การพัฒนาทักษะการคิดเชิงวิจารณญาณด้วยวิธีสหวิทยาการ ในหน่วยการเรียนรู้เรื่อง การเปลี่ยนแปลงสภาพภูมิอากาศ สำหรับนักเรียนมัธยมศึกษาตอนต้น

The Development of Critical Thinking Skills with Interdisciplinary Approach on the Climate Change Unit for Lower Secondary Students

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บทคัดย่อ

การวิจัยนี้มีจุดมุ่งหมายเพื่อพัฒนาทักษะการคิดเชิงวิจารณญาณของนักเรียนมัธยมศึกษาตอนต้น โดยการพัฒนาหน่วยการเรียนรู้เรื่อง การเปลี่ยนแปลงสภาพภูมิอากาศ ด้วยวิธีสหวิทยาการ และประเมินผลของการใช้หน่วยการเรียนรู้นี้ การวิจัยและพัฒนาหน่วยการเรียนรู้แบ่งออกเป็น 4 ขั้นตอน ดังนี้ ขั้นที่ 1 สร้างหน่วยการเรียนรู้เรื่อง การเปลี่ยนแปลงสภาพภูมิอากาศ โดยวิธีสหวิทยาการ เพื่อพัฒนาทักษะการคิดเชิงวิจารณญาณ โดยการวิเคราะห์เอกสารและผลงานวิจัยที่เกี่ยวข้อง และประเมินคุณภาพโดยผู้เชี่ยวชาญ ขั้นที่ 2 ขั้นปรับปรุงคุณภาพหน่วยการเรียนรู้ โดยการวิจัยเชิงปฏิบัติการ (action research) กับกลุ่มนักเรียนมัธยมศึกษาปีที่ 1 โรงเรียนเกาะสิเหร่ จำนวน 30 คน โดยได้ทดลองจัดประสบการณ์ตามแผนจัดการเรียนรู้ ขั้นที่ 3 ขั้นทดลองใช้หน่วยการเรียนรู้ โดยการวิจัยเชิงทดลองแบบ Nonrandomized Control group Pretest-Posttest Design และขั้นที่ 4 ขั้นประเมินผลของการใช้หน่วยการเรียนรู้ โดยการวิจัยในครั้งนี้ใช้รูปแบบการจัดกิจกรรมการเรียนรู้ตามรูปแบบ 2(CPA) ซึ่งเป็นรูปแบบการพัฒนาทักษะการคิดเชิงวิจารณญาณที่ผู้วิจัยพัฒนาขึ้น มีขั้นของการจัดการเรียนรู้ 6 ขั้น ประกอบด้วย ขั้นที่1 ท้าทายและทำให้กระจ่าง ขั้นที่ 2 รวบรวมข้อมูล ขั้นที่ 3 ประมวลและประเมินข้อมูล ขั้นที่ 4 ลงความเห็นข้อมูล ขั้นที่ 5 ประยุกต์ใช้ความรู้ และขั้นที่ 6 ประเมินความรู้ กลุ่มตัวอย่างที่ใช้ในการวิจัยครั้งนี้ ได้แก่ นักเรียนชั้นมัธยมศึกษาปีที่ 1 ภาคเรียนที่ 2 ปีการศึกษา 2556 โรงเรียนบ้านทุ่งคา จ. ภูเก็ต ซึ่งมาจากการสุ่มแบบเฉพาะเจาะจงจากห้องเรียนที่มีคะแนนทักษะการคิดเชิงวิจารณญาณไม่แตกต่างกันทางสถิติที่ระดับ .05

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**รองศาสตราจารย์ ดร. อาจารย์ที่ปรึกษาวิทยานิพนธ์ มหาวิทยาลัยศรีนครินทรวิโรฒ

จำนวน 2 ห้องเรียน จากจำนวน 4 ห้องเรียนแบ่งเป็นกลุ่มทดลอง 1 ห้องเรียน จำนวน 35 คน และกลุ่มควบคุม 1 ห้องเรียน จำนวน 35 คน เครื่องมือที่ใช้ในการวิจัยประกอบด้วย แผนการจัดกิจกรรมการเรียนรู้เรื่อง การเปลี่ยนแปลงสภาพภูมิอากาศ โดยวิธีสหวิทยาการ และแบบทดสอบวัดทักษะการคิดเชิงวิจารณญาณที่ผู้วิจัยพัฒนาขึ้นตามแนวทางแบบวัดการคิดเชิงวิจารณญาณของคอร์เนล (Cornell Critical Thinking Test Level X) ข้อมูลที่ได้นำมาใช้วิเคราะห์เพื่อตรวจสอบสมมติฐานงานวิจัยโดยใช้ค่าสถิติ t-test ค่าเฉลี่ยเลขคณิต และส่วนเบี่ยงเบนมาตรฐาน

ผลการวิจัย พบว่า

1) ภายหลังจากการจัดการเรียนรู้ด้วยหน่วยการเรียนรู้การเปลี่ยนแปลงสภาพภูมิอากาศ นักเรียนในกลุ่มทดลองมีทักษะความคิดเชิงวิจารณญาณหลังเรียนสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05

2) นักเรียนในกลุ่มทดลองมีทักษะความคิดเชิงวิจารณญาณหลังเรียนสูงกว่าทักษะความคิดเชิงวิจารณญาณหลังเรียนของกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05

คำสำคัญ : ทักษะความคิดเชิงวิจารณญาณ, วิธีสหวิทยาการ, รูปแบบ 2(CPA)

Abstract

The purposes of the study were to develop critical thinking skills for lower secondary students by developing the climate change unit with interdisciplinary approach and to evaluate the results of the unit implementation on the students' critical thinking skills. The research study was conducted through four steps as follow: Step 1: Establishing the climate change unit with interdisciplinary approach for enhancing critical thinking skills, through synthesizing information from texts, journals, and relevant research reports. After that, the unit was efficiency assessed by experts. Step 2: Improvement of the unit qualities. The unit was modified with action research on 30 students (Mattayomsuksa 1) at Kohsirae School. Step 3: Experiment of the unit. The research design for experiment of the unit is Nonrandomized Control group Pretest-Posttest Design. And step 4: Evaluation of the unit. The 2(CPA) model, the model for enhancing critical thinking skills, was used in the research that consists of 6 steps as follow; step 1: clarification & challenge, step 2: data collection, step 3: judging & processing Information, step 4: inference, step 5: applying knowledge, and step 6: assessment were used in this study. The samples used in the study were Mattayomsuksa 1 students on the second semester of 2013 school year in Banthongkha School. The samples were purposively sampling from two classroom that the critical thinking skills scores of two groups were not different at the 0.05 level of significance. The sample was randomly assigned to form the experimental group (35 students). Another class was the control group (35 students) using the normally learning. The instruments used in the research were the climate change unit with interdisciplinary approach and the critical

thinking skills test that adapted from Cornell Critical Thinking Test Level X. The data were analyzed by using mean and standard deviation. Research hypotheses were tested by t-test.

The results revealed that:

1. The students' scores of experimental group in each critical thinking skill and in total mean score after using the revised unit were statistically higher than the students' mean scores before using the revised unit in the same group at the 0.05 level of significance.

2. The students' critical thinking skills scores after studying the revised unit of experimental group was significantly different at 0.05 level of significance above the students' critical thinking skills scores after studying the climate change without using the revised unit of control group.

Keywords : Critical Thinking Skills, Interdisciplinary Approach, 2(CPA) model

Introduction

According to Thailand's National Education Act of B.E. 2542 (A.D. 1999) and Amendments (Second National Education Act B.E. 2545 (A.D. 2002)) (2003: 13), "The substance of the curricula, both academic and professional, shall aim at human development with desirable balance regarding knowledge, critical thinking, capability, virtue and social responsibility." that conform with a current trend in education stresses that students preparing for the 21st century must acquire a variety of critical thinking skills. What is critical thinking, and why is it so important? The Critical Thinking Community defined critical thinking as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven & Paul, 2007: 1). Critical thinking has also been referred to as metacognition (Tempelaar, 2006) or the process of "thinking about thinking" as defined and originally purposed by Flavell (1979). Critical thinking skills are important because they enable students "to deal effectively with social, scientific, and practical problems" (Shakirova, 2007: 42).

Critical thinking is essential to effective learning and productive living. At the level of practical decision making, Nosich (2005: 29) explained that "critical thinking helps when we are simply trying to deal with ordinary tasks: how to study more effectively, find a strategy when stuck in an airport, decide what kind of cloths to buy" and Paul (1995: 257) said that teaching students intellectual skills is not enough. Students must be educated to think critically in the "strong sense" which is "necessary to moral integrity and responsible citizenship".

Critical thinking requires rigorous intellectual work. It is not easy and nor should it be. Scheffler (1973: 144) wrote "To be reasonable is a difficult achievement. The habit of reasonableness is not an airy abstract entity that can be skimmed off the concrete body of thought and practice". Furthermore, "Educational skill is not instinctive but rather the product of training and experience, leading to a mastery of [intellectual] rules" (Scheffler. 1973: 145).

It is widely recognized nowadays that critical thinking has become a necessary ingredient in all levels of education. Educators and educational policy makers agree that one of the desirable goals of education is that students are able to think critically. In Thailand, many have felt the need to inculcate critical thinking more seriously in educational curricula. Thais have gone so far as to include a clause in the newly promulgated Constitution that a bill on education be passed by Parliament. At the moment the act is being considered by various factors and agencies. The core of the proposed act is the idea that the students be able to think critically and independently. Although there are widespread disagreements on what critical thinking actually is, there is an agreement that it has become very important in the world deluged by huge amount of information (Hongladarom 2002).

Today, the interdisciplinary approach is a key concept to the advancement of school curriculum at all levels. It has now become debated as to whether an interdisciplinary approach is the best course for a curriculum. Though it has many advantages such as expanding student understanding and achievement between all disciplines or enhancing communication skills, it also has disadvantages such as integration confusion and time-consuming curriculum preparation (Jones. 2010: 1).

Interdisciplinary approach to teaching requires planning that looks at the foundational objectives of a number of curriculum areas. Connecting curriculum in the interdisciplinary approach is an efficient way to help teachers deal with knowledge that grows at exponential proportions. A unit of study that uses the interdisciplinary approach enables teachers to teach the whole student and make links between disciplines. One goal for this approach is to give students a more relevant, less fragmented and stimulating experience (Jacobs. 1994: 10).

The purpose of this approach is to dissolve the boundaries of areas of study and encourage learning across the curriculum. Educators must develop a plan where they can see the natural areas for integration and develop thematic units. Student learning outcomes should include a well-rounded education where critical thinking and transfer of knowledge is evident with the school and the outside world.

The climate change provides an integrated and interdisciplinary approach to a true understanding of climate of our planet.

Interdisciplinary is defined as a concept view and curriculum approach that deliberately applies a variety of methodology and language from an array of discipline fields to examine a theme, problem, issue, experience, or topic. An interdisciplinary approach integrates thinking and learning skills and unifies content and process. Climate change education also improves critical thinking skills through interdisciplinary approach. It offers a historical perspective and improves our ability to predict future events. To understand climate processes that affect us now and tomorrow, meteorologists look for evidence of what happened in the past. This connects students to the past, as well as challenges them to think about the future.

Related Theory and Concepts

Development of a Model of Enhancing Critical Thinking Skills: 2(CPA) Model

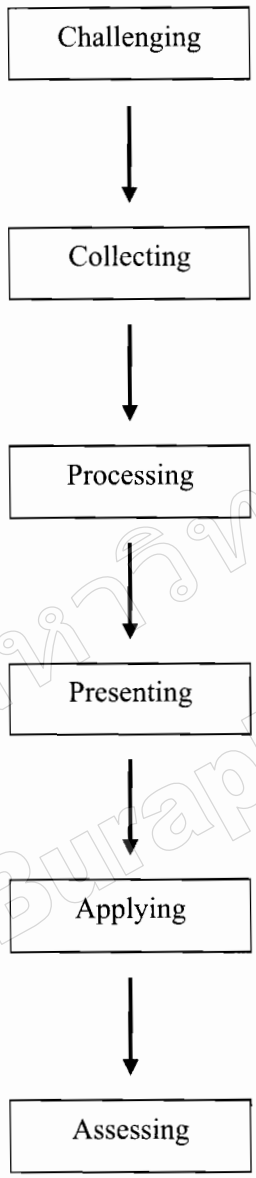
Table 1 summarizes the main processes identified from the literature, showing similarities and differences in approaches to defining the construct of critical thinking. Most of these include five steps: elementary clarification, elementary and advanced/in depth clarification, inference, judgment and strategies or tactics. Different authors have combined the same basic processes in different ways in order to facilitate analysis. The following table contains lists of the critical thinking processes identified by selected earlier authors, shown as steps followed by critical thinkers.

TABLE 1 SUMMARY OF CRITICAL THINKING MODELS

Authors	Steps Proposed				
	Step 1	Step 2	Step 3	Step 4	Step 5
Brookfield (1987)	Identifying and challenging assumptions	Challenging the importance of context	imagine and explore alternatives	reflective skepticism	-
Norris & Ennis (1989)	Elementary clarification	Basic support	Inference	Advanced clarification	Strategies and tactics
Henri (1992) Clulow & Brace Govan (2001)	Elementary clarification	In-depth clarification	Inference	Judgment	Strategies
Garrison, Anderson & Archer (2001)	Triggering events	Exploration	Provisional	Resolution	-
Hare et al. (1998)	Elementary Clarification	In-depth clarification	Inferencing	Judgment	Application of strategies

Researcher considered advantage and disadvantage of critical thinking models in table 1. Researcher adapted and modified them include 6 steps in 2(CPA) Model for enhancing critical thinking skills.

2(CPA) Model



Step 1: Challenging

Here an issue, dilemma, or problem that emerges from experience is identified or recognized. This includes sharing basic information, asking informational questions, rewording a problem statement, and pointing out connections. The teacher will explicitly communicate learning challenges or tasks that become stimuli.

Step 2: Collecting

The purpose of this step is to obtain information to keep on record, to make decisions about important issues, to pass information on to others. Primarily, data are collected to provide information regarding a specific topic.

The most important issue related to data collection is selecting the most appropriate information or evidence to answer questions. To plan data collection must think about the questions to be answered and the information sources available. Also, beginning to think ahead about how the information could be organized, analyzed, interpreted and then reported to various audiences.

Step 3: Processing

Operations performed on a given set of data to extract the required information in an appropriate form such as diagrams, reports, or tables. Students will gather the ideas and determine conclusions. This process also includes identifying the strain of the information, knowledge and ideas to

distinguish the difference of opinion, interpret and explain the problem, and identify the gap between the knowledge and information.

Step 4: Presenting

The process by which a conclusion is inferred from multiple observations is called inductive reasoning. The conclusion may be correct or incorrect, or correct to a certain degree of accuracy, or correct in certain situations. Conclusions inferred from multiple observations may be tested by additional observations.

Students in each group share comments, exchange views with the rules, comment the facts or opinions and seek the best solution that may be consensus or controversy between them.

Step 5: Applying

This step is a process of knowledge creation and application by using the tactics and strategies, applying the solution, the actual and expected conclusion, and creating new knowledge or ideas for the multiple choice answers.

Step 6: Assessing

This step is the process of gathering, analyzing, interpreting and using information about students' progress and achievement to improve teaching and learning. Furthermore, this step is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit and public, setting appropriate criteria and high standards for learning quality, systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards, and using the resulting information to document, explain, and improve performance.

The Cornell Critical Thinking Test Level X

The Cornell Critical Thinking Test Level X (CCTTX) created by Ennis and Millman (1985). It is a multiple-choice test with 71 items and three options that evaluates students' critical thinking ability in applying inductive reasoning and deductive reasoning, evaluating reliability of reports, credibility of statements, and assumptions in arguments. Members of the Illinois Critical Thinking Project have intensively discussed each item and there is agreement that the items in the CCTTX do test critical thinking ability. This is "one basis for content validity." (Ennis, Millman and Tomko 1985: 15) Another basis for content validity claim is that all the answers to the CCTTX can be defended. For the Cornell Thinking Test Level X, the reliability coefficients range from .67 to .90 (Ennis, Millman and Tomko: 1985).

Interdisciplinary Approach

Interdisciplinary is defined as a concept view and curriculum approach that deliberately applies a variety of methodologies and languages from an array of discipline fields to examine a

theme, problem, issue, experience, or topic. An interdisciplinary approach integrates thinking and learning skills and unifies content and process. Students get a range of stimulating and motivating curriculum experiences that engage them in thoughtful confrontation with subject matter while fostering abstract thinking.

Traditionally, disciplines have been viewed as discrete and autonomous. However, this traditional notion of academic disciplines fails to reflect the changing context of higher education (Devlin. 2007: 10). As Squires noted, disciplines are not historically fixed; they evolve and change over time. They are culturally and historically situated. Interdisciplinary recognizes the subtleties of the nature of academic disciplines. There are a number of possible forms that interdisciplinary might take, but there are points of common agreement. Interdisciplinary refers to research or study that integrates concepts from different disciplines resulting in a synthesised or co-ordinated coherent whole. Interdisciplinary is to create a theme to take content from any subject connected with that theme which is sometimes called thematic interdisciplinary studies.

While there are many statistical reports which conclude that students of interdisciplinary techniques have higher test scores in both core knowledge and critical thinking problems, there is also a need for interdisciplinary techniques to better remember basic discipline lessons later in life. In an article titled "Interdisciplinary Instruction", Duerr (2008: 177) explains the importance of an interdisciplinary approach to the life of a student by stating, "With interdisciplinary instruction, students can become more involved in their learning and teachers can work toward eliminating discipline lines. Students can become independent, confident individuals who 'learn how to learn' and develop lifelong learning skills". The interdisciplinary approach is a team-taught enhancement of student performance, an integration of methodology and pedagogy, and a much needed lifelong learning skill. Students who have the skills that interdisciplinary courses provide are so valuable to our future that they are now sought out by colleges and businesses.

Students who are taught with an interdisciplinary technique in which the students master higher order thinking skills and integrated pedagogy become very attractive to top colleges and wealthy business. Youngblood explains that the foundation of interdisciplinary techniques will lead to a future of discovery and innovation. For example, the chemist Willard Libby who discovered radiocarbon dating, applied his findings in Chemistry to the discipline of Archeology and won the Nobel Prize the discovery in 1960 (Youngblood. 2008: 2).

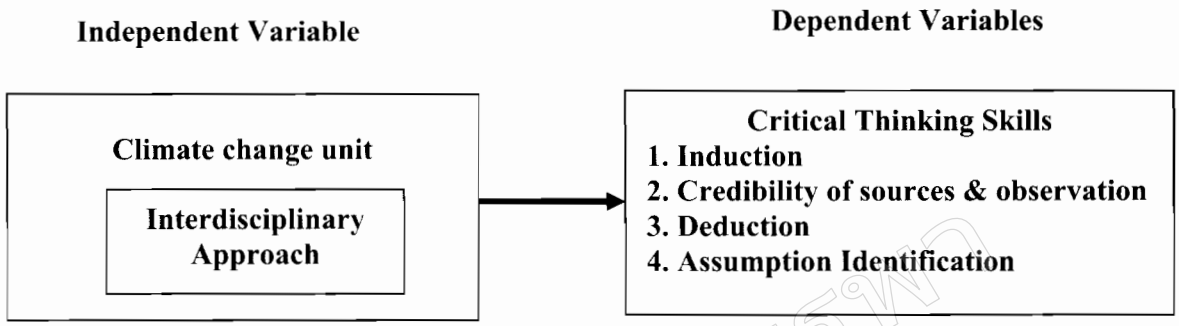
Research Hypotheses

The hypotheses of this study are:

1. Students who learn through the climate change unit have significantly higher post-test scores of critical thinking skills than pre-test scores in the same group.

2. Students who learn through the climate change unit have significantly higher post-test scores of critical thinking skills than students who do not learn in such unit.

Conceptual Framework



Objectives of the Study

The purposes of this study are as follows:

1. To develop a climate change unit to enhance lower secondary students' critical thinking skills

2. To implement the climate change unit to enhance lower secondary students' critical thinking skills

3. To evaluate the critical thinking skills after using the climate change unit on the lower secondary students who are participated in this study.

Research Hypotheses

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2. Students who learn through the climate change unit have significantly higher post-test scores of critical thinking skills than students who do not learn in such unit.

Research Methodology

This research aims to develop climate change unit and instructional plans which emphasize developing critical thinking skills for lower secondary school students.

Sources of Data

Sources of data of the research study included two main stages: 1) field trial study stage and 2) field study stage. Sources of all data are detailed below.

1. Sources of Data of Field Trial Study Stage

1.1 Teacher

A science teacher who teaches science for lower secondary students at Kohsirae School in Phuket province and is trained to teach

students to follow the lesson plans on climate change to develop critical thinking.

1.2 Student

Population

Four classrooms of seventh grade (Mathayomsuksa 1) students who studied science topics in the first semester of the 2013 academic year at Kohsirae School in Phuket province.

Sample

A classroom of seventh grade (Mathayomsuksa 1) students (30 students) who studied science topics in the first semester of the 2013 academic year at Kohsirae School in Phuket province.

2. Sources of Data of Field Study Stage

2.1 Teacher

A science teacher who teaches science for lower secondary students at Banthongkha School in Phuket province and is trained to teach students to follow the lesson plans on climate change unit.

2.2 Student

Population

Four classrooms of seventh grade (Mathayomsuksa 1) students who studied science topics in the second semester of the 2013 academic year at Banthongkha School in Phuket province.

Sample

Two classroom of seventh grade students who studied science topics in the second semester of the 2013 academic year at Banthongkha School in Phuket province. The sample was randomly assigned to form the experimental group (35 students). Another class was the control group (35 students).

Variables

1. Independent Variable

The climate change unit based on interdisciplinary approach

2. Dependent Variables

Critical thinking skills

Research Procedures

Three stages of research procedures to develop the climate change unit with interdisciplinary approach to enhance critical thinking skills for lower secondary students are described as follows:

1. Unit development stage

The unit in this study was developed in five steps: 1) studying the basic information, 2) designing a draft unit, 3) evaluating the draft unit by experts, 4) piloting the draft unit and 5) revising the draft unit. The details of the results of each step are summarized as follows:

Step 1 Studying of the basic information: This step started with studying and analyzing the related documents regarding the unit development. The gathered data were used to indicate the students' prior skills on critical thinking, to guide the selecting of the appropriate climate change content and activities, and to select the appropriate approach and assessments.

Step 2 Designing a draft unit: The analysis of the results of the basic information was used to design the unit components which

consisted of: 1) unit principle, 2) learning outcomes, 3) climate change contents and learning activities, 4) lesson plans and 5) unit assessment and evaluation. All of the draft unit components were developed based on the critical thinking models [2(CPA) model], interdisciplinary approach and critical thinking framework.

Step 3 Evaluating of the draft unit by experts: Before using the draft unit in the pilot study, the quality of the draft unit was evaluated and verified by three experts, namely, a science education teacher, an education teacher, and a teacher who taught climate change, regarding the appropriateness and consistency of the draft unit.

Step 4 Piloting the draft unit: The draft unit was tried out in the pilot study for testing the quality of the draft unit. The draft unit was used as a part of a science course for 7th grade students at Kohsirae School for 10 weeks of the first semester of the 2013 academic year. This unit was designed to have three learning periods per week. The total time using the draft unit was 24 learning periods (8 weeks) for instructing with lesson plans and 4 learning periods (2 weeks) at the beginning and at the end of the draft implementation for gathering data for revising the draft unit.

Step 5 Revising the draft unit: The gathered data from the pilot study were used for revising the draft unit. The draft unit was adjusted for suitable time for doing the activities and revision of the wording of the draft unit and avoiding the ambiguity.

2. Unit implementation stage

The revised unit was implemented for two classes of 7th grade students (experimental and control groups) who enrolled in this study in the second semester in the 2013 academic year at Banthongkha School. The total time for teaching and learning with the revised unit was 10 weeks of 28 learning periods (8 weeks) for instructing with lesson plans and 4 learning periods (2 weeks) at the beginning and at the end of the revised unit implementation for gathering data on the effectiveness of the revised unit. After the revised unit was used, the data for unit evaluation were gathered by using the critical thinking skills test.

3. Unit evaluation stage

The gathered data from the revised unit were of both quantitative and qualitative types. For testing the research hypotheses, the quantitative data were used for analyzing by using the program of Statistic Package for the Social Science (SPSS). The collected quantitative data were analyzed and tested by t-test. For examining other effects of the revised curriculum implementation, the qualitative data were used for analyzing in terms of a content analysis.

Research Results

After revising the draft unit according to the data gathered from conducting the pilot study, the revised unit was implemented as a science course for 7th grade students in the second semester of the 2013 academic year

at Banthongkha School, Phuket province, Thailand. The revised unit was implemented for 8 weeks (3 learning periods a week).

The sample group of the unit implementation was 70 students (two classrooms) who studied science. They were divided into two classes. The first class of 35 students (one classroom) that was the experimental group studied the climate change by following the revised unit on Tuesdays and Thursdays, and the other class was the control group (35 students) studying the climate change without following the revised unit on Mondays and Fridays. During the revised unit, data and information was gathered by using the critical thinking skills test. The gathered data in unit implementation were used for evaluation of the effectiveness of the revised unit by testing the two research hypotheses. The gathered data and results of testing research hypotheses are presented below.

The critical thinking skills test was used to collect data of both experimental group and control group at the beginning and at the end of the class. The students' critical thinking skills mean scores before and after using the revised unit in each question and the results of t-test dependent for pair sample statistics analysis were presented in TABLE 2.

TABLE 2 THE COMPARISION OF THE STUDENTS' CRITICAL THINKING SKILLS MEAN SCORES BEFORE AND AFTER USING THE REVISED UNIT OF THE EXPERIMENTAL GROUP.

Critical thinking skills	Full score	Before using the revised unit		After using the revised unit		$\overline{D}$	t	α
		Mean	S.D.	Mean	S.D.			
1. Induction	23	9.50	2.71	18.42	1.37	8.92	6.62	0.05
2. Credibility of sources & observation	24	10.03	2.85	18.92	1.58	8.89	4.32	0.05
3. Deduction	14	5.34	1.63	9.82	1.00	4.48	2.91	0.05
4. Assumption Identification	10	3.34	1.44	7.53	0.89	4.19	6.00	0.05
Total	71	28.21	4.34	54.68	2.75	25.95	3.63*	0.05

*Level of statistically significant at .05

The students' critical thinking skills score after using the revised unit of experimental group was used for comparing with the students' critical thinking skills score without using the revised unit of control group of the critical thinking skills test by using t-test as shown in TABLE 3.

TABLE 3 THE COMPARISION OF THE STUDENTS' CRITICAL THINKING SKILLS MEAN SCORE OF POST-TEST OF EXPERIMENTAL GROUP AND CONTROL GROUP.

Critical thinking skills	Full score	Post-test scores of experimental group		Post-test scores of control group		$\bar{D}$	t	α
		Mean	S.D.	Mean	S.D.			
1. Induction	23	18.42	1.37	9.43	2.74	8.99	9.61	0.05
2. Credibility of sources & observation	24	18.92	1.58	9.40	3.14	9.52	3.28	0.05
3. Deduction	14	9.82	1.00	5.05	2.25	4.77	8.33	0.05
4. Assumption Identification	10	7.53	0.89	3.33	1.49	4.20	3.27	0.05
Total	71	54.68	2.75	27.20	5.30	27.48	9.36*	0.05

* Level of statistically significant at .05

Summary of the research findings

The gathered results from the revised unit implementation were evaluated for the effectiveness of the unit on students' critical thinking skills by testing two research hypotheses. The results of the unit evaluation after implementation of the unit indicated that:

1. The students' scores of experimental group in each critical thinking skill and in total mean score after using the revised unit were statistically higher than the students' mean scores before using the revised unit in the same group at the 0.05 level of significance.

2. The students' critical thinking skills scores after studying the revised unit of experimental group was significantly different at the 0.05 level of significance above the students' critical thinking skills scores after studying the climate change without using the revised unit of control group.

The results of evaluation on effectiveness of the unit implementation indicated that the climate change unit for lower secondary students enabled students to enhance their critical thinking skills.

Conclusions and Discussions

The result of research indicated that the students' critical thinking skills were improved after studying the climate change unit to enhance critical thinking skills with statistical significance. The research hypotheses were supported because the results of testing research hypothesis found that the students' scores of experimental group in each critical thinking skill and in total mean score after using the revised unit were statistically higher than the students' mean scores before using the revised unit in the same group at the 0.05 level of significance. Also the students' critical

thinking skills scores after studying the revised unit of experimental group were significantly different at the 0.05 level of significance above the students' critical thinking skills scores after studying the climate change without using the revised unit of control group.

1. The findings of students' critical thinking skills were supported by the following:

1.1 This unit with interdisciplinary approach enhanced the improvement of students' critical thinking skills because of using the climate change unit. This result was supported by Repko who stated that interdisciplinary instruction fosters advances in ability of thinking critically and other educational researchers (Kavaloski 1979, Newell 1990, Field et al. 1994, Vess 2009) have identified a number of distinct educational benefits of interdisciplinary learning including gains in the ability to thinking critically.

1.2 The unit in this study was developed by using activities for promoting critical thinking skills. Therefore, this unit was constructed with the integration between the climate change content and critical thinking skills by using the critical thinking model [2(CPA) Model]. This corresponded with Sternberg (1987: 258) who noted that any critical thinking program "must cross disciplines, so that students can see directly the relevance of these [critical thinking] principles across subject-matter areas. This agrees with Toynton (2005: 110) who stated that for enhancing critical thinking, more than one context or one discipline needs to be encountered. If educators insist on including "critical thinking" to the learning outcomes at the program level, he asserts, they should make clear that the development of this skill requires viewing "the approaches, products, and processes" of relevant disciplines "from a detached and comparative viewpoint". Therefore, interdisciplinary instruction fosters advances in critical thinking skills (Repko, 2009: 2).

Recommendations for further studies

There were several recommendations for future studies suggested by the findings of this study as follows:

1. The study should be extended into a larger sample of subject which consists of the different sample characteristics such as low, normal, and high level students. This would allow results to be generalized to the population of the school.

2. The patterns of students' critical thinking skills should be studied for setting the standard level of this ability. It would be useful for a future study of critical thinking skills shift.

3. The interdisciplinary approach and the critical thinking model [2(CPA) Model] should be employed and its effectiveness should be further examined in other science themes or non-science themes.

4. The study found the success of using the interdisciplinary approach to improve

critical thinking skills which was one type of higher-order thinking. Therefore, the future study should be conducted on how to use the interdisciplinary approach for improvement of others types of higher-order thinking such as problem solving and creative thinking.

5. The future studies should investigate students who were taught by this unit to study how they apply their knowledge and critical thinking skills in their life. In addition, the students should be tested several times over a course of at least one year for studying the retention time on students' critical thinking skills.

References

Brookfield, S. (1987). *Developing critical thinkers*. San Francisco: Jossey-Bass.

_____. (2005). *The power of critical theory: Liberating adult learning and teaching*. San Francisco: Jossey Bass.

Devlin, M. (2007). *Improving Teaching in Tertiary Education: Institutional and Individual Influences*. Keynote address at Excellence in Education and Training Convention, Singapore Polytechnic, Singapore, 31 August, 2007.

Duerr, Laura L. (2008). *"Interdisciplinary Instruction, Educational Horizons."* Retrieved August 8, 2011, from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/3e/0c/3a.pdf

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-development inquiry. *American Psychologist*, 34, 906–911.

Garrison, D. R., Anderson, T., and Archer, W. (2001). Critical Thinking, Cognitive Presence, and Computer Conferencing in Distance Education. *The American Journal of Distance Education 15*(1),7–23.

Glaser, E. (1941). *An experiment in the development of critical thinking*. New York: Teachers College Columbia University.

Hannel, G.I., & Hannel, L. (1998). The seven steps to critical thinking: A practical application of critical thinking skills. *National Association of Secondary School Principals Bulletin*, 82 (598): 87-93.

Hare, W. (1998). Critical thinking as an aim of education. *Inquiry: Critical Thinking Across the Disciplines*, 18(2): 38-51.

Hongladarom, Soraj (2002). *Asian Philosophy and Critical Thinking: Divergence or Convergence?* Retrieved April 23, 2014 from http://pioneer.netserv.chula.ac.th/~hsoraj/web/APPEND.html

Jones, Casey (2010) *Interdisciplinary Approach - Advantages, Disadvantages, and the Future Benefits of Interdisciplinary Studies, ESSAI*: Vol. 7, Article 26.

Miller,M.A.,and Badcock,D.E. (1996). *Critical Thinking Applied to Nursing*. Missouri:Mosby-Tear Book.

Norris, S.P., & Ennis, R.H. (1989). *Evaluating critical thinking*. Pacific Grove, CA: Midwest Publications Critical Thinking Press.

Nosich, G. (2005). *Learning to think things through: A guide to critical thinking across the curriculum* (2nd ed.). Upper Saddle River, NJ: Pearson-Prentice Hall.

Repko. (2009). *Assessing Interdisciplinary Learning Outcomes*. Retrieved September 1, 2011, from http://www.uta.edu/ints/faculty/REPKO_Outcomes_AEQ.pdf

Schafersman, S. (1991). *An Introduction to Critical Thinking*. Retrieved July 21, 2010, from http://www.freeinquiry.com/critical-thinking.html

_____. (1997). *An introduction to science: Scientific thinking and the scientific method* (pp. 1-7). Retrieved April 17, 2010, from University of Miami Web site: http://geoweb.tamu.edu/courses/geol641/docs/ScientificMethod.pdf

Scheffler, I. (1973). *Reason and teaching*. New York: Bobbs-Merrill Company.

Scriven, M. (1985). *Critical for survival*. National Forum, 55: 9-12.

Scriven, M., & Paul, R. (2007). *Defining critical thinking*. The Critical Thinking Community: Foundation for Critical Thinking. Retrieved January 2, 2008, Retrieved April 23, 2014 from http://www.criticalthinking.org/aboutCT/define_critical_thinking.cfm

Shakirova, D.M. (2007). Technology for the shaping of college students' and upper-grade students' critical thinking. *Russian Education & Society*, 49(9), 42-52.

Sternberg, R. (1987). Questions and answers about the nature and teaching of thinking skills. In J. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 251-259). New York: W.H. Freeman and Co.

Tempelaar, D. T. (2006). The role of metacognition in business education. *Industry and Higher Education*, 20(5), 291–297

Toynton, R. (2005). Degrees of disciplinarity in equipping students in higher educationfor engagement and success in lifelong learning. *Active Learning in Higher Education*, 6, 2, 106-117.