students play a key role in the success of the 10 economic sectors which have been targeted. Additionally, as can be seen from Figure 1, Science & Technology students were in the enrolled majority at the vocational education level in 2013 (lower than bachelor).

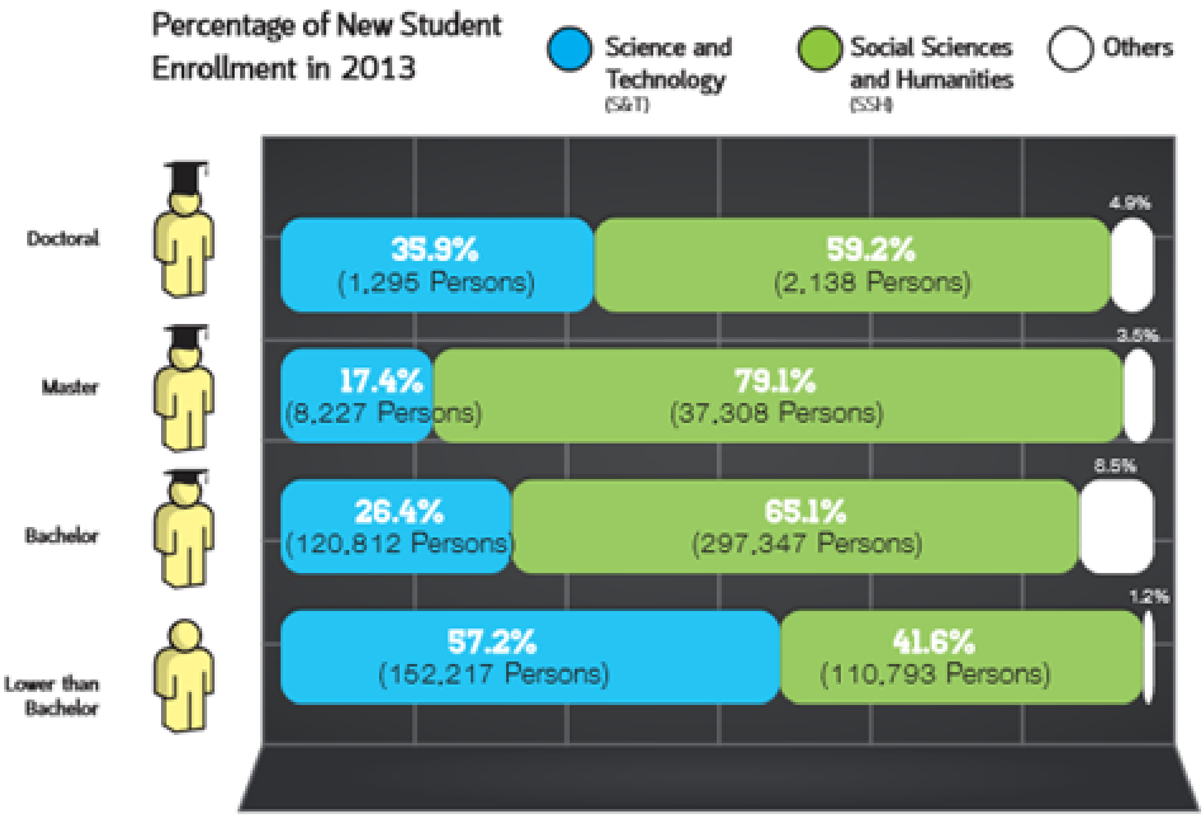

Figure 1. Thai new student discipline enrolment (2013) Source: Thailand Science Technology and Innovation Profile (2014)

In the current climate of rapid technological change, it is therefore becoming necessary for knowledge workers to acquire 21st century skills (Reeve, 2016). Recognized components of this are Science, Technology, Engineering, and Mathematics (STEM) education, which has become integral to TVET (technical and vocational education and training) education. In Thailand however, studies and scholars have noted that TVET has not been able to provide sufficient highly-qualified and well-trained technicians for a rapidly changing economy (UNESCO Bangkok, 2011).

This was further confirmed by Chalamwong et al. (2012) which determined that employers are still looking for semi-skilled labor, especially people equipped with technical skills, yet vocational institutions have not been very successful in producing highly-qualified graduates. And as sad as it is to report, according to a 2015 study from the Thailand Research Fund (TRF), results from logical thinking and analytical skills testing of 1,029 vocational students showed that only 2.09% passed the exam, while the average was only 36.5% (Rujivanarom, 2016).

Problem Statement

Education in Thailand takes 20% of the budget and represents 6% of the GDP, but 80% of the education budget goes to support administrative costs (Concern over 'inefficient' education spending, 2015). Furthermore, test scores continue to decline, with PISA (Programme for International Student Assessment) results of Thai students being among the lowest in the world (Sothayapetch, Lavonen, & Juuti, 2013; Yuenyong, 2013), with logical thinking and analytical skills of students tested being at abysmal lows of 2.09% passing (Rujivanarom, 2016). Given the depth and breadth of these problems, the researchers undertook a study to research the authentic and expected performance of integrated science process skills of vocational certificate students and teachers, along with a needs assessment exploration prioritized and classified by institution type.

Research Objectives

The aim of the research was to study: (1) authentic and expected performance of integrated science process skills of vocational certificate students (2) to explore a needs assessment (3) to prioritize and (4) to compare the needs assessment of integrated science process skills (classified by types of institutions).

Literature Review

Science Education in the 21st Century

In research from Thailand and South Korea, researchers suggest that science education and research should be community focused, with science teaching focused on inquiry and inspiration, with students going out into their communities to help solve problems (Jho, Hong, & Song, 2016; Punyain, 2017). What the students gain most are problem-solving skills and working in a team, which helps students understand about how learning takes place (Novak & Gowin, 2002). Also, using community based teaching helps relieve teachers' anxieties, because they have peers and experts to support the new teaching strategies (Jho et al., 2016).

This is consistent with the US National Science Education Standards (1996), which has stated that the central strategy in teaching science is the inquiry into authentic questions generated from student experiences. Sadler (2004), also states that learning in the 21st Century should not focus on rigorous content, but instead focus on learning and scientific process skills (Osman, Hamid, & Hassan, 2009). Such skills help students to understand the nature of knowledge, which allows them to construct and apply knowledge through discovery, exploration, and experiment, including building up critical and rational decision-making skills (NCREL, 2003).

Thus, the advancement of science is both a social process and a public process. That is, science relies on many inter-personal processes and social phenomena (Edmonds, Gilbert, Ahrweiler, & Scharnhorst, 2011). It is also at the core of most societies in the world, not only in technical, military, and economic ways, but also in the cultural impacts it has, providing ways of thinking about ourselves, our society, and our environment (Buang, Halim, & Meerah, 2009; Guest, Livett, & Stone, 2006). Thus, it is imperative that there is a focus on the development of science learning (Project 2061, 2009; Patricio, 2010), with Kuhn (1962) emphasizing that science learning provides individuals curiosity to expand and explore new knowledge to enhance the quality of life.

Thai Science Education Reform

The 20th constitution of the Kingdom of Thailand was officially promulgated on April 6th, 2017, although yet there is no publicly available English version. The researchers therefore, used an older version (2007), to discover constitutional guarantees for science education. In the older version, it clearly states in Article 86, the importance of science education and research, as well as the need to promote innovation and new inventions (Constitution of the Kingdom of Thailand B.E. 2550).

In 2008, the Basic Education Core Curriculum B.E. 2551 (2008) was released which in Strand 8 under the topic of Nature of Science and Technology Science, it is stated that Thai students are to be taught the ‘application of scientific process and scientific reasoning in investigation for seeking knowledge and problem-solving, and understanding that science, technology, society and the environment are interrelated’.

These policies are also consistent with the Institute for the Promotion of Teaching Science and Technology (2013), in which guidance stipulates that science knowledge is derived from scientific process skills. Furthermore, focus needs to be placed on developing teachers' quality in science teaching, while developing awareness about the nature of science, contexts of science, socio-scientific issues, and the relation between science, technology, and society (Sothayapetch et al., 2013).

Current Thai Science education policy is also being guided by the new National Economic and Social Development Plan, 2017-2021 (Office of the Prime Minister, 2016), which specifically addresses science and technology, research, and innovation, within the context of a digitally empowered, knowledge-based economy. Additionally, under the six strategies in the plan, there is strong emphasis on developing human resources as well as research and innovations to improve Thailand's competitiveness, under what is being labeled as Thailand 4.0 (Jones & Pimdee, 2017; Office of the Prime Minister, 2016). Thailand 4.0 is the conceptualization of a Thai version of Industry/Industrie 4.0 (Germany Trade and Invest, 2017; Roblek, Meško, & Krapež, 2016) and the Internet of Things (IoT).

A new 20-year Strategic Education Plan (2017 to 2036) was also announced in early 2017 (by the 21st Thai education minister in 18 years), in which focus was stated to be on 'bestowing skills for the 21st century' and 'inspiring students' (Mala, 2017a). Also, noteworthy in this new 20-year plan is the desire to increase the ratio of vocational to general students from the current 38:62 to 60:40 over the next 20 years.

Vocational Education Science Learning Problems

Global economic competition increasingly requires nations to compete on the quality of goods and services, which requires a labor force with a range of mid-level trade, technical and professional skills alongside the high-level skills associated with university education (OECD, 2011). Furthermore, according to UNESCO, technical and vocational education is going through a period of intensive change and reorientation, with a multiplicity of educational systems being developed to cope with rapid technological advances and the changing needs of the global labor market. As the needs of a society change, the educational process must change with it (Drucker, 2007) due to the continuing and rapid changes in technology.

As such, vocational education science teaching needs to be focused on the practical or applied nature of science. Applied science involves the scientific process of observing, surveying, investigating, and experimenting, with the student involved in self-discovery and the application of scientific knowledge in resolving issues at school, home, and at work (Ministry of Education, 2008). This is consistent with

Asunta (1997), who studied Finnish science students and indicated that practical work and demonstrations, aiming at learning process skills, have long been accepted as an integral part of Finnish teaching and learning of science subjects.

In Thailand however, research has shown that multiple challenges exist in student science education. An often-repeated theme is that teachers remain fixated on traditional classroom methods, with the role of students being to listen and memorize content knowledge, rather than exploring knowledge through activities.

Moreover, another major problem is the lack of qualified Thai science education teachers. Reasons for this are numerous, but they include the problem that many current Thai teachers are facing retirement age, only teachers with degrees in education can obtain a Thai reaching license (efforts however are underway to change this), qualified graduates in STEM often opt for higher paying positions in industry (Mala, 2017b), and out-of-field teaching. This therefore contributes to the vicious cycle of constantly decreasing science related test scores (Boston College, 2001; Karsli, Sahln, & Ayas, 2009; Rujivanarom, 2016; Sothayapetch et al., 2013), and employer unwillingness to hire unqualified vocational student applicants (UNESCO, 2011; UNESCO Bangkok, 2011).

Science Process Skills

The science process skill is a process which scientists use to solve problems and obtain knowledge, which use the scientific approach to train students in their ability to seek knowledge, solve problems, and conduct experiments by themselves (Myers, 2006; Özgelen, 2012). Science process skills are also known as procedural skills, experimental, and investigating science habits of mind or scientific inquiry abilities (Harlen, 1999).

The scientific process skills are divided in two parts. These include:

(1) Basic science process skills contain skills including observation, classifying, measuring, calculation, using space/time relationships, communicating, inferring, and predicting (Dahsah, Seetee, & Lamainil, 2017).

(2) Integrated scientific process skills contains skills including formulating hypotheses, defining operationally, identifying, and controlling variables, experimenting, interpreting data, and making inferences (Martin, Sexton, Franklin, Gerlovich, & McElroy, 2005; Ngoh, 2009).

Training students to gain scientific process skills is an advantage since they can apply such skills to search for new knowledge and to solve problems in various situations. In addition, the scientific process emphasizes decision-making skills and problem-solving skills which are considered as significant and necessary skills in learning (Anderson, 2002; Reeve, 2014). Martin et al. (1994) add that the scientific process skills encourage students to acquire knowledge from doing.

Overall, the problem of science education of certificate vocational students requires an immediate action to elevate students' academic performance. Thus, this research aims to study authentic and expected performance of integrated process skills and to explore its needs assessment to know what causes problem in science learning.

Needs Assessment

Kaufman, Rojas, and Mayer (1993) indicated that a needs assessment is a process used to identify needs by prioritizing essential needs. It is a systematic process for determining and addressing needs, or "gaps" between current conditions and desired conditions or "wants" (Kaufman et al., 1993; Kraisuth & Panjakajornsak, 2017). The process of needs identification includes the pre-assessment preparation (King, 2012), while the evaluation consists of data collection, data analysis, and essential needs prioritization (Watkins, Meiers, & Visser, 2012).

This is consistent with O'Reilly (2016) which indicated that conducting a needs assessment is one of the first steps in setting programmatic goals or developing strategic plans. A needs assessment is further defined as an evaluation of an organization's current environment relative to the preferred environment, with the difference between the two identified as the organization's needs (Szuba, Rogers, & Malitz, 2005).

From educational policy directives in the US state of Colorado, the goal of the needs assessment is stated to be twofold: to ascertain existing capabilities and to determine the gap that exists, if any, between the current state and the desired end state (King, 2012). The needs assessment accomplishes more than just identifying a gap, however, the process also serves to: provide direction for programs, projects, and activities; allow staff to determine priorities and allocate limited resources to activities that will have the greatest impact; create cohesion through the alignment of goals, strategies, professional development, and desired outcomes; enable benchmarking and monitoring of implementation and impact; and assist with continuous improvement activities by helping staff identify change, which instructional and other practices are working, and the strategies associated with the greatest success.

Developing and executing the needs assessment is often the most important and time-consuming step in the process of setting related goals for a specific educational program (Szuba et al. 2005). Needs assessments can include data collection from many sources. Existing documentation, such as historical budgets, student achievement, and target population demographics, is typically available in program files. Interviews, focus groups, and environmental scans provide additional information on current practice. Surveys, however, remain the most common form of needs assessment, as they are relatively easy to administer and provide data in an accessible format (King, 2012).

Yildirim and Simsek (1997) investigated the effectiveness and efficiency of the curriculum development process in Turkish vocational schools, and indicated that a needs assessment is an important activity in identifying the required skills and knowledge in a certain area. Vocational schools need to determine the competencies required in industry and update current courses or design new ones accordingly. Therefore, to keep up with the changes in industry, vocational schools need to carry out needs assessment constantly and to search for ways to update their curriculum.

Method

Evans (2013) analyzed 460 articles on assessment feedback in higher education over a 12-year period, and discussed the importance of authentic and performance assessment. For integrated scientific process skills, multiple scholars including Martin et al. (2005), Ngoh (2009), and Padilla (1990), referred to 5 required skills including formulating hypotheses, defining operationally, identifying, and controlling variables, experimenting, and interpreting, and making inferences.

Population and Sample

The population of the study included 2,526 teachers and students from Thailand's Education Region 3 in academic year 2015. Multistage random sampling was used to select the 345 vocational students and science teachers from 6 schools in Phitsanulok's Educational Region 3, from which the total number of respondents was validated by use of Yamane's (1973) formula, while allowing for a 4.5% error.

n = N / [1 + N (e)2] - Where n is the sample size, N is the population size, and e is the level of precision.

Research Tools

A questionnaire was used to collect data from 345 teachers and students by use of multi-stage random sampling. The questionnaire items were designed using a 5-level Likert type agreement scale (Likert, 1967). The questionnaire consisted of 5 areas of questions which totaled 33 items. The reliability of the questionnaire was determined to ensure that the responses collected through the instrument were reliable and consistent. The reliability value of 0.88 was calculated by using Cronbach's alpha (Cronbach, 1990) to ensure whether there was internal consistency within the items. The questionnaire was then used to evaluate both authentic and expected performance of scientific process skills of vocational certificate students which the scales being defined as follows: 1 = Very low, 2 = Low, 3 = Medium, 4 = High and 5 = Very high.

Data Analysis

Data analysis was conducted in four steps. These included:

Step 1: The examination of the integrated scientific process skills of 297 vocational certificate students and 48 vocational certificate science teachers. The data was analyzed using descriptive statistics including mean ( ) and standard deviation (S.D.).

Step 2: The examination of the needs assessment of integrated scientific process skills was analyzed by use of Matrix analysis (Thammasaeng, Pupat, & Phetchaboon, 2016; Wongwanich, 2015) as follows:

Quartile 1 means above average

Quartile 2 means on average

Quartile 3 means below average with urgent improvement needed

Quartile 4 means below average.

Step 3: Prioritization and analysis of the needs assessment data was conducted by use of the modified priority needs index (PNIModified) (Silsawang, Boosabong, &

Ajpru, 2014; Wongwanich & Wiratchai, 2005). To get standard scores, the needs were assessed by finding the differential value between desired outcome (I) and actual results (D) (Wongwanich, 2005). The formula for the calculation is as follows:

PNI Modified (PNIModified) = (I - D)/ D

PNI = priority needs index

I = mean desired outcome

D = mean actual results

Step 4: Last, to compare needs assessment of integrated science process skills (classified by types of institutions), analysis was conducted by use of One-way ANOVA (Thammasaeng et al., 2016).

Results

Respondent's Characteristics

The total number of respondents included 345 individuals who were either teachers (48-13.91%) or students (297-86.09%) involved in vocational science education in Thailand's Region 3 in Phitsanulok Province. Table I and Figure 2 show the results of performance evaluation of integrated scientific process skills of vocational certificate education. According to Table I, the authentic performance of integrated scientific process skills was found to be at a medium level ($\bar{X}$=3.19, S.D. =0.25), with expected performance at a high level ($\bar{X}$=4.12, S.D. =0.52).

Table I. Mean ($\bar{X}$) and Standard Deviation (S.D.) of Authentic and Expected Performance of Integrated Scientific Process Skills

	Authentic			**Expected**		
Dependent variables	$\bar{X}$	**S.D.**	**results**	$\bar{X}$	**S.D.**	**results**
1.Formulating Hypotheses	3.08	0.45	Medium	4.11	0.57	High
2.Defining Operationally	3.24	0.32	Medium	4.09	0.58	High

3.Identifying and Controlling Variables	3.21	0.52	Medium	8.66	4.13	High
4.Experimenting	3.05	0.58	Medium	4.14	0.59	High
5.Interpreting and Making Inferences	3.35	0.57	Medium	4.15	0.58	High
Totals	3.19	0.25	Medium	4.12	0.52	High

Needs Assessment Analysis

The needs assessment analysis of integrated scientific process skills of vocational certificate students is shown in Figure 3. According to Figure 3, it is shown that the needs assessment of 5 integrated scientific process skills (formulating hypotheses, defining operationally, identifying, and controlling variables, experimenting, and interpreting and making inferences) fall in Quartile 3 which need an urgent improvement.

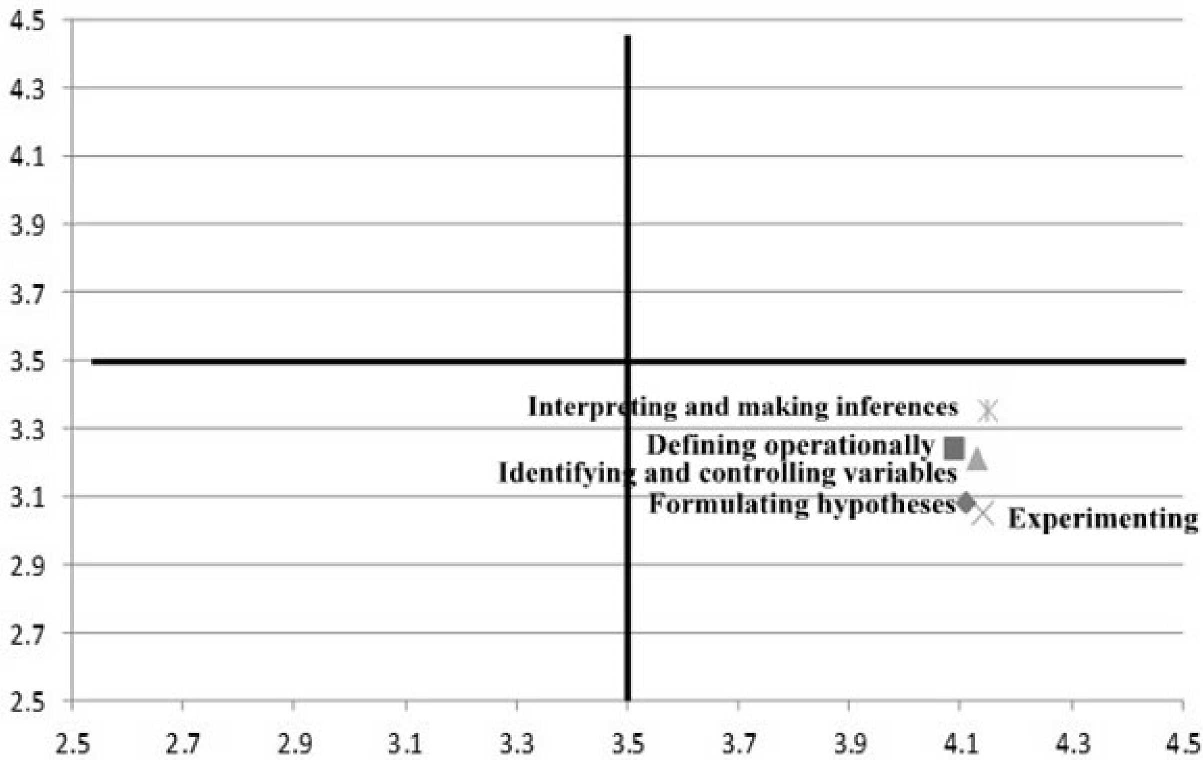

Figure 3. Needs assessment analysis of integrated scientific process skills.

Prioritizing needs assessment of integrated scientific process skills of vocational certificate students is shown in Table II. According to Table III, it was found that PNI(Modified) appears between 0.23-0.35 which identified the following skills targeted for improvement. From weakest to strongest, it was determined that experimenting was the weakest. However, formatting hypotheses was a bit better. Interpreting and making inferences, identifying, and controlling variables and defining operationally, were next in their order of need for improvement.

The comparison of needs assessment of integrated scientific process skills of vocational certificate students classified by institution type is shown in Table III. According to Table III, it was found that needs assessment of integrated scientific process skills of vocational certificate students in technical colleges, vocational colleges, polytechnic colleges, and industrial and community colleges are not different, as confirmed by a significance level of 0.05. When comparing all the integrated scientific process skills, the results show that all skills need significant improvement.

Model assessments are accomplished with the use of fit statistics, and in regression modeling, R^2 is commonly used. The R^2 is a descriptive index, and the evaluation of goodness-of-fit is somewhat subjective as where is R^2 good? $R^2= 0.50$? $R^2 = 0.30$? $R^2 = 0.10$? There are no fixed guidelines for R^2, thus it is desirable to supplement it with the F-test used in Table III (Iacobucci, 2009). The F statistic tests the null hypothesis because it comes with a corresponding statistical distribution. Thus, the F-test tells us whether the model is capturing a significant amount of variance.

Table II. Assessment Results and Prioritizing of Needs Assessment of Integrated Scientific Process Skills of Vocational Certificate Students.

Items	Integrated scientific process skills	I	D	$PNI_{(Modified)}$	Prioritizing
1	Formatting hypotheses	4.11	3.08	0.33	2
2	Defining operationally	4.09	3.24	0.26	4
3	Identifying and controlling variables	4.13	3.21	0.28	3
4	Experimenting	4.14	3.05	0.35	1
5	Interpreting and making references	4.15	3.35	0.23	5
	Total	4.12	3.19		

Table III. Comparsion of Needs Assessment of Integrated Scientific Process Skills of Vocational Certificate Students (Classified by Institutions).

Integrated Scientific Process Skills	Source of Variance	SS	df	MS	F	Sig
1. Formatting hypotheses	Between Groups	0.831	5	0.166	0.793	0.555
	Within Groups	71.005	339	0.209		
	Total	71.836	344			
2. Defining operationally	Between Groups	0.631	5	0.126	1.201	0.308
	Within Groups	35.621	339	0.105		
	Total	36.252	344			
3. Identifying and controlling variances	Between Groups	2.605	5	0.521	1.949	0.086
	Within Groups	90.643	339	0.267		
	Total	93.248	344			
4. Experimenting	Between Groups	2.731	5	0.546	1.588	0.163
	Within Groups	116.589	339	0.344		
	Total	119.321	344			
5. Interpreting and making inferences	Between Groups	1.988	5	0.398	1.221	0.299
	Within Groups	110.383	339	0.326		
	Total	112.371	344			
Total	Between Groups	0.252	5	0.050	0.801	0.550
	Within Groups	21.364	339	0.063		
	Total	21.616	344			

Table IV also shows items from the questionnaire along with their results.

Table IV. Questionnaire items for Level of Need.

Item	Mean	SD	Level of Need

The assumptions.			
1. I can understand the assumptions from the problem set.	4.58	0.560	most
2. I can understand the rules of the assumption.	4.42	0.540	much
3. I can tell how to test assumptions from the given data.	4.39	0.551	much
The definition of action.			much
1. I can define the meaning and scope of words	4.38	0.532	much
2. I can define the action of a word or variable.	4.57	0.557	most
3. I can improve the definition of action.	4.35	0.524	much
Defining and controlling variables			
1. I can control the parameters that are set and the assumptions made.	4.38	0.547	much
2. I can define the dependent, independent, and control variables.	4.40	0.501	much
3. I can tell and control the conditions and circumstances of either the constant or non-constant variables.	4.40	0.557	much
The trials.			much
I can decide the design of each experiment.	4.35	0.526	much
2. I can follow the experiment's plans.	4.38	0.503	much
3. I take note of each experiment and its results.	4.39	0.539	much
Interpretation of information and conclusions.			much
1. The interpretation of results is very clear and conclusive.	4.39	0.551	much
2. I can interpret or describe the properties of the data.	4.39	0.566	much
3. I can describe the meaning of the information provided in different ways.	4.40	0.531	much

Discussion

Integrated Scientific Process Skills Performance

Integrated scientific process skills performance of Thai vocational certificate students was found to be at a 'medium' level, which can be partially attributed to traditional teaching methods used by vocational science teachers. In terms of teaching materials, it was shown that it does not correlate with the methods they actually use, their lack of actual integrated scientific process skills, and the large numbers of classroom students. This is consistent with Nigerian vocational education research by Audu, Igwe, and Onoh (2013), which suggested that vocational education played a significant role in equipping labor with employment skills for the 21st century, yet infrastructure, quality teachers and workshop facilities were lacking.

According to studies, teachers feel that they understand integrated scientific process skills, however, their understanding of the skills is often inaccurate (Lotter, Harwood, & Bonner, 2007). This was recently confirmed by Thailand's National Science Technology, and Innovation Policy Office (2012), in which it was revealed that vocational certificate graduates have science knowledge skills below average when compared to national testing.

Also, numerous studies indicate that science teaching is learning by doing, as well as through activities (Glynn & Britton, 1984; Alexander & Kulikowich, 1994). To correct the lack of hands-on activities, the Thai Office of the Vocational Education Commission (OVEC) developed a Graduate Diploma Program B.E. 2556 (2013) to improve knowledge and skills, creativity, and knowledge seeking skills, where learners are expected to construct knowledge and to integrate their knowledge in other fields. However, the reality can be somewhat disappointing, as there is an 'implementation gap' when it comes to what is officially written and what takes place (Trowler, 2002).

Matrix Analysis

From the Matrix analysis of the five skill needs assessment of integrated scientific process skills, it was determined that an urgent improvement was needed, and that all survey respondents' skills needed to be developed (Rujivanarom, 2016). The integrated scientific process skills are considered as a tool to seek knowledge, and the skills can be applied with other courses. This is consistent with Meyers and Jones (1993) which stated that to achieve real learning, students need to acquire integrated scientific process skills to expand their knowledge and to be able to experiment and discover on their own.

Needs Assessment Prioritization

From the results of prioritizing the needs assessment of integrated scientific process skills using $PNI_{Modified}$, 'experimenting' was shown to be skill most urgently needed to be acquired, as it is an activity which initiates students' learning; allowing them to interact with elements, and encourages them to seek knowledge and solved problems ($PNI_{Modified} = 0.36$).

The 'interpreting data and making inferences' became the least needed integrated scientific process skill as it does not require complex thinking processes ($PNI_{Modified} = 0.23$). Padilla (1990) points out that education is to teach "thinking processes" which refers to integrated scientific process skills, which focus on identifying and controlling variables skill and defining operationally. The referred skills are the beginning of all scientific process and are needed to be developed. Last, it is suggested that curiosity and participation of learners are key factors to develop their abilities in science learning (Maltese & Tai, 2010; National Association for Gifted Children, 2008).

Needs Assessment

Assessment The needs assessment of integrated scientific process skills of vocational certificate students was found to be 'not different' when compared between institutions, including technical colleges, vocational colleges, polytechnic colleges, and industrial and community colleges. This is interpreted to suggest that students in each institution need to improve their integrated scientific process skills.

Conclusion

Confirmation of the study's results can also be found in the World Economic Forum's 2015-2016 Global Competitiveness Report (Schwab, 2015), which ranked Thailand 32nd out of 140 countries total, with an overall score of 4.6 (Figure 4). (For comparison purposes, Singapore ranked 2nd, with a score of 5.7). What is interesting to note from Figure 4's data is the scores on innovation, higher education and training, and labor market efficiency shown in Figure 4, all seeming to support the analysis and results of this study.

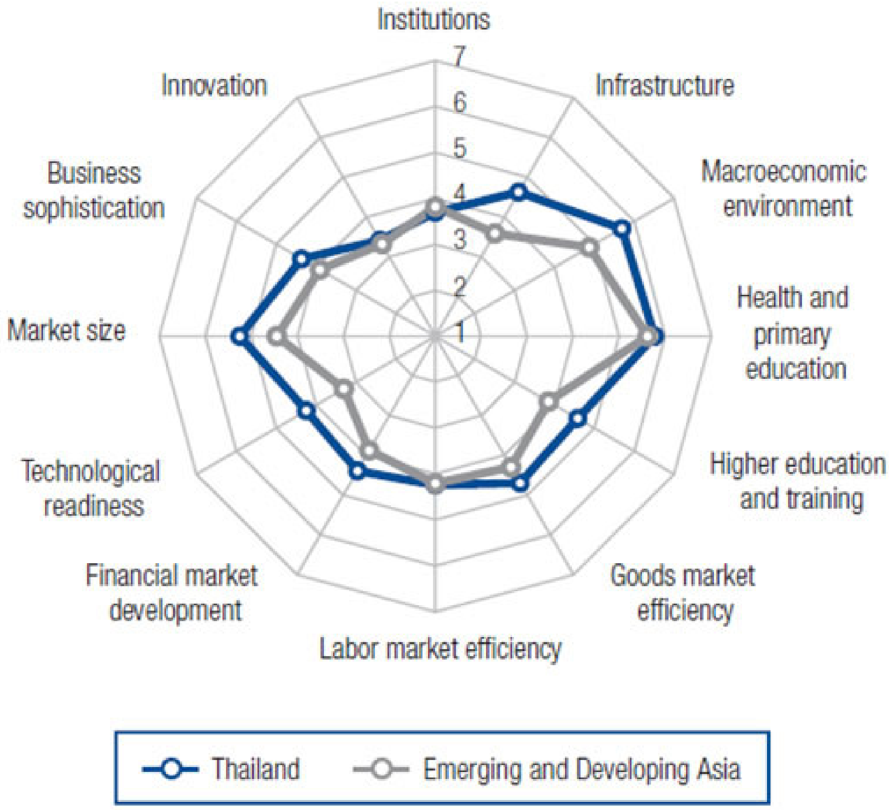

Figure 4. Thailand's global competitiveness ranking

Note: Sourced from the Global Competitiveness Report 2015–2016 (Schwab, 2015).

Furthermore, according to the ASEAN (Association of Southeast Asian Nations) Charter's Article 1, paragraph 10, the role of education is human resource development which can be achieved through life-long learning, and in science and technology, for the empowerment of the people and to strengthen the ASEAN community (Roy, 2009). However, the journey of concept to reality in Thailand can be a long and bumpy road, with readiness and knowledge in integrated scientific process skills needing an urgent improvement.

Recommendations

1. Research should be developed for courses and activities that promote the skills of the mixed science process. These include experimental skills, hypothesis skills, interpretation skills and conclusion skills, and skills to define and control the variables. Also, further efforts should be given for defining the definitions of the action sequences.

2. Create a curriculum that can help with the development of teachers' ability in content development. Also, thought needs to be given in helping organize teaching activities using multi-media. Furthermore, teachers should make available the measurements and assessments to students with advanced scientific process skills.

3. Future development of teaching activities in integrated science process skills should also be focused on integration with all subjects.

About the authors

Pongsuwat Sermsirikarnjana is a doctoral candidate in the Faculty of Industrial Education at the King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. He received both his BA degree in Science-Chemistry and a MS in Science Education from Naresuan University in Phitsanulok Province, Thailand.

mrpongsuwat@gmail.com

Krissana Kiddee presently teaches graduate level students in measurement and evaluation. She received both her Master of Education and her PhD in Measurement and Evaluation of Education from Thailand's Chulalongkorn University. Prior to this, she studied for her BA in mathematics at Srinakharinwirot University.

kiddee240@gmail.com

Phadungchai Pupat presently teaches graduate level students in measurement and evaluation. He received both his BA degree in Mathematics – Physics and Master of Education in Measurement and Evaluation of Education from Khon Kaen University, which was followed by a PhD in Measurement and Evaluation from Chulalongkorn University.

pdc_2500@yahoo.com

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