



**INSTRUCTIONAL DESIGN MODEL IN ORDER TO THE STEM
EDUCATION FOR DEVELOPING STUDENT'S ACADEMIC
ACHIEVEMENTS AND ATTITUDES TOWARD SCIENCE IN
CHEMISTRY SUBJECT ON THE RATE OF CHEMICAL REACTION
ISSUE OF SECONDARY STUDENTS AT THE 11TH GRADE LEVEL**

**Tiptunya Duangsri¹ⁱ,
Panwilai Chomchid²,
Janpen Phusopha³**

^{1,2}Department of Science Education, Faculty of Education
Rajabhat Maha Sarakham University, Maha Sarakham, Thailand 44000

³Department of Psychology, Faculty of Science and Technology
Rajabhat Maha Sarakham University, Maha Sarakham, Thailand 44000

Abstract:

The aims of this research were to develop an innovative instructional lesson plan based on the model of the STEM Education instructional designing model (STEM Model) with the effectiveness of processing and performance resulting outcomes to be effective (E1/E2) according to the criteria level of 70/70, to compare between students' academic achievements of their pretest and posttest assessments with the STEM Model, to compare between students' academic achievement of their posttest assessment and their standardized criterion of 70% threshold, to assess students' perceptions of their attitudes toward science after the STEM Model were administered, and to analyze the associations between students' academic achievements and their attitudes toward science after the STEM Model were administered, completely. The sample target group consisted of 22 secondary students at the 11th grade level in chemistry class from Mahawichanukul School under the Maha Sarakham Secondary Educational Service Area Office 26 with the purposive sampling technique was selected. Research instruments were composed of an innovative instructional lesson plan based on the concept of the STEM Model on the *Rate of Chemical Reaction* Issue was administered for a total of 16 hours in six weeks, which was reviewed by the 5-professional experts was very high appropriate, the 30-item *Chemistry Achievement Test* (CAT) was assessed, and students' perceptions were assessed and adapted from the original of the 70-item *Test*

ⁱ Correspondence: email tiptunya_aim@hotmail.com, plc71@hotmail.com, toansakul35@yahoo.com.au

Of Science-Related Attitudes (TOSRA) to the 21-item *Science Attitude Assessment Model (SAAM)*. Statistically significant was analyzed with mean, percentage, standard deviation and testing the hypothesis with the Pearson's correlation was used. The results of these research findings that following as: an innovative instructional lesson plan based on the model of the STEM Model with the effectiveness of processing and performance resulting outcomes to be effective (E1/E2) evidence of 78.41/74.24, which according to the criteria level at 70/70. The average means scores of students' academic achievements of their posttest ($\bar{X} = 22.27$, S.D. = 3.18) was a higher than pretest ($\bar{X} = 10.86$, S.D. = 2.57) outcomes, statistically significant was differentiated between their pretest and posttest designs at the level of .05. Comparisons between students' academic achievement of their CAT was a higher than standardized criterion of 70% threshold with the STEM Model, statistically significant was differentiated between their posttest designs and the criterion of 70% threshold at the level of .05, differently. Assessing students' perceptions of their SAAM to the STEM Model indicated that of a high level and Cronbach alpha coefficient value was 0.88, validity. Associations between students' academic achievements and their attitudes toward science after using the STEM Model, the predictive efficiency (R^2) value indicated that 86% of the variances in the CAT to their chemistry class were attributable to their SAAM, relatively.

Keywords: instructional design model, STEM education, student's academic achievements, attitudes toward science, chemistry class

1. Introduction

During World WAR II, a considerable amount of training materials for the military were developed based on the principles of instruction, learning, and human behavior. Tests for assessing a learner's abilities were used to screen candidates for the training programs. After the success of military training, psychologists began to view training as a system, and developed various analysis, design, and evaluation procedures (Reiser & Dempsey, 2012). In 1946, Edgar Dale outlined a hierarchy of instructional models, organized intuitively by their concreteness (Clark, 2009). Skinner's 1954 article "*The Science of Learning and the Art of Teaching*" suggested that effective instructional materials, called programmed instructional materials, should include small steps, frequent questions, and immediate feedback; and should allow self-pacing (Reiser & Dempsey, 2012). Robert F. Magar popularized the use of learning objectives with his 1962 article "*Preparing Objectives for Programmed Instruction*". The article describes how to write objectives including desired behavior, learning condition, and assessment (Reiser & Dempsey, 2012). In 1956, a committee led by Benjamin Bloom published an influential Taxonomy with three domains of learning: cognitive (what one knows or

thinks), psychomotor (what one does, physically) and affective (what one feels, or what attitudes one has). These taxonomies still influence the design of instruction (Wikipedia, the Free Encyclopedia, 2012). The influence of constructivist theory on instructional design became more prominent in the 1990s as a counterpoint to the more traditional cognitive learning theory (Reiser, (2001). Constructivists believe that learning experiences should be "authentic" and produce real-world learning environments that allow the learner to construct their own knowledge (Reiser, (2001). This emphasis on the learner was a significant departure away from traditional forms of instructional design (Reiser & Dempsey, 2012).

Instructional design, or instructional systems design (ISD), is the practice of creating "instructional experiences which make the acquisition of knowledge and skill more efficient, effective, and appealing"(Merrill, Drake, Lacy, & Pratt, 1996). The process consists broadly of determining the state and needs of the learner, defining the end goal of instruction, and creating some "intervention" to assist in the transition. The outcome of this instruction may be directly observable and scientifically measured or completely hidden and assumed.¹² There are many instructional design models, for example; the ISD based on the ADDIE model with the five phases: analysis, design, development, implementation, and evaluation. As a field, instructional design is historically and traditionally rooted in cognitive and behavioral, though recently constructivism has influenced thinking in the field (Mayer, 1992). The concept of learning design arrived in the literature of technology for education in the late 1990s and early 2000s (Conole & Fill, 2005) with the idea that "*designers and instructors need to choose for themselves the best mixture of behaviourist and constructivist learning experiences for their online courses*" Carr-Chellman & Duchastel, 2000). But the concept of learning design is probably as old as the concept of teaching. Learning design might be defined as "*the description of the teaching-learning process that takes place in a unit of learning (e.g., a course, a lesson or any other designed learning event)*" (Koper, 2006). The instructional design model, Guaranteed Learning, was formerly known as the Instructional Development Learning System (IDLS). The model was originally published in 1970 by Peter J. Esseff, PhD and Mary Sullivan Esseff, PhD in their book entitled *IDLS—Pro Trainer: How to Design, Develop, and Validate Instructional Materials* (Esseff & Esseff, 1998). In this research study was designed the instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students in the components of the Guaranteed Learning Model are the following: design a task analysis, develop criterion tests and performance measures, develop interactive instructional materials, validate the interactive instructional materials, and create simulations or performance activities.

The global urgency to improve STEM education may be driven by environmental and social impacts of the twenty-first century which in turn jeopardizes global security and economic stability. The complexity of these global factors reach beyond just helping students achieves high scores in math and science assessments. Focused on previous research studies on the effects of students' academic show empirical evidence on the positive effect on students' performance through the adoption of innovations in the technology of teaching and learning was designed. However, innovations do not affect all teaching models and learning styles equally (Merino and Serradell, 2014). Rather, it depends on some variables, such as the strategy of a school towards the adoption of instructional design models, students' abilities, innovation, physics laboratory instruments and materials are used in the upper secondary educational process by teachers and students. The selection of this research modelology that matches the innovations on instructional lesson plans with the instructional design models from a controlling and the experimental physics laboratory environment inventories, to set-up performed within the STEM education model, and using an empirical model based on structural equations. To predict the research results shows that motivation is the main variable affecting performance of students' foster creativity thinking abilities in physics, to confirm the importance of these factors as a source of educational efficiency.

This research study was to provide participants an awareness of the necessity to prepare students to enter the national and global STEM learning activities, to engage participants in activities focused on the why, what, and how of STEM Education, to develop the lesson plan for sharing this professional development with their STEM professional instructional design for education system in Thailand. STEM education is an approach to teaching and learning that integrates the content and skills of science, technology, engineering, and mathematics. STEM Standards of Practice guide STEM instruction by defining the combination of behaviors, integrated with STEM content, which is expected of a proficient STEM student. These behaviors include engagement in inquiry, logical reasoning, collaboration, and investigation. The goal of STEM education is to prepare students for post-secondary students' achievements and the 21st century workforce. Teacher or student poses a real world problem, complex question, or global issue, students brainstorm potential solutions or construct explanations, to provide time for students to think through the STEM disciplines related to a real world problem or issue, to use students' previous experiences as the basis for explaining concepts, to identify and analyze connections to STEM careers, to encourages students to apply learned concepts and skills in new situations, to demonstrate understanding through performance-based tasks, and to assesses students' knowledge and/or skills, which this instructional design model in order to the STEM education for developing student's

academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students at the 11th grade level.

Academic achievement or (academic) performance is the extent to which a student, teacher or institution has achieved their short or long-term educational goals. Cumulative GPA and completion of educational degrees such as High School and Bachelor's degrees represent academic achievement. Academic achievement is commonly measured through examinations or continuous assessments but there is no general agreement on how it is best evaluated or which aspects are most important of procedural knowledge, such as; skills or declarative knowledge or facts (Ward, Stoker, & Murray-Ward, 1996). Furthermore, there are inconclusive results over which individual factors successfully predict academic performance, elements such as test anxiety, environment, motivation, and emotions require consideration when developing models of school achievement (Ziedner, 1998). Individual differences in academic performance have been linked to differences in intelligence and personality (von Stumm, Hell, & Chamorro-Premuzic, 2011). Students with higher mental ability as demonstrated by IQ tests and those who are higher in conscientiousness (linked to effort and achievement motivation) tend to achieve highly in academic settings. A recent meta-analysis suggested that mental curiosity (as measured by typical intellectual engagement) has an important influence on academic achievement in addition to intelligence and conscientiousness (von Stumm, Hell, & Chamorro-Premuzic, 2011). In this research study integrates of the comparisons between students' academic achievements of their pretest and posttest assessments with the STEM Model on the *Rate of Chemical Reaction Issue* of secondary students at the 11th grade level in chemistry class, and their posttest assessment with their standardized criterion of 70% threshold were analyzed.

Consequently, the promotion of favourable attitudes towards science, scientists and learning science, which has always been a component of science education, is increasingly a matter of concern. However, the concept of an attitude towards science is somewhat nebulous, often poorly articulated and not well understood. This research study offers, therefore, a review of current knowledge about attitudes towards science, what influences there are on their formation, and their impact on subject choice. Using the short version of the *Test of Science Related Attitudes* (TOSRA) (Fraser, 1981; Santiboon and Fisher, 2005) that it used to assesses science-related attitudes along seven dimensions: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science (Fraser, 1981). Fraser developed the survey to measure seven science related attitudes among secondary school students. Fraser based his design on the early work of Klopfer (1971). In his classification system, Klopfer's first scale was called "*Manifestation of favorable attitudes towards science and*

scientists." The TOSRA was used to associate student outcomes and the classroom-learning environment, particularly to add the measure of students' attitudes towards science and achievement. This research study references the extensive of Santiboon and Fisher's work that it was shown high reliability results for modifying version from the origin was all measured to assess changes in students' attitudes toward science and science related science content issues. In this research study, modified of the 21-item *Science Attitude Assessment Model* (SAAM) from the *Test of Science Related Attitudes* (TOSRA) was to assess students' perceptions of their attitudes toward science after the STEM Model were administered, and to analyze the associations between students' academic achievements and their attitudes toward science after the STEM Model were administered.

The principles of development of the brain and multiple intelligences are required to achieve learners' balanced development that has therefore prescribed the following eight learning areas: Thai Language; Mathematics; Science; Social Studies, Religion and Culture; Health and Physical Education; Art, Occupations and Technology; and Foreign Languages. In terms of the Strands and Learning Standards in *Learning Area of Science*, which it contains of eight Strands and 13 Learning Standards. In this research study would be selected at the Strand 3: *Substances and Properties of Substances*: properties of materials and substances; binding forces between particles; changes in the state of substances; solution formation and chemical reaction of substances, chemical equations and separation of substances, and *Learners' Quality for Grade 10-12 graduates* is to understand kinds of important particles that form components of atomic structures, sequencing of elements in the Periodic Table, chemical reactions and writing chemical equations, and factors affecting rates of chemical reaction. In terms of this research study focused on the *Rate of Chemical Reaction Issue* of secondary students at the 11th grade level from the Standard Sc 3.2: Understanding of principles and nature of change in the state of substances; solution formation; reaction; investigative process for seeking knowledge and scientific mind; and communication of acquired knowledge that could be applied for useful purposes (Ministry of Education, 2015).

2. Modelology

The Basic Education Core Curriculum B.E. 2551 (2008) and B.E. 2555 (2012: Draft) is aimed at the full development of learners in all respects - morality, wisdom, happiness, and potentiality for further education and livelihood. The following goals have consequently been set for achievement upon completing basic education at inculcating learners with the following five key competencies: *Communication Capacity, Thinking Capacity, Problem-Solving Capacity, Capacity for Applying Life Skills, and Capacity for*

Technological Application. The Standard Sc 3.2 is obtained indicating standard of learner for understanding of principles and nature of change in the state of substances; solution formation; reaction; investigative process for seeking knowledge and scientific mind; and communication of acquired knowledge that could be applied for useful purposes. The key stage indicators of learners in grade level at 10-12 are focused on Experiment and explain the rates of chemical reactions and factors affecting chemical reactions and apply the knowledge gained for useful purposes. Researcher team was designed of the instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students at the 11th grade level of this research modelology are followed as:

3. Research Objectives

1. To develop an innovative instructional lesson plan based on the model of the STEM Education instructional designing model (STEM Model) of secondary students at the 11th grade level in chemistry class with the effectiveness of processing and performance resulting outcomes to be effective (E1/E2) according to the criteria level of 70/70.
2. To compare between students' academic achievements of their pretest and posttest assessments with the STEM Model on the *Rate of Chemical Reaction Issue* of secondary students at the 11th grade level in chemistry class.
3. To compare between students' academic achievements of their posttest assessment and their standardized criterion of 70% threshold.
4. To assess students' perceptions of their attitudes toward science after the STEM Model were administered.
5. To analyze the associations between students' academic achievements and their attitudes toward science after the STEM Model were administered, completely.

4. Research Procedures

The instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students at the 11th grade level was designed of this research procedures in four steps of research procedures that followed as:

Step I: Created the Lesson Plan of the Instructional Innovation with the STEM Model

The innovative instructional strategies with the STEM education was created and designed on 1 main lesson instructional plan to seven learning activities in 16 hours in four weeks. The Stem Model was improved to assess the quality, accuracy, suitability, clarity, feasibility, application and consistency of plan elements by the 5-professional experts.

Step II: The Quality of an Instructional Innovation of the STEM Model was Checked

In the practicing instructional design, STEM educators lack cohesive understanding of STEM education. Therefore, they could benefit from a STEM education conceptual framework. The process of integrating science, technology, engineering, and mathematics in authentic contexts can be as complex as the global challenges that demand a new generation of STEM experts. Using the instructional innovation with the STEM Model was checked by the advisors and the professional experts with the *Index of Item Objective Congruence* (IOC). Researcher team was selected the STEM Model that it had the high quality of appropriability.

Step III: Created the Chemistry Achievement Test (CAT)

To create the academic achievement represents performance outcomes that indicate the extent to which a student has accomplished specific goals that were the focus of activities in instructional environments, specifically in upper secondary school in Thailand. School systems mostly define cognitive goals that either applies across multiple subject areas. Investigations of curriculum, content, objectives, expected learning outcomes, and lesson plans were created the *Chemistry Achievement Test* (CAT) were assessed students' academic achievements of their pretest and posttest designs. The CAT was tried out with another sample group and proved by the professional experts. The 30-item *Chemistry Achievement Test* (CAT) on the *Rate of Chemical Reaction* Issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed.

Step IV: The Science Attitude Assessment Model (SAAM)

An aim of this study was to explore the psychometric attitudes of the short version of the *Test of Science-Related Attitude* (TOSRA). The 21-item *Science Attitude Assessment Model* (SAAM) from the *Test of Science Related Attitudes* (TOSRA) was developed to measure seven science-related attitude scales: social implications of science, normality of scientists, attitude toward scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, & career interest in science. The SAAM has been extensively field tested and is commonly used in science education research and evaluation. Scores are meant to be interpreted only at the item level, not as

a whole instrument to adapt to the Thai version that it obtained of 21 items (Santiboon and Fisher, 2005) was assessed students' perceptions of their attitudes toward science in chemistry class.

4.1 Target Group

To administer to the target groups in this study, which sample consisted of 22 secondary students at the 11th grade level in chemistry class from Mahawichanukul School under the Maha Sarakham Secondary Educational Service Area Office 26 with the purposive sampling technique was selected in the 2nd semester of academic year 2016.

4.2 Research Instruments

A. The Instructional STEM Education Model (STEM Model)

The instructional design model in order to the STEM education was designed on chemistry learning plan for a main learning lesson plan on the rate of chemical reaction issue, it called *the Instructional STEM Education Model* (STEM Model). The STEM Model obtained of seven learning activities, such as; Definition of the rate of chemical reaction, Concepts about chemical reactions, concentration of substance with chemical reaction, surface area of the substance with the rate of chemical reaction, temperature and rate of chemical reaction, catalysts and chemical retardants, and making Bath Bomb Soap were learning activities in six weeks.

B. The Chemistry Achievement Test (CAT)

The *Chemistry Achievement Test* (CAT) was created to assess students' academic achievements of their pretest and posttest designs. The CAT was tried out with another sample group and proved by the professional experts. The 30-item *Chemistry Achievement Test* (CAT) on the *Rate of Chemical Reaction* Issue was created by the researcher team of 30 optional items in 4 multiple choice options.

C. The Science Attitude Assessment Model (SAAM)

The *Science Attitude Assessment Model* (SAAM) was adapted into the Thai version that it obtained of 21 items (Santiboon and Fisher, 2005) was assessed students' perceptions of their attitudes toward science in chemistry class from the original of 70-Item the *Test of Science-Related Attitude* (TOSRA) (Fraser, 1981).

4.3 Data Analysis

An innovative instructional lesson plan based on the model of the STEM Education instructional designing model (STEM Model) was assessed with the *Index of Item Objective Congruence* (IOC) value by the 5-professional experts. The STEM model was assessed with the *Processing Effectiveness* (E1) and *Performance Resulting Effectiveness* (E2) at 75/75 criteria from the students' academic outcomes and their learning academic

achievements with the average means scores, standard deviation and percentage were analyzed. Students' academic achievements of their pretest and posttest assessments were assessed from the 30-item *Chemistry Achievement Test* (CAT) and their attitudes toward science to their standardized criterion of 70% threshold with the compare means of independent *t*-test analysis. Associations between students' academic 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.

5. Results

This research study was to create the instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students at the 11th grade level were provided. The purposes of this research study were to analyze of the processing performances and the performance results (E_1/E_2) efficiency. Students' academic achievements with the pre-test and post-test designs were assessed. Students' academic achievements of their post-test assessment and their standardized criterion of 70% threshold to their attitudes toward science of were associated. Using the STEM Model lesson plans were managed the instructional activities, the *Pre-Test* and *Post-Test Assessments* were designed, students' academic achievements was assessed with the 30-item *Chemistry Achievement Test* (CAT) were compared, and students' perceptions of their CAT to their SAAM were determined. Statistically significant were analyzed with the Simple and Multiple Correlations, Standardized Regression Weight Validity (β), and Coefficient Determinant Predictive Value (R^2) were associated.

5.1 Validity and Reliability of the Research Instruments

A. The IOC Value of the STEM Model

The STEM Model was created learning plan offers the counselor to verify the content validity for students' academic activities, teaching materials, and evaluation in the learning management plan was corrected as suggested by the advisors and the 5-professional experts with the were reviewed and assessed the validity of content, purpose learning with the IOC value (*Index of Item Objective Congruence*). The evaluation criteria used for the appropriateness will be from the average of 3.51 to 5.00, which is the mean of the quality criteria of the learning management with the STEM Model plan based on the average of the experts' assessment, the research plan developed by the researcher was 4.20 to 4.80, and the acceptable accuracy must have scoring scale ranged

from 0.50 to 1.00. It appears that the research plan developed by the researcher has an average of 4.88, and the total confidence validity value was 0.90; it means as in the most appropriate the highest quality level.

B. Validations of the Chemistry Achievement Test (CAT)

The 30-item *Chemistry Achievement Test (CAT)* on the rate of chemical reaction issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed of student' learning achievements of their pretest and posttest assessments. Using the CAT tests of achievement, the qualifying examination is difficult and the classification criteria for an exam with 30 difficulty settings (P) ranged from 0.45 to 0.65, and discrimination (B) values ranged from 0.21 to 0.67. The reliability of the Lovett's equation was 0.81.

C. Validity of the Science Attitude Assessment Model (SAAM)

Internal consistency (Cronbach alpha coefficient) and the mean correlation were obtained for sample in this present study as indicates of reliability for the 21-item *The Science Attitude Assessment Model (SAAM)*). The Cronbach alpha reliability indicated was 0.88.

5.2 The Effectiveness of Processing and Performance Resulting Outcomes (E1/E2)

To analyze the effectiveness of the STEM Model of secondary students at the 11th grade level in science class with the processing and performance resulting effectiveness at 70/70 criteria was assessed. Table 1 reports of the effectiveness of the innovative instructional lesson plan.

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

Efficiency Type	Total Score	\bar{X}	S.D.	Percentage
Efficiency Performance Processes (E1)	100	78.41	5.25	78.41
Efficiency Performance Results (E2)	30	22.27	3.18	74.24
The Lessoning Effectiveness (E1/E2) = 78.41/74.24				

Table I shows the result for the effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Model. Effectiveness of lessons during the learning process (E1) reveals of 78.41 and the performance effectiveness (E2) indicate that of 74.24, so the lessoning effectiveness (E1/E2) evidences of 78.41/74.24 over the threshold setting is 70/70.

5.3 Students' Academic Achievements of their Pretest and Posttest Designs

To compare between students' academic achievements of their pretest and posttest assessments with the STEM Model secondary students at the 11th grade level in

chemistry class with the 30-item *Chemistry Achievement Test* (CAT) was assessed. Table 2 reports the statistically significance of the difference between students' academic outcomes of their pretest and posttest assessments. Using paired comparisons between different assessments of the same CAT as reports in Table 2.

Table 2: Average Mean, Standard Deviation, Mean Difference for the CAT

Assessing Test	Total score (\bar{X} =30)	Standard Deviation	Mean Diff.	t-Value	ANOVA (η^2)
Pretest	10.86	2.57			
Posttest	22.27	3.18	11.41	36.42***	0.68***

$N = 22$, * $\rho < 0.05$, ** $\rho < 0.01$, *** $\rho < 0.001$

Table 2 reported to identify teachers' contributions to students' academic achievements. These assessments can be thought of as pre-test and post-test designs. The average mean scores of pretest of 10.86 and posttest revealed as 22.27. In most case, the standard deviation for the pretest as 2.57 and for the posttest as 3.18, and the mean difference between pre-tests and post-tests of 11.14 were compared. It also provides support the learning management in the STEM Model that teacher needed to take differences into consideration when planning and designing chemistry curriculum in the chemistry class were assessed with the independent t-test and ANOVA (η^2) significantly ($\rho < 0.001$).

5.4 Students' Post Academic Achievements and Standardized Criterion of 70% Threshold

Students' academic outcomes of their posttest assessments, the average mean scores of the CAT with the 30-item *Chemistry Achievement Test* (CAT) was assessed and the criteria learning outcomes at 70% were compared. Students' responses of their learning outcomes indicated that an average mean score (\bar{X}) = 22.27, standard deviation (S.D.) = 3.18, and percentage of average score = 74.23. The organizing learning activities in STEM education with a criterion of 70% threshold were compared. Table 3 reports of the relationships between students' scientific process skills and the criterion of 70% threshold.

Table 3: The Mean, Standard Deviation, Total Score, the Criteria Score of 70%, Mean Different and Independent Variable t-test for the STEM Model

Students' Number	Total Score	Criteria Score 70%	Mean	S.D.	df	t-test	Sig. (p)
22	30	21.00	22.27	3.18	21	1.88*	.037*

In Table 3 reported that the comparisons of mean scores on students' academic outcomes of their posttest assessments that organizing learning activities in the STEM Model with a criterion of 70% threshold were compared at the 11th grade level with 70% of the 22 students when analyzing the difference using t-test statistics (One-Way ANOVA), it was found that the *t*-test indicated that was 1.88 and statistically significant at the level of .05, differently.

5.5 Students' Perceptions of their Attitudes toward Science

The mean correlation was obtained for sample in this present study as indicates of scale reliability for the 21-item *Science Attitude Assessment Model* (SAAM) that it has 5 optional components and the five response alternatives are: *Almost Never*, *Seldom*, *Sometimes*, *Often* and *Very Often*. The Cronbach alpha reliability indicated was 0.88. Students' responses of their perceptions with the SAAM revealed at a high level ($\bar{X} = 4.34$, S.D. = 6.79).

5.6 Associations between Students' Academic Achievements and their Attitudes toward Science

The potential for students' academic achievements of their posttest assessment to their attitudes toward science with the STEM Model in chemistry class were assessed. Correlation's studies identified significant relationships were also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships as a whole reported in Table 4.

Table 4: Associations between Students' Posttest Achievements for the CAT and their TOSRA in Term of Simple Correlation (*r*), Multiple Correlations (*R*) and Standardized Regression Coefficient (β)

Variables	Mean (\bar{X})	S.D.	Simple Correlation (<i>r</i>)	Standardized Regression Validity (β)	Multiple Correlation (<i>R</i>)	Efficiency Predictive Value (<i>R</i> ²)
Posttest Assessment (CAT)	22.85	2.01	0.6144***	0.9342***	0.9253***	0.8562***
SAAM	4.34	6.79				

N = 22, * $\rho < 0.05$, ** $\rho < 0.01$, *** $\rho < 0.001$

Simple correlation and multiple regressions analyses were conducted to examine whether associations exists between students' academic achievements of their posttest assessment to their perceptions of their creative thinking abilities with the innovative instructional lesson plans based on the model of learning management in a STEM Education Model. Table 4 shows the correlations between posttest assessment (CAT)

and their attitudes towards science. The TOSRA attitudes toward science were relative significantly, when using a simple correlation analysis (r) indicated of 0.6144 and standardized regression validity (β) indicated of 0.9342. The multiple correlation (R) was 0.9253 and the predictive efficiency (R^2) value indicated that 86% of the variances in students' attitudes toward science to their chemistry class was attributable to their post learning achievement in their science. The coefficient of determination denoted R^2 is a number that indicates the proportion of the variance in the dependent variable (CAT) that is predictable from the independent variable (SAAM). It provides a measure of how well observed outcomes are replicated by the STEM education model, based on the proportion of total variation of students' academic outcomes explained by the STEM Education instructional model.

6. Conclusions

To create the instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue of secondary students at the 11th grade level. Academic achievement is commonly measured through examination or continuous assessments with the processing and performance resulting effectiveness (E_1/E_2) of the innovative instructional lesson plans based on the model of learning management. Learning factors are the extent to which a student's individual capabilities can influence their academic or learning performance. This research study has found that students with higher academic performance and persistence demonstrate utilization of intrinsic goals, when compared with students who focus on extrinsic ones. Since publication of an article describing TOSRA (Fraser, 1978), requests for copies of the test have been received from researchers and teachers in different developed and developing countries. Although the TOSRA to design to measure in seven distinct science-related attitudes among secondary school students. However, It was noted previously that modified the SAAM from the TOSRA can be used by teachers or researchers to monitor student progress towards achieving attitude aims: that is, a teacher might employ SAAM to obtain intonation about the science-related attitudes of individual students or, preferably, whole classes. This could be done at one particular time or could involve changes in attitudes occurring over time.

The purposes of this research study were to analyze of the processing performances and the performance results (E_1/E_2) efficiency. Students' academic achievements with the pre-test and post-test designs were assessed. Students' academic achievements of their post-test assessment and their standardized criterion of 70% threshold to their attitudes toward science of were associated. Using the STEM Model lesson plans were managed the instructional activities, the *Pre-Test* and *Post-Test*

Assessments were designed, students' academic achievements was assessed with the 30-item *Chemistry Achievement Test* (CAT) were compared, and students' perceptions of their CAT to their SAAM were determined. Statistically significant were analyzed with the Simple and Multiple Correlations, Standardized Regression Weight Validity (β), and Coefficient Determinant Predictive Value (R^2) were associated.

In terms of the validity and reliability of the research instruments, the IOC value (*Index of Item Objective Congruence*). The evaluation criteria used for the appropriateness will be from the average of 3.51 to 5.00, which is the mean of the quality criteria of the learning management with the STEM Model plan based on the average of the experts' assessment, the research plan developed by the researcher was 4.20 to 4.80, and the acceptable accuracy must have scoring scale ranged from 0.50 to 1.00. It appears that the research plan developed by the researcher has an average of 4.88, and the total confidence validity value was 0.90; it means as in the most appropriate the highest quality level. The 30-item *Chemistry Achievement Test* (CAT) on the rate of chemical reaction issue was created by the researcher team of 30 optional items in 4 multiple choice options was assessed of student' learning achievements of their pretest and posttest assessments. Using the CAT tests of achievement, the qualifying examination is difficult and the classification criteria for an exam with 30 difficulty settings (P) ranged from 0.45 to 0.65, and discrimination (B) values ranged from 0.21 to 0.67. The reliability of the Lovett's equation was 0.81. The 21-item *Science Attitude Assessment Model* (SAAM) that it has 5 optional components and the five response alternatives are: *Almost Never*, *Seldom*, *Sometimes*, *Often* and *Very Often*. The Cronbach alpha reliability indicated was 0.88.

The effectiveness of the innovative instructional lesson plans based on the model of learning management in a STEM Education Model. Effectiveness of lessons during the learning process (E1) reveals of 78.41 and the performance effectiveness (E2) indicate that of 74.24, so the lessoning effectiveness (E1/E2) evidences of 78.41/74.24 over the threshold setting is 70/70. To identify teachers' contributions to students' academic achievements, the district would need assessments at two points in time: before learning begins and at the end of the chemistry course. These assessments can be thought of as pre-test and post-test designs. The average mean scores of pretest of 10.86 and posttest revealed as 22.27. In most case, the standard deviation for the pretest as 2.57 and for the posttest as 3.18, and the mean difference between pre-tests and post-tests of 11.14 were compared. It also provides support the learning management in the STEM Model that teacher needed to take differences into consideration when planning and designing chemistry curriculum in the chemistry class were assessed with the independent t-test and ANOVA (*eta*²) significantly ($\rho < 0.001$).

Focused on comparisons of mean scores on students' academic outcomes of their posttest assessments that organizing learning activities in the STEM Model with a

criterion of 70% threshold were compared at the 11th grade level with 70% of the 22 students when analyzing the difference using t-test statistics (One-Way ANOVA), it was found that the *t*-test indicated that was 1.88 and statistically significant at the level of .05, differently. Correlation's studies identified significant relationships were also considered important to investigate associations that involved simple correlation and multiple regression analyses of relationships. Associations between the students' learning outcomes of their posttest assessment (CAT) and their attitudes towards science were assessed. The SAAM attitudes toward science were relative significantly, when using a simple correlation analysis (*r*) indicated of 0.6144 and standardized regression validity (β) indicated of 0.9342. The multiple correlation (*R*) was 0.9253 and the predictive efficiency (R^2) value indicated that 86% of the variances in students' attitudes toward science to their chemistry class was attributable to their post learning achievement in their science. The coefficient of determination denoted R^2 is a number that indicates the proportion of the variance in the dependent variable (CAT) that is predictable from the independent variable (SAAM). It provides a measure of how well observed outcomes are replicated by the STEM education model, based on the proportion of total variation of students' academic outcomes explained by the STEM Education instructional model.

7. Discussions

Science plays an important role in our present and future world communities, as it concerns all of us in our daily lives and livelihoods. Science also involves technologies, instruments, devices and various products at our disposal, which facilitate our life and work. All these benefit from our scientific knowledge, which is combined with creativity as well as other disciplines. Science enables us to develop our thinking skills in various respects—logical, creative, analytical and critical. It also enables us to acquire essential investigative skills for seeking knowledge, and allows the ability for systematic problem-solving, and for verifiable decision-making based on diverse data and evidences. Science is essential to the modern world, which is intrinsically a knowledge society. All of us therefore need to be provided with scientific knowledge so as acquire knowledge and understanding of nature and man-made technologies that can be applied through logical, creative and moral approaches.

Many global challenges need an international approach supported by further development in science and technology to adequately address these challenges (Thomas & Watters, 2015). Yet numerous educational research studies have indicated that students' interest and motivation toward STEM learning has declined especially in western countries and more prosperous Asian nations. Concern for improving STEM education in many nations continues to grow as demand for STEM skills to meet

economic challenges increasingly becomes acute (English, 2016). Driven by genuine or perceived current and future shortages in the STEM workforce, many education systems and policy makers around the globe are preoccupied with advancing competencies in STEM domains. However, the views on the nature and development of proficiencies in STEM education are diverse, and increased focus on integration raises new concerns and needs for further research (Marginson and et al., 2013).

The global urgency to improve STEM education may be driven by environmental and social impacts of the twenty-first century which in turn jeopardizes global security and economic stability. The complexities of these global factors reach beyond just helping students achieve high scores in math and science assessments. Friedman (2005) helped illustrate the complexity of a global society, and educators must help students prepare for this global shift. In response to these challenges, the USA experienced massive STEM educational reforms in the last two decades. The process of integrating science, technology, engineering, and mathematics in authentic contexts can be as complex as the global challenges that demand a new generation of STEM experts. Educational researchers indicate that teachers struggle to make connections across the STEM disciplines. Consequently, students are often disinterested in science and math when they learn in an isolated and disjointed manner missing connections to crosscutting concepts and real-world applications. The following paper will operationalize STEM education key concepts and blend learning theories to build an integrated STEM education framework to assist in further researching integrated STEM education.

The results of this research study have probably got some ideas of how experiments should be run. Why don't researchers just look at something, poke it with a stick, and then study the changes? Researchers are always making things super complicated. The reason ran a pretest-posttest experiment is to see if your manipulation, the thing that to be able to looking at, has caused a change in the participants. Since student is being manipulated in the same way, any changes and see across the group of participants is likely from the manipulation. This means teachers test them before doing the experiment, then teachers run their experimental manipulation, and then teachers test them again to see if there are any changes. So how does this really work? This is the research designed for assessing students' assessments of their pretest and posttest techniques were compared. In conclusion, most research suggests that extracurricular activities are positively correlated to academic achievement. It has been mentioned that more research could be conducted to better understand the direct of this relationship. Together this information can give us a better understand the exact aspects to consider when considering the impact that participation in extracurricular activities can have on academic achievement (Carlson & Sullivan, 1999).

Information on reliability and validity are provided. If information on a particular psychometric was not found, it is indicated as "no information provided." It should be noted that this is not necessarily an indication of a lack of reliability or validity within a particular scale/instrument, but rather a lack of rigorous testing, for various reasons, by the developers or other researchers. A correlation of at least 0.80 is suggested for at least one type of reliability as evidence; however, standards range from 0.50 to 0.99 depending on the intended use and context for the research instruments are used. In this research study was selected the research instruments, which are validate and reliable of the research instruments, the IOC value (*Index of Item Objective Congruence*). The evaluation criteria used for the appropriateness with the mean of the quality criteria of the learning management with the STEM Model plan based on the average of the experts' assessment, the research plan developed by the researcher was 4.20 to 4.80, and the acceptable accuracy must have scoring scale ranged from 0.50 to 1.00. It appears that the research plan developed by the researcher has an average of 4.88, and the total confidence validity value was 0.90; it means as in the most appropriate the highest quality level. The 30-item *Chemistry Achievement Test* (CAT) was created by the researcher team was assessed of their pretest and posttest assessments. Using the CAT tests of achievement, the qualifying examination is difficult and the classification criteria for an exam with 30 difficulty settings (P) ranged from 0.45 to 0.65, and discrimination (B) values ranged from 0.21 to 0.67. The reliability of the Lovett's equation was 0.81. The 21-item *Science Attitude Assessment Model* (SAAM), the Cronbach alpha reliability indicated was 0.88. Suggestions that these research instruments are appropriability for using them in this research study.

Finally, the proposed conceptual framework must be tested through educational research methods to determine if these concepts improve the teaching and learning of STEM content. A research agenda must be crafted to test theories under a variety of conditions to determine the best approach to integrated STEM. For further investigation in integrated STEM education, researchers need to document in more detail their interventions, curriculum, and programs implemented, especially how subjects are integrated and supported. More evidence needs to be collected on the nature of integration, scaffolding used, and instructional designs applied. Clear outcomes need to be identified and measured concerning how integrated STEM education promotes learning, thinking, interest, and other characteristics related to these objectives.

However, these recommendations were made in the context of the American education system; they could prove helpful in many other countries' educational systems as well, especially in the context of the Thai education system, similarly. Implementations of this research study goals are provided of the instructional design model in order to the STEM education for developing student's academic achievements and attitudes toward science in chemistry subject on the rate of chemical reaction issue

of secondary students at the 11th grade level for enabling learners to learn this subject with emphasis on linking knowledge with processes, acquiring essential skills for investigation, building knowledge through investigative processes, seeking knowledge and solving various problems. Learners are allowed to participate in all stages of learning, with activities organized through diverse practical work suitable to their levels.

References

1. Carlson, L. E., and Sullivan, J. F. (1999). Hands-on engineering: learning by doing in the integrated teaching and learning program. *The International Journal of Engineering Education*, 15(1) 20–31.
2. Carr-Chellman A. and Duchastel P. (2000). The ideal online course. *British Journal of Educational Technology*, 31(3): pp. 229–241, July 2000.
3. Clark, W. B. (2009). *The history of instructional design and technology*. Retrieved from <https://www.slideshare.net/benton44/history-of-instructional-design-and-technology?from=embed>
4. Conole G., and Fill K. (2005). A learning design toolkit to create pedagogically effective learning activities. *Journal of Interactive Media in Education*, 2005 (08).
5. English, L. (2016). STEM education K-12: perspectives on integration. *International Journal of STEM Education*, 3(3): pp. 1–8.
6. Esseff, P. J. and Esseff, M. S. (1998). *Instructional development learning system (IDLS)*. (8th ed.). ESF Press: pp. 1–12.
7. Fraser, B. J. (1981). *TOSRA: Test of science-related attitudes handbook*. Hawthorn, Victoria: Australian Council for Educational Research.
8. Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Farrar, Straus, and Giroux.
9. Klopfer, L.E. (1971). *Evaluation of learning in science*. In B.S. Bloom, J.T. Hastings, and G.F. Madaus (Eds), *Handbook on Summative and formative Evaluation of Student Learning*. New York: McGraw-Hill.
10. Koper, R. (2006). Current research in learning design. *Educational Technology & Society*, 9 (1): pp. 13–22.
11. Marginson, S., Tytler, R., Freeman, B., and Roberts, K. (2013). *STEM: Country comparisons*. Melbourne: Australian Council of Learned Academies.
12. Mayer, R. E. (1992). Cognition and instruction: Their historic meeting within educational psychology. *Journal of Educational Psychology*. 84 (4): pp. 405–412.

13. Merino, D. C., & López, E. S. (2014). [*An analysis of the determinants of students' performance in e-learning*](#). Retrieved on 2014/1/31 from https://scholar.google.com/citations?view_op=view_citation&citation_:2osOgNQ5qMEC
14. Merrill, M. D., Drake, L., Lacy, M. J., and Pratt, J. (1996). Reclaiming instructional design (PDF). *Educational Technology*. 36 (5): pp. 5–7.
15. Ministry of Education. (2015). *Basic education curriculum core B.E.2551 (A.D. 2008)*. Retrieved from <http://www.skn.ac.th/kan2551.htm>
16. Reiser, R. A. (2001). A history of instructional design and technology: Part II: A history of instructional design. *ETR&D*, Vol. 49, No. 2, 2001: pp. 57–67.
17. Reiser, R. A., & Dempsey, J. V. (2012). *Trends and issues in instructional design and technology*. Boston: Pearson.
18. Santiboon, T. & Fisher D. L. (2005). *Learning environments and teacher-student interactions in science classes in Thailand*. Proceedings of the Fourth International Conference on Science, Mathematics and Technology Education Sustainable Communities and Sustainable Environments: Envisioning a Role for Science, Mathematics and Technology Education, Victoria, Vancouver, Canada.
19. Thomas, B., & Watters, J. (2015). Perspectives on Australian, Indian and Malaysian approaches to STEM education. *International Journal of Educational Development*, 45(November 2015): pp. 42–53.
20. von Stumm, S., Hell, B., and Chamorro-Premuzic, T. (2011). The hungry mind: Intellectual curiosity in the third pillar of academic performance. *Perspective on Psychological Science*. 6 (6): pp. 574–588.
21. Ward, A., Stoker, H. W., and Murray-Ward, M. (1996). Achievement and ability tests - definition of the domain. *Educational Measurement*, 2. University Press of America: pp. 2–5.
22. Wikipedia, the Free Encyclopedia. (2012). *Bloom's Taxonomy*. Retrieved from Wikipedia on April 18, 2012 at https://en.wikipedia.org/wiki/Bloom%27s_taxonomy
23. Ziedner, M. (1998). *Test anxiety: The state of the art*. New York: New York: Plenum Press.

Tiptunya Duangsri, Panwilai Chomchid, Janpen Phusopha
INSTRUCTIONAL DESIGN MODEL IN ORDER TO THE STEM EDUCATION FOR DEVELOPING STUDENT'S
ACADEMIC ACHIEVEMENTS AND ATTITUDES TOWARD SCIENCE IN CHEMISTRY SUBJECT ON THE RATE
OF CHEMICAL REACTION ISSUE OF SECONDARY STUDENTS AT THE 11TH GRADE LEVEL

Creative Commons licensing terms

Author(s) will retain the copyright of their published articles agreeing that a Creative Commons Attribution 4.0 International License (CC BY 4.0) terms will be applied to their work. Under the terms of this license, no permission is required from the author(s) or publisher for members of the community to copy, distribute, transmit or adapt the article content, providing a proper, prominent and unambiguous attribution to the authors in a manner that makes clear that the materials are being reused under permission of a Creative Commons License. Views, opinions and conclusions expressed in this research article are views, opinions and conclusions of the author(s). Open Access Publishing Group and European Journal of Education Studies shall not be responsible or answerable for any loss, damage or liability caused in relation to/arising out of conflicts of interest, copyright violations and inappropriate or inaccurate use of any kind content related or integrated into the research work. All the published works are meeting the Open Access Publishing requirements and can be freely accessed, shared, modified, distributed and used in educational, commercial and non-commercial purposes under a [Creative Commons Attribution 4.0 International License \(CC BY 4.0\)](https://creativecommons.org/licenses/by/4.0/).