European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.583771 Volume 3 │Issue 6 │2017

COMPARISONS BETWEEN TEACHING EFFECTIVENESS IN CORDING TO THE GUIDELINES OF THE STEM EDUCATION AND CONVENTIONAL LEARNING METHODS ON ELECTROCHEMISTRY ISSUE OF SECONDARY STUDENTS AT THE 11TH GRADE LEVEL

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Abstract:
The aims of this research study were to create the instructional lesson plan with the *STEM education* instructional method on *Electrochemistry Issue* of secondary students at the 11[th] grade level in two groups that consisted of 43-conventional students' learning controlling group and 44-STEM education's learning experimental group from Sarakhampittayakom School under the Secondary Educational Service Area Office 26 with the *Random Assignment Sampling* technique was selected with the efficiency of the processing performances and the performance results (E_1/E_2) at the determining criteria as 75/75 to promote students' learning achievements of their the *STEM education method* (STEME) and their *Conventional Learning Method* (CLM). Students' learning achievements of their post-test learning outcomes to their STEME and CLM were compared, students' responses of their science process skills with the STEME and CLM were created, students' solving problem abilities of their post learning outcomes with the STEME and CLM were assessed, and to associate between students' learning achievements of their science process skills to their solving-problems thinking abilities on electrochemistry issue were analyzed. Using the instructional design model with the STEME and CLM innovative lesson plans were administered, students' learning achievements were assessed with the 40-item *Learning Achievement Test* (LAT), students'

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perceptions of their scientific process skills with the 20-item *Scientific Process Skill Test* (SPST), and their solving problem abilities were assessed with the 36-item *Solving Problem Ability Assessment* (SPAA). The results of these research findings have revealed as: students were evaluated to determine performance criteria with the efficiency of the processing performance and the performance results (E_1/E_2) of 77.24/75.18 for the STEME innovation lesson plans, which was higher than standardized criteria of 75/75. Students' learning achievements of their STEME and CLM assessing differences were also found evidence at the 0.001 level, significantly. Students' responses of their scientific process skills of their STEME and CLM were differentiated evidence at the 0.001 level, significantly. Associations between students' learning achievements and their scientific process skills, the coefficient predictive values (R^2) indicated that 37% and 56% of the variance in scientific process skills for the CLM and the STEME, students' learning achievements and their solving problem abilities, the coefficient predictive values (R^2) indicated that 53% and 76% of the variance in solving problem abilities for the CLM and the STEME, and students' solving problem abilities and their scientific process skills, the coefficient predictive values (R^2) indicated that 46% and 72% of the variance in scientific process skills for the CLM and the STEME, respectively. Suggestions that STEM degree holders have a higher income create critical thinkers, increases science literacy, and enables, which students of innovators. Innovation leads to new products and processes. The innovation and science literacy depends on a knowledge base in the STEM areas of a basic understanding of physic prefer than the conventional leaning method (5E Inquiry Model) among Thailand students are lagging behind other developing countries.

Keywords: teaching effectiveness, STEM education, conventional learning method, pretest and posttest designs, scientific process skill, solving problem ability

1. Introduction

As the world moves into the Twenty-First Century, a massive change, along the lines of a global paradigm shift is occurring. It is affecting frames of reference about the ways of life, work, and society, and how they are viewed and organized. There is a big transition of society that at the heart of the transition is the globalization of economic activity, political relations, information, communications, and technology. This transition has major implications for the profession of teaching (Milliken, 2004). Similarly, Hood described the new world as; *"..in the 21st Century we have a much better understanding of how things work, or how they don't work, to a prescribed set of rules. Societies,* *parents, the workplace, students, are all different. So are the problems. The answers, or the rules, need to be different*" (Hood, 1999). Since the production of information has appeared more important than industrial production, the driving force for the 21st century has become the intellectual capital of citizens. To cope with the demands of the 21st century, people need to know more than core subjects. They need to know how to use their knowledge and skills — by thinking critically, applying knowledge to new situations, analyzing information, comprehending new ideas, communicating, collaborating, solving problems, making decisions. Learning skills are cognitive skills that the Partnership defines in three broad categories; information and communication; thinking and problem solving; and interpersonal and self-directional skills (Partnership for 21st Century Skills, 2008). These learning skills and including are as follows; Information and communication skills; Thinking and problem solving skills; and Interpersonal and self-directional skills**.** To follow these elements may not be enough to get successful results. Because of the postmodern instructional design is suitable for the new world. In the postmodern instructional design process, instruction should be designed based on individual needs. Constructivist theory emphasizes the individual learner. In postmodernist view, when developing instruction, instructional designer should focus on the learning process rather than the content or information because information changes rapidly.

2. STEM Education

Students are extremely curious and impressionable, so instilling an interest at an early age could spark a lasting desire to pursue a career in any of these fields. By the time a student is ready to enter the work force, they must have enough knowledge to make invaluable contributions to our nation's STEM education. It is also important that schools have an ample amount of teachers who are experts in STEM, and these subjects should always be considered as high demand subjects. Student learning outcome performances clearly state the expected knowledge, skills, attitudes, competencies, and habits of mind that students are expected to acquire at an institution of higher education. Transparent student learning outcomes statements are; specific to institutional level and/or content level, clearly expressed and understandable by multiple audiences, prominently posted at or linked to multiple places across the other context, to be updated regularly to reflect current outcomes, and to be receptive to feedback or comments on the quality and utility of the information provided.

2.1 What is STEM?

STEM stands for science, technology, engineering, and mathematics. STEM is important because it pervades every part of our lives. Science is everywhere in the world around us. Technology is continuously expanding into every aspect of our lives. Engineering is the basic designs of roads and bridges, but also tackles the challenges of changing global weather and environmentally-friendly changes to our home. Mathematics is in every occupation, every activity we do in our lives. By exposing students to STEM and giving them opportunities to explore STEM-related concepts, they will develop a passion for it and hopefully pursue a job in a STEM field. A curriculum that is STEM-based has real-life situations to help the student learn. Programs like Engineering For Kids integrates multiple classes to provide opportunities to see how concepts relate to life in order to hopefully spark a passion for a future career in a STEM field. STEM activities provide hands-on and minds-on lessons for the student. Making math and science both fun and interesting helps the student to do much more than just learn.

2.2 Why STEM?

In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past (National Science Foundation, 2016).

2.3 Who benefits from STEM?

STEM education helps to bridge the ethnic and gender gaps sometimes found in math and science fields. Initiatives have been established to increase the roles of women and minorities in STEM-related fields. STEM education breaks the traditional gender roles. In order to compete in a global economy, STEM education and careers must be a national priority. Each and every decision made uses an aspect of STEM to understand the implications.

In conclusion, STEM education is critical to help the United States remain a world leader. If STEM education is not improved, the United States will continue to fall in world ranking with math and science scores and will not be able to maintain its global position. STEM education in school is important to spark an interest in pursuing a STEM career in students. However, teachers do not carry the whole burden of STEM education. Parents also must encourage their children to pursue STEM activities and increase awareness and interest at home and in extracurricular activities of the merits of STEM education.

2.4 STEM Education in Thailand

STEM Education is an educational approach that integrates knowledge from four fields: Science, Technology, Engineering, and Mathematics. Teaching STEM in primary and secondary education can help students become interested in STEM careers and build a nation's STEM-educated workforce that can be used to meet the demands of business and industry in a complex and technology-driven economy. Under the Newton Fund, British Council Thailand is working with The Institute for the Promotion of Teaching Science and Technology (IPST) and the Office of Vocational Education Commission (OVEC) to develop STEM Education programme for the national curriculum in Thailand. The programme will support knowledge exchange and partnership opportunities between UK and Thailand and increase the understanding of and engagement with science, technology, engineering, and mathematics in Thailand (British Council in Thailand, 2015).

2.5 The Basic Core Curriculum B.E. 2558 (A.D. 2015) (Draft)

The Basic Core Curriculum B.E. 2558 (A.D. 2015) (Draft) has improved and developed from the original curriculum from the Basic Core Curriculum B.E. 2551 (A.D. 2008) has prescribed a structure of minimum time to be allotted to each subject area for each grade level. Schools are given opportunities to increase learning time allotment, depending on their readiness and priorities. Improvement has been made to the process of measuring and evaluating learners' performance as well as criteria for graduation at each educational level. Adjustment has also been made for streamlining certification which correlates with learning standards, thus facilitating application of certifying documents. From the context of this basic core curriculum problem of learning management in science classroom in physics course is integrated. The problem of achievement of learning management at source has been achieved as low. The Institute the Promotion of Teaching Science and Technology (IPST) has been trying to solve the problems of learning management model with the integration of science education, this is just the beginning. Although there are eight centers, eight centers are located in different parts of the country (Ministry of Education, 2015).

The Institute the Promotion of Teaching Science and Technology (IPST) has been trying to solve the problems of learning management model with the integration of science education, this is just the beginning. Although there are eight centers, eight centers are located in different parts of the country (Ministry of Education, 2015). In terms of the *Learning Standards and Indicators* in science learning core, the learning standards serve as the goals in developing learners' quality, monitoring for internal quality assurance is essential, as it indicates the extent of success in achieving the quality as prescribed in the pertinent standards. Indicators specify what learners should know and be able to perform as well as their characteristics for each grade level, indicators reflect the learning standards with the eights strands with the thirteen science standards. In the context of chemistry contents, they are obtained at the Strand 3: Substances and Properties of Substances; Standard Sc3.1: Understanding of properties of substances; relationship between properties of substances and structures and binding forces between particles; investigative process for seeking knowledge and scientific mind; and communicating acquired knowledge for useful purposes. The keys stage indicators are to experiment and explain properties of solids, liquids and gases, Categorise substances into groups by using their state or other student-prescribed criteria prescribed, Experiment and explain separation of materials through sifting, precipitation, filtering, sublimation and evaporation, Explore and categorise various substances used in daily life by using their properties and utilization for useful purposes as criteria, Discuss selection of correct and safe application of each kind of substance (Ministry of Education, 2008).

2.6 How to Teach Effectively?

In this research study, research team plans to design of the target of our teaching effectiveness. There are some principles of effective teaching that can be applied in virtually any educational situation. However, research team will need to implement them differently, based on whether research team is leading a first grade classroom, teaching a neighbor a new skill, Develop an understanding of the topics research team will be teaching. Research team has to know more than our students do if research team is going to present material to them. In addition, research team should be willing to admit when research team don't know the answer to a question to help the student research the answer if possible, or look it up on our own and answer it later. Earn the trust and respect of our students. This is essential to getting them to listen to what research team has to say and follow our guidance. Try to connect with students on an appropriately personal level. In our school setting, this can be as simple as asking a child about his pets after class. It may be harder, but even more important, to do with resistant students. Understand our students' learning styles. Moreover, our teaching methods to them as much as possible were improved. This is much easier in a small group or one-on-one than it is in a classroom, but it can still be done. Provide visual, auditory, and hands-on activities to meet our students' needs for having a variety of tools and resources available to them.

2.7 The Conventional Learning Method

The main purpose of this research study was to compare of the instructional design model for teaching effectiveness in cording to the guidelines of the STEM education and conventional learning methods. The conventional learning method is designed from the 5E-Inquiry Learning Model that it used to instruct for teaching and learning from the Thai's policy in science classes, which it has followed as the Basic Core Curriculum B.E. 2551 (A.D. 2008). The conventional learning method is an instructional model based on the constructivist approach to learning, which says that learners build or construct new ideas on top of their old ideas. The 5 E's can be used with students of all ages, including adults. Each of the 5 E's describes a phase of learning, and each phase begins with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate. The 5 E's allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning, and to continually assess their understanding of a concept.

Based on as above mentioned concept, the researchers adopted the STEM Education and conventional learning methods to compare and provide academic capacity for learning and promoting scientific creativity in science laboratories of the enable learners to be productive and skilled in their thinking processes. Thus, the model of STEM Education and the conventional learning methods were used to compare of designing teaching and learning was integrated into the model of science experiment of the upper secondary students at the 10^{th} grade level at Sarakhampittayakom School under the Secondary Educational Service Area Office 26 in Maha Sarakham Province in Thailand is the context of research limitation in this study.

3. Methodology

The changing world is called as postmodern world and postmodernism as a main stream philosophical approach spread around the world and become influential. It is affecting frames of reference about the ways of life, work, and society, and how they are viewed and organized. They should know how to use their knowledge and skills. These learning skills can be summarized under the three main subtitles; information and communication skills, thinking and problem-solving skills, interpersonal and self-directional skills. When educational problems are changing, at the same time solution proposals to these problems are also changing. Therefore, to achieve the goals for 21 Century Learning Skills require the new approaches and new methods. Because of as the world changed down to the ground the students also are affected from the change. Prensky (2001) highlights the technology effects on the new students surrounded by characterized the new students with their impact environments. This research study was to design and compare the instructional design models of teaching effectiveness in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level were as research methodology. The target of students' learning activities and their innovation was *Water Battery Invention*.

3.1 Research Aims

1. To create the instructional lesson plan with the STEM education instructional method on the on *Electrochemistry Issue* of secondary students at the 11th grade level with the processing and performance resulting effectives at 75/75 criteria.
2. To compare between students' learning achievements of their learning effectiveness in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level.
3. To compare between students' responses of their scientific process skills to their learning effectiveness in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level.
4. To compare between students' performances of their solving problem abilities to their learning effectiveness in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level.
5. To associate between students' learning achievements of their scientific process skills to their solving problem abilities in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level.

3.2 Research Procedures

Step 1: Creating and Validating the Quality of Innovation and Learning Management Plans

The *STEM Education Innovative Learning Plan* and the *Conventional Learning Lesson Plan* on the Electrochemistry Issue, which consists of 8 learning units, namely; Redox reaction, Redundancy equation, Galvanic cell, Electric potential of the cell, Types of Aliens, Electrolyte cells, Benefits of electrolyte cells, and Technological advances on the principles of electrochemical cells of 8-sub instructional lesson plans in 4 weeks of 12 hours. The *STEM Education Innovative Learning Plan* and the *Conventional Learning Lesson Plan* were assessed the quality and effectiveness by the 5-professional experts with the assessment, the quality, accuracy, suitability, clarity, feasibility, and consistency of the plan instructions.

Step 2: Creating the Learning Achievement Test (LAT)

The 30-item *Learning Achievement Test* (LAT) ***was*** analyzed the relationship between the content and metrics and study the measurement and evaluation guide as a guide for creating quizzes. Creating the quizzes consistent with the content and expected learning outcomes, which are multiple choice types on 50 items to use 40 items, the criteria is to answer the truth answer 1 or wrong answer to 0 points. Taking the LAT to the 3-previous experts who examined the learning plan to determine whether each test met the intended learning objectives and covered the content, consisting of 3 professional experts were assessed to comply with the quality and appropriateness criteria by having the same experts evaluate the consistency of the test with the purpose of learning (IOC), which has consistency criteria, perfectly.

Step 3: Creating the Scientific Process Skill Test (SPST)

The 20-item *Scientific Process Skill Test* (SPST) was analyzed the relationship between scientific process skills and metrics to determine the number of items. Creating a science process skills test is in line with the content and indicators/expected learning outcomes obtained with a multiple choice multiple choice quizzes with 20 items in 4 options. The integrated science process skills test consists of 5 skills, namely; hypothesis skills, Defining operational skills, Skills to define and control variables, Experimental Skills, and Interpretation skills and conclusions. The professional experts were estimated the consistency between the science process skills test and the Index of Item Objective Congruence (IOC).

Step 4: The Solving Problem Ability Assessment (SPAA)

The *Solving Problem Ability Assessment* (SPAA) was analyzed the relationship between problem solving ability and metrics to determine the number of items. Creating the

SPAA to assess the ability to solve problems in accordance with the content and indicators/expected learning outcomes was designed. The SPAA was a subjective one on three scenarios were identified. There were four questions in each of the four scenarios. The four-step of the SPAA was followed as Weir's thinking theory. Three sets of the SPAA were used. Each of the four questionnaire questions consisted of 12 questions, including 12 questionnaires. The Cronbach coefficient alpha coefficient was used to analyze the reliability of the whole of the SPAA.

3.3 Sample

The target group for this research study was the upper secondary educational school students who sat at the 11th grade level which sample size of two groups that consisted of 43-conventional students' learning controlling group and 44-STEM education's learning experimental group from Sarakhampittayakom School under the Secondary Educational Service Area Office 26 with the *Random Assignment Sampling* technique was selected.

3.4 Data Analysis

Using the foundational statistic with percentage, mean, standard deviation for analyzing the basically data was examined. The validity and reliability of research instruments were assessed with internal consistency Cronbach alpha reliability and discriminant validity. Statistically significant was differentiated data to compare with the independent variable t-test and ANOVA results (eta^2). Associations between students' learning achievements of their posttest outcomes and their creative thinking abilities to their perceptions toward their physics laboratory classroom environments with simple and multiple correlations, standardized regression weight abilities and the coefficient predictive value (R^2) were used.

4. Results

Research on comparisons of teaching effectiveness in cording to the guidelines of the STEM education and conventional learning methods on electrochemistry issue of secondary students at the 11th grade level to make connections between past and present learning experiences and Anticipate activities and focus students' thinking on the learning outcomes of current activities were designed. Students should become mentally engaged in the concept, process, or skill to be learned and encouraged learners to assess their understanding and abilities and lets teachers evaluate students' understanding of key concepts and skill development. To create the instructional lesson plan with the *STEM education* instructional method in two groups that consisted of 43-conventional students' learning controlling group and 44-STEM education's learning experimental group. The efficiency of the processing performances and the performance results (E_1/E_2) at the determining criteria as 75/75 to promote students' learning achievements of their *STEM education method* (STEME) and their *Conventional Learning Method* (CLM) were evaluated. Students' learning achievements of their post-test learning outcomes to their STEME and CLM were compared, students' responses of their science process skills with the STEME and CLM were created, students' solving problem abilities of their post learning outcomes with the STEME and CLM were assessed, and to associate between students' learning achievements of their science process skills to their solving-problems thinking abilities on electrochemistry issue were analyzed. Using the instructional design model with the STEME and CLM innovative lesson plans were administered, students' learning achievements were assessed with the 40-item *Learning Achievement Test* (LAT), students' perceptions of their scientific process skills with the 20-item *Scientific Process Skill Test* (SPST), and their solving problem abilities were assessed with the 36-item *Solving Problem Ability Assessment* (SPAA).

4.1 Validity and Reliability of Research Instruments

A. Validity of the STEM Education Innovative Learning Plan

The standardized criteria of the meaning, quality, and appropriateness, ranging from 3.51 to 5.00, are accepted as a learning management plan that can be applied. Professional experts were evaluated the average is 4.20 - 5.00, which is equal, quality and most appropriate. The learning plan can be used.

B. Validity of the Conventional Learning Lesson Plan

The 5-professional experts reported of their evaluation of the ***Conventional Learning Lesson Plan*** of the meaning, quality, and appropriateness, ranging from 3.51 to 5.00, are accepted as a learning management plan that can be applied, and the average value is 3.67 - 5.00, which is equal to quality and most appropriate.

4.2 The Effectiveness of the Innovative Instructional Lesson Plans

To analyze the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method of secondary students at the 10^{th} grade level in physics laboratory environment classes with the processing and performance resulting effectiveness at 75/75 criteria. Table 1 and Table 2 report of the effectiveness of the innovative instructional lesson plans.

Table 1: Score Total, Mean, Standard Deviation, and Percentage for the Effectiveness Innovative Instructional Lesson Plans for the STEM Education Method

Efficiency Type	Total Score	$\bar{X}$	S.D.	Percentage
Efficiency Performance Processes (E_1)	70	54.07	1.60	77.24
Efficiency Performance Results (E_2)	40	30.02	2.61	75.18
The Lessoning Effectiveness (E1/E2) = 77.24/75.18				

N = 44

Table 1 shows the result for the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Method. Effectiveness of lessons during the learning process (E1) reveals of 77.24 and the performance effectiveness (E2) indicate that of 75.18, so the lessoning effectiveness (E1/E2) evidences of 77.24/75.18 over the threshold setting is 75/75.

Table 2: Score Total, Mean, Standard Deviation, and Percentage for the Effectiveness Innovative Instructional Lesson Plans for the Conventional Learning Method

Efficiency Type	Total Score	$\bar{X}$	S.D.	Percentage
Efficiency Performance Processes (E_1)	70	52.23	4.74	74.61
Efficiency Performance Results (E_2)	40	26.19	4.19	65.48
The Lessoning Effectiveness (E1/E2) = 74.61/65.48				

N = 43

Table 2 shows the result for the effectiveness of the innovative instructional lesson plans based on the model of learning management in the *Conventional Learning Method*. The effectiveness of lessons during the learning process (E1) reveals of 74.61 and the performance effectiveness (E2) indicate that of 65.48, so the lessoning effectiveness (E1/E2) evidences of 74.61/65.48 lower than the threshold setting is 75/75.

4.3 Comparisons between Students' Responses of their Scientific Process Skills of their Instructional Activities with the STEM Education and Conventional Learning Methods

Using the 20-item *Scientific Process Skill Test* (SPST) was assessed students' scientific process skills of their instructional activities with the STEM education and conventional learning methods of secondary students at the 10th grade level in chemistry environment classes. Table 3 reports the statistically significance of the difference between students' scientific process skills learning outcomes of their STEME and CLM methods. Using paired comparisons between different assessments of the same SPST as reports in Table 3.

Table 3: Average Mean, Standard Deviation, Mean Difference of the CLM and ATEME Groups for the SPST

Student's Group	N	Total score ($\overline{X}$ =40)	Standard Deviation	Mean Diff.	*t*-Value	ANOVA (eta^2)
CLM Group	43	26.91	4.19	3.09	4.18***	0.64***
STEME Group	44	30.02	2.61			

*ρ < 0.05, **ρ < 0.01, ***ρ < 0.001

In Table 3, students' responses of their scientific process skills to their instructional activities with the STEM education and conventional learning methods were compared. These assessments can be thought of as the STEME and CLM methods. The average mean scores of CLM learning group of 26.91 and the STEME group as 30.02. In most case, the standard deviation for the CLM as 4.19 and for the STEME as 2.61, and the mean difference indicated that of 3.09 were compared. It also provides support the learning management in a STEM Education Method that teacher needed to take differences into conventional learning method that consideration when planning and designing chemistry curriculum in the chemistry classes were assessed with the independent t-test and ANOVA (*eta^2*) significantly ($\rho < 0.001$).

4.4 Comparisons between Students' Responses of their Solving Problem Skills of their Instructional Activities with the STEM Education and Conventional Learning Methods

Using the 36-item *Solving Problem Ability Assessment* (SPAA) was assessed students' of their solving problem abilities to their instructional activities with the STEM education and conventional learning methods of secondary students at the 10^{th} grade level in chemistry environment classes. Table 3 reports the statistically significance of the difference between students' scientific process skills learning outcomes of their STEME and CLM methods. Using paired comparisons between different assessments of the same SPAA as reports in Table 4.

Table 4: Average Mean, Standard Deviation, Mean Difference of the CLM and ATEME Groups for the SPAA

Student's Group	N	Total score ($\overline{X}$ =36)	Standard Deviation	Mean Diff.	*t*-Value	ANOVA (eta^2)
CLM Group	43	27.14	2.33	1.72	3.92**	0.42**
STEME Group	44	28.86	1.75			

*ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

In Table 3, students' responses of their solving problem abilities to their instructional activities with the STEM education and conventional learning methods were compared. These assessments can be thought of as the STEME and CLM methods. The average mean scores of CLM learning group of 27.14 and the STEME group as 28.86. In most case, the standard deviation for the CLM as 2.33 and for the STEME as 1.75, and the mean difference indicated that of 1.72 were compared. It also provides support the learning management in a STEM Education Method that teacher needed to take differences into conventional learning method that consideration when planning and designing chemistry curriculum in the chemistry classes were assessed with the independent t-test and ANOVA (eta^2) significantly ($\rho < 0.01$).

4.5 Associations between Students' Learning Achievements of their Scientific Process Skills and their Solving Problem Abilities Creative Thinking Abilities with the Innovative Conventional Learning Method

Given the potential for students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities with the innovative instructional lesson plans based on the model of learning management in the *Conventional Learning Method* in chemistry, other student, teacher and classroom qualities were explored to determine their relationship with students' perceptions of their SPST and SPAA. Correlation's studies identified significant differences in students' learning achievements and their perceptions according to achievements made etc. In this study, it was also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships as a whole reported in Table 5.

Simple correlation and multiple regressions analyses were conducted to examine whether associations exists between students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities with the innovative instructional lesson plans based on the model of learning management in the STEM Education and Conventional Learning Methods in chemistry. Table 5 shows the correlations between students' learning achievements of their LAT to their SPST and their perceptions of their SPAA with the innovative instructional lesson plans based on the model of learning management in the CLM in chemistry, when using a simple correlation analysis (r). The multiple regressions, R, were 0.62, 0.75, and 0.67 and the predictive efficiency (R^2) of the LAT and SPST, LAT and SPAA, and SPST and SPAA values indicated that 38%, 57% and 72%, of the variances in students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities were attributable to their perceptions of their chemistry classroom environment with the conventional learning method, significantly.

Table 5: Associations between Students' Posttest Achievements for the LAT and their SPST to their SPAA in Term of Simple Correlation (r), Multiple Correlations (R) and Standardized Regression Coefficient (β) for the CLM

Variables	CLM Group		Simple correlation (r)	Correlation Validity (β)	Multiple Correlation (R)	Efficiency Predictive Value (R^2)
	$\bar{X}$	S.D.				
LAT	67.27	10.46	0.19*	0.12*	0.616*	0.379*
SPST	60.69	11.16				
LAT	67.27	10.46	0.41***	0.25**	0.753**	0.567**
SPAA	74.71	6.47				
SPST	60.69	11.16	0.24*	0.23*	0.668*	0.446*
SPAA	74.71	6.47				

N = 43, *ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

4.6 Associations between Students' Learning Achievements of their Scientific Process Skills and their Solving Problem Abilities Creative Thinking Abilities with the Innovative STEM Education Method

Given the potential for students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities with the innovative instructional lesson plans based on the model of learning management in the *STEM Education Method* in chemistry, other student, teacher and classroom qualities were explored to determine their relationship with students' perceptions of their SPST and SPAA.

Table 6: Associations between Students' Posttest Achievements for the LAT and their SPST to their SPAA in Term of Simple Correlation (r), Multiple Correlations (R) and Standardized Regression Coefficient (β) for the CLM

Variables	STEME Group		Simple correlation (r)	Correlation Validity (β)	Multiple Correlation (R)	Efficiency Predictive Value (R^2)
	$\bar{X}$	S.D.				
LAT	75.18	6.50	0.47***	0.42***	0.766*	0.587**
SPST	72.73	10.14				
LAT	75.18	6.50	0.71***	0.68***	0.883**	0.780***
SPAA	86.31	7.23				
SPST	72.73	10.14	0.67***	0.63***	0.828***	0.686***
SPAA	86.31	7.23				

N = 44, *ϱ < 0.05, **ϱ < 0.01, ***ϱ < 0.001

Correlation's studies identified significant differences in students' learning achievements and their perceptions according to achievements made etc. In this study, it was also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships as a whole reported in Table 6.

Simple correlation and multiple regressions analyses were conducted to examine whether associations exists between students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities with the innovative instructional lesson plans based on the model of learning management in the STEM Education and Conventional Learning Methods in chemistry. Table 6 shows the correlations between students' learning achievements of their LAT to their SPST and their perceptions of their SPAA with the innovative instructional lesson plans based on the model of learning management in the STEME in chemistry, when using a simple correlation analysis (r). The multiple regressions, *R*, were 0.77, 0.88, and 0.83 and the predictive efficiency (R^2) of the LAT and SPST, LAT and SPAA, and SPST and SPAA values indicated that 59%, 78% and 69%, of the variances in students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities were attributable to their perceptions of their chemistry classroom environment with the STEM Education method, significantly.

5. Conclusions

This research study was to compare of the teaching effectiveness in cording to the guidelines of the *STEM Education* and *Conventional Learning Methods* on electrochemistry issue of secondary students at the 11^{th} grade level. Because of as the world moves into the 21^{st} century, a massive change, along the lines of a global paradigm shift is occurring. It is affecting frames of reference about the ways of life, work, and society, and how they are viewed and organized. Students are extremely curious and impressionable, so instilling an interest at an early age could spark a lasting desire to pursue a career in any of these fields. STEM stands for science, technology, engineering, and mathematics. STEM is important because it pervades every part of our lives. Everybody also must encourage their children to pursue STEM activities and increase awareness and interest at home and in extracurricular activities of the merits of STEM education. The Institute the Promotion of Teaching Science and Technology (IPST) under the Ministry of Education of Thailand has been trying to solve the problems of learning management model with the integration of science education, this is just the beginning. The Basic Core Curriculum B.E. 2558 (A.D. 2015) (Draft) has improved and developed *Learning Standards and Indicators* in science learning core, the learning standards serve as the goals in developing learners' quality, monitoring for internal quality assurance is essential, as it indicates the extent of success in achieving the quality as prescribed in the pertinent standards.

The principles of effective teaching that can be applied in virtually any educational situation to provide visual, auditory, and hands-on activities to meet our students' needs for having a variety of tools and resources available to students. The conventional learning method is an instructional model based on the constructivist approach to learning, which says that learners build or construct new ideas on top of their old ideas. The 5 E's can be used with students of all ages, including adults. Each of the 5 E's describes a phase of learning, and each phase begins with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate. The instructional designing models of *STEM Education* and the *Conventional Learning Methods* were used to compare of designing teaching and learning was integrated into the model of science experiment of the upper secondary students at the 10^{th} grade level at Sarakhampittayakom School under the Secondary Educational Service Area Office 26 in Maha Sarakham Province in Thailand is the context of research limitation in this study.

5.1 Validity and Reliability of Research Instruments

A. Validity of the STEM Education Innovative Learning Plan

The standardized criteria of the meaning, quality, and appropriateness, ranging from 3.51 to 5.00, are accepted as a learning management plan that can be applied. Professional experts were evaluated the average is 4.20 - 5.00, which is equal, quality and most appropriate. The learning plan can be used.

B. Validity of the Conventional Learning Lesson Plan

The ***Conventional Learning Lesson Plan*** of the meaning, quality, and appropriateness, ranging from 3.51 to 5.00, are accepted as a learning management plan that can be applied, and the average value is 3.67 - 5.00, which is equal to quality and most appropriate.

5.2 The Effectiveness of the Innovative Instructional Lesson Plans

Effectiveness of lessons during the learning process (E1) of the STEME method reveals of 77.24 and the performance effectiveness (E2) indicate that of 75.18, so the lessoning effectiveness (E1/E2) evidences of 77.24/75.18 over the threshold setting is 75/75.

The *Conventional Learning Method*, the effectiveness of lessons during the learning process (E1) reveals of 74.61 and the performance effectiveness (E2) indicate that of 65.48, so the lessoning effectiveness (E1/E2) evidences of 74.61/65.48 lower than the threshold setting is 75/75.

5.3 Comparisons between Students' Responses of their Scientific Process Skills of their Instructional Activities with the STEM Education and Conventional Learning Methods

Using the 20-item *Scientific Process Skill Test* (SPST) was assessed in cording to the STEME and CLM methods, the average mean scores of CLM learning group of 26.91 and the STEME group as 30.02. In most case, the standard deviation for the CLM as 4.19 and for the STEME as 2.61, and the mean difference indicated that of 3.09 were compared. It also provides support the learning management in a STEM Education Method that teacher needed to take differences into conventional learning method that consideration when planning and designing chemistry curriculum in the chemistry classes were assessed with the independent t-test and ANOVA (eta^2) significantly ($\rho < 0.001$).

5.4 Comparisons between Students' Responses of their Solving Problem Skills of their Instructional Activities with the STEM Education and Conventional Learning Methods

Using the 36-item *Solving Problem Ability Assessment* (SPAA) was assessed in cording to the STEME and CLM methods. The average mean scores of CLM learning group of 27.14 and the STEME group as 28.86. In most case, the standard deviation for the CLM as 2.33 and for the STEME as 1.75, and the mean difference indicated that of 1.72 were compared. It also provides support the learning management in a STEM Education Method that teacher needed to take differences into conventional learning method that consideration when planning and designing chemistry curriculum in the chemistry classes were assessed with the independent t-test and ANOVA (eta^2) significantly ($\rho < 0.01$).

5.5 Associations between Students' Learning Achievements of their Scientific Process Skills and their Solving Problem Abilities Creative Thinking Abilities with the Innovative Conventional Learning Method

The correlations between students' learning achievements of their LAT to their SPST and their perceptions of their SPAA with the innovative instructional lesson plans based on the model of learning management in the CLM in chemistry, when using a simple correlation analysis (r). The multiple regressions, R, were 0.62, 0.75, and 0.67 and the predictive efficiency (R^2) of the LAT and SPST, LAT and SPAA, and SPST and SPAA values indicated that 38%, 57% and 72%, of the variances in students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities were attributable to their perceptions of their chemistry classroom environment with the conventional learning method, significantly.

5.6 Associations between Students' Learning Achievements of their Scientific Process Skills and their Solving Problem Abilities Creative Thinking Abilities with the Innovative STEM Education Method

The correlations between students' learning achievements of their LAT to their SPST and their perceptions of their SPAA with the innovative instructional lesson plans based on the model of learning management in the STEME in chemistry, when using a simple correlation analysis (r). The multiple regressions, R, were 0.77, 0.88, and 0.83 and the predictive efficiency (R^2) of the LAT and SPST, LAT and SPAA, and SPST and SPAA values indicated that 59%, 78% and 69%, of the variances in students' learning achievements of their posttest assessment to their scientific process skills and their perceptions of their solving problem abilities were attributable to their perceptions of their chemistry classroom environment with the STEM Education method, significantly.

6. Discussion

The comparisons of teaching effectiveness in cording to the guidelines of the *STEM Education* and *Conventional Learning Methods* on electrochemistry issue of secondary students at the 11th grade level. Research team offers a range of STEM and *Conventional Learning Methods* (the 5E Inquiry Learning Model) related curriculum services from individual course evaluation and redesign to new school curriculum development including capstones and laboratory activities. Master Teachers, Principals, STEM Supervisors offered a range of services based upon research on effective principals, upper secondary school in youth student age motivation theory and classroom evaluation. Our team would be assisted researcher in analyzing root cause factors and designing customized school improvement plans. We randomized control Trials, Quasi-experimental, Qualitative, Mixed-methods. We have conducted a wide-range of independent program/policy evaluations, including both efficacy and effectiveness studies, as well as design experiments that use rigorous feedback to develop an effective program. We are experts in design and data-analysis for experimental and quasi-experimental studies, as well as collection and analysis of survey, interview, and observation data.

Formative and Summative, Proficiency-based, and School Readiness Assessments were associated. Our services range from evaluation and redesign to developing new frameworks to administration, data analysis to developing reporting/feedback systems is provided. Our focus is to inform practice and policy through research tested practices. The team can assist researcher in a data analysis and assessment, curriculum and instruction, project-based learning, professional development in math and science, leadership issues, observation & post-observation conferencing support of our research successfully. To create the instructional lesson plan with the *STEM education* instructional method on *Electrochemistry Issue* of secondary students at the 11th grade level in two groups that consisted of 43-conventional students' learning controlling group and 44-STEM education's learning experimental group from Sarakhampittayakom School under the Secondary Educational Service Area Office 26 with the *Random Assignment Sampling* technique was selected with the efficiency of the processing performances and the performance results (E_1/E_2) at the determining criteria as 75/75 to promote students' learning achievements of their the *STEM education method* (STEME) and their *Conventional Learning Method* (CLM). Students' learning achievements of their post-test learning outcomes to their STEME and CLM were compared, students' responses of their science process skills with the STEME and CLM were created, students' solving problem abilities of their post learning outcomes with the STEME and CLM were assessed, and to associate between students' learning achievements of their science process skills to their solving-problems thinking abilities on electrochemistry issue were analyzed, the results of these research findings are following as Margaret Blackwell (2015) concludes, "*Because technology is predominant across many workplace fields and will continue to be even more so in the future, all children will need to have a comprehensive understanding of STEM regardless of their chosen career paths.*" I agree with that assessment, but not just because technology is going to be predominant across many workplace fields. A good foundation in STEM subjects promotes critical thinking and problem-solving, which are skills that will help anybody face life's challenges better, exactly.

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