THE DEVELOPMENT OF LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS ON "PROPERTIES OF MATTER" AND "DESIGN AND TECHNOLOGY" FOR HIGH SCHOOL STUDENTS IN THAILAND

A DISSERTATION

BY

YUPADEE SENKAO

Presented in partial fulfillment of the requirements for the

Doctor of Education degree in Science Education

at Srinakharinwirot University

May 2005

The Dissertation titled

"The Development of Learning Units Integrated between Science and Career & Technology Subjects on "Properties of Matter" and "Design and Technology" for High School Students in Thailand"

by

Yupadee Senkao

has approved by the Graduate School as partial fulfillment of the requirements for the Doctor of Education degree in Science Education of Srinakharinwirot University

..... Dean of the Graduate School

(Assistant Professor Dr.Pensiri Jeradechakul)

Date... May, 20 2005

Oral Defense Committee

..... Chair

(Dr.Manat Boonprakob)

..... Co-advisor

(Associate Professor Dr.Supaluk Prachayasittikul)

..... Co-advisor

(Dr.Pramuan Siripunkaew)

..... Reader

(Dr.Chinda Tambunchong)

..... Reader

(Dr.Chachawan Surasawadi)

ACKNOWLEDGEMENTS

I would like to thank the Institute for Promotion of Teaching Science and Technology (IPST) for supporting my doctoral studies at Srinakharinwirot University. I am grateful for accepting the importance of science education and the support for my endeavor to become a good teacher in this field.

My great appreciation goes to Dr.Manat Boonprakob as my major advisor Associate Professor Dr.Supaluk Prachayasittikul and Dr.Pramuan Siripunkaew my dissertation committee for their valuable advice, Professor Dr.John W. Moor, co-adviser at University of Wisconsin-Madison, USA and Associate Professor Dr.Prayong Pongthongchareon, former Director of Science Education Center, Srinakharinwirot University for their guidance, encouragement and consideration which implemented to the successful completion of this research and my doctoral studies. They were willing to give consultancy and suggestion and help examine defects by paying attention to me consistently until this research completed well. I would like to express my sincere thank to all of them.

I would like to thank Dr.Chinda Tambunchong and Dr.Chachawan Surasawadi my readers for their valuable suggestions; Assistant Professor Dr. Chanthanee Indrasuta for editing the final draft of this research study and also thank to Professor Dr.Peter W. Hewson for his advice and assistance during my stay at University of Wisconsin-Madison, USA.

I would like to thank the President of Rajabhat Valaya-Alongkorn University, the Dean of Faculty of Science and Technology and my colleagues for their support.

I would like to thank the experts, examiner of learning unit quality and instruments, Associate Professor Dr.Somsan Wongyounoi, Associate Professor Dr.Prasert Sripairote, Associate Professor Dr.Sunee Hemaprasit and Dr.Sompratana Wongboonnuk from Srinakharinwirot University, Mrs.Sriluck Pholwattana from Benjamarachalai School, Dr.Chachawan Surasawadi and Mr.Ouppagarn Jeeraphanthu from the IPST for their suggestion in learning unit development and evaluation, examination and correction the questionnaires, the evaluation form, the opinion test and the achievement test which used in this research. I would like to thank the principal, the head of science and career &

technology subject groups and the staff at Surasakmontri School for their assisstance. Special thanks to Mrs. Sirimane Lawasuit and Mrs. Oradee Wipasvong and the students at Surasakmontri School for their collaboration in the research performance until this research was completed well, and also all science and career & technology teachers for their information by answering the questionnaires.

During the study process, many dear friends have provided will power especially in rough moments. I hope they all know how much I have appreciated their kindness.

Finally, I would like to thank my mother, and my cousins who encouraged and supported me for studying consistently. All their support has significantly supplied to acquiring this goal. I would like to remind of teachers' favor, offering the knowledge to me since former to present time with my great respect.

Yupadee Senkao

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

Chapter Page

LIST OF TABLES

TABLE PAGE

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF TABLES (continued)

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER 1
INTRODUCTION

Background

Thailand's Education Reform:

Education is a major component in the development of human resources in Thailand. Research studies carried out over the last decade by Thailand's Ministry of Education (MOE) have identified numerous problems throughout its primary and moderate educational systems. Some of the problems identified by the MOE include the following:

1. The formulation of curriculum by central authorities neither reflect nor respond to the needs of educational institutions in the provinces and the society.
2. Curriculum and learning development in mathematics, science and technologies fail to produce leaders in these fields. It is believed that improvements in the teaching and learning procedures will enhance skills, creativity, and proper attitudes among Thai people.
3. The application of curriculum fails to foster the foundations of critical thinking, to create life long management skills, and to enable learners to effectively tackle fast changes in social and economic areas.

Because of the severity of these problems, Thailand's Ministry of Education (MOE) implemented the new National Education Act B. E. 2544 (MOE. 2001). The new education act aims at the full development of the Thai people: physical and mental health; intellect; knowledge; morality; integrity; and a desirable way of life in harmony with other people. Some important provisions of the act are described.

- Education shall be based on the principle that all learners are capable of learning and self development.
- Participation from local authorities and communities in the management of education will be encouraged.
- The nation will be strengthened by enhancing the quality of manpower and the creation of jobs.
- All segments of societies (temples, schools, families, etc.) will be encouraged to participate in the continuous development of knowledge.

- The reform of the entire curriculum; through the creation of national standards, development of student-centered teaching-learning strategies, instructional materials, and assessment tools.
- The Basic Education Committee from the MOE will be responsible for developing a national core curriculum.
- All schools (urban, rural) will draw from the national core curriculum to design their own curricula incorporating community needs and the individual student differences.
- All schools will organize activities that draw upon students actual experiences.
- All schools will be responsible for assessing learners' performance through observation of their development, personal conduct, learning behavior, participation in activities, and results of the tests accompanying the teaching- learning process.
- Teachers, instructors, and administrators must use their roles to promote and encourage learners to acquire knowledge using various media and student-centered teaching- learning strategies.

(MOE.2001: 2-3).

The new curriculum

The researcher uses the above provisions as guidelines to develop the dissertation. The focus of the dissertation is to develop teaching-learning approaches that emphasize the application of problem-solving to everyday life situations including an approach that integrates scientific knowledge with the process of technology relevant to the topic "Properties of Matter" using inquiry based and problem - solving strategies.

There are a variety of teaching strategies with primary emphases on actual teaching-learning situations such as, self learning, group learning, learning from nature and integrated learning. Teachers should apply different approaches and methodologies that focus on individual learner's total development. The integration involves the teaching-learning of all subjects, for example, management of environment preservation and development, thinking, and scientific analysis. A basic definition is offered by Humphreys (Humphreys; Post; & Ellis. 1981: 11) as "An integrated study is one in which children broadly explore knowledge in various subjects related to certain aspects of their environment." Such integration of different subjects and learning procedures is stipulated by common goals and focuses on learner centered approach.

According to the National Education Act B.E. 2542 (known as the Basic Education Curriculum. 2001), the curriculum shall be based on "unity in policy and diversity in practice." It is a twelve-year core curriculum, which is flexible, provides core content areas, learning standards, and benchmark for each grade level. The core curriculum includes only subjects required for improving the quality of Thai life, good citizenship, life skills, careers, and further education (MOE. 2001: 3). To achieve this end, educational institutions have to prepare institutional curricula in each subject group appropriate to local environment as specified by the standard established by the MOE.

The core content areas are assembled into eight areas: 1) Thai language, 2) mathematics, 3) science, 4) social studies, 5) religion and culture, 6) health and physical education, 7) art, career and technology, and 8) foreign language. Instructional strategies are to integrate the eight areas throughout the 12 years of schooling.

The new curriculum was implemented through out the country in the year 2003. Presently Thai schools need to satisfy national standard that incorporates local needs.

It has been an immense challenge for the district schools to meet the goals set by the Ministry of Education. This research study will assist district schools and teachers to meet the national goals by 1) designing and implementing a science learning unit related to "Design and Technology" and "Properties of Matter" and 2) designing and implementing student achievement assessment tools.

According to the national standards, there are eight areas of science which include 1) living beings and life existence processes, 2) life and environment, 3) properties of matter, 4) forces and mobility, 5) energy, 6) evolution of the earth, 7) astronomy and space, 8) nature of science and technology. Within the content area of "career and technology" are the categories of a) family welfare, b) house work, c) career, d) design and technology, and e) information technology.

The Thai MOE encourages all teachers to use problem-solving and inquiry approaches in the classroom. Student-centered instruction is characterized by pedagogical technique as inquiry. Inquiry is balanced with other classroom activities–class discussion, reading and problem-solving, basic activities to introduce the skill, as does the preferred

approach for harmonizing different teaching strategies (Layman. 1996: 34). These strategies have been shown to be effective for promoting understanding of science. Problem-based learning has as its organizing center the ill-structured problem. In this approach teachers assume the role of cognitive and meta-cognitive coach rather than knowledge holder and disseminator; students assume the role of active problem solvers, decision-makers, and meaning -makers rather than passive listeners.

In addition, career and technical education provides not only job skills, as it did throughout the 1900s, but also higher order thinking, problem solving, and collaborative work skill (Camp & Doolittle. 1999). Furthermore, students can examine understandings of science by various processes from international and local learning resources, think critically and make decisions in choosing appropriate data to solve the problems. This is also link between local knowledge and scientific process that can be applied in everyday life experiences to hopefully create scientific careers. This dissertation includes problem-solving as one of its emphases. "Properties of matter" and "Design and Technology" with emphasis on problem-based learning is focused in this study.

In teaching science, problem solving of teaching-learning processes which involve cooperative learning has been shown to require higher-order thinking skills. Science-technology education can help students integrate what they learn in classes by combining content knowledge concerning a variety of technologies, thereby gaining a deeper understanding of the process of designing and evaluating technologies that comes only through experience. Students should learn technological processes which include the identification of problems, and the development and evaluation of solutions, as well as the scientific process. One reason that the researcher is interested in studying integrated curriculum (Properties of Matters and Design and Technology) is that it helps reduce repetition of content, including problem-based learning activities that encourage active learning and the analysis of technological process for problem-solving in daily life.

This study used a curriculum development model that was developed and used in Thailand. The six-step curriculum development model is discussed in more details in Chapter 3. The six steps are the following:

1. Basic data for diagnosis of needs

2. The development of learning unit outline
3. The examination of learning unit outline
4. Pilot study
5. Field experiment of integrated learning units
6. Evaluation and improvement

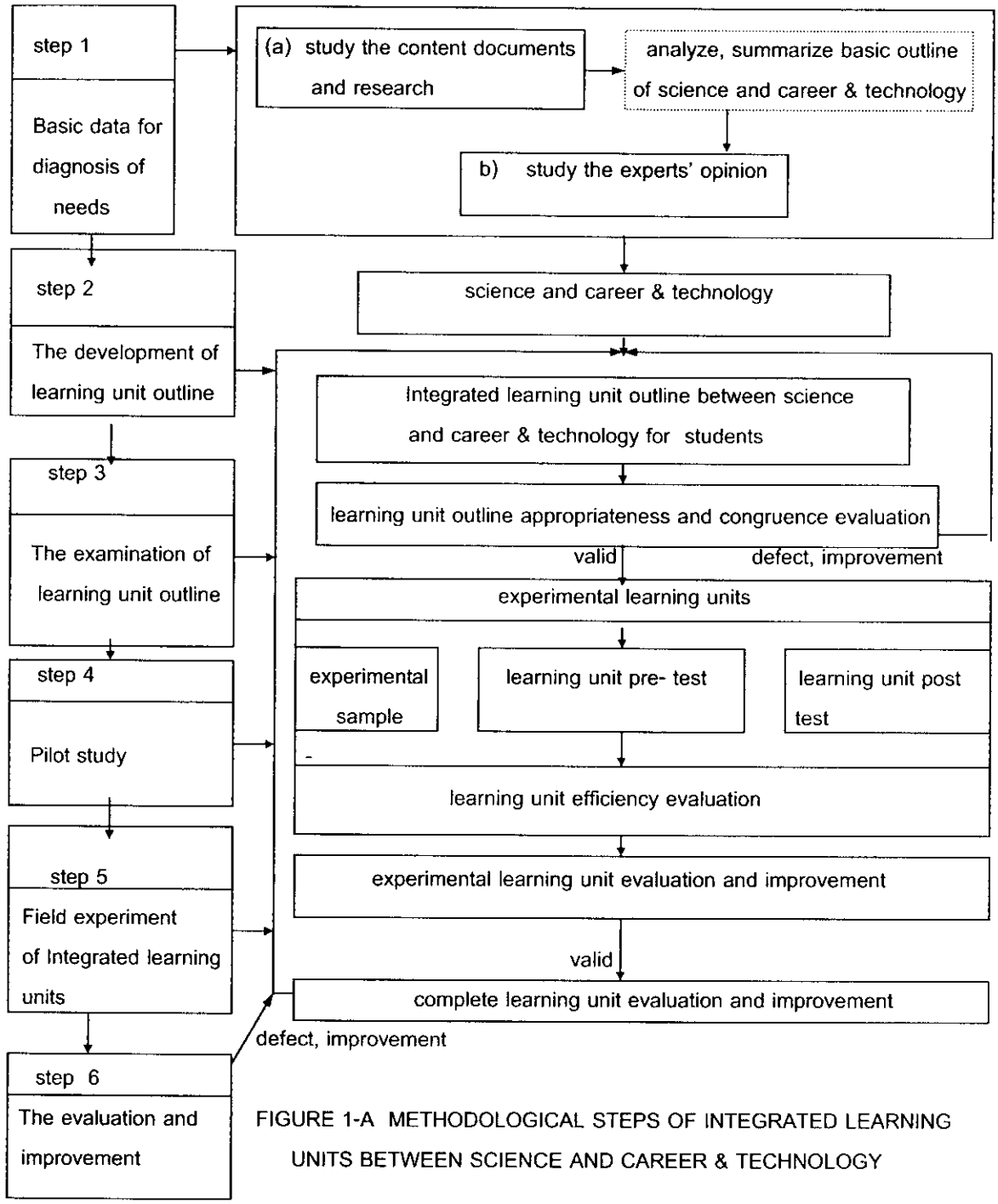


FIGURE 1-A METHODOLOGICAL STEPS OF INTEGRATED LEARNING UNITS BETWEEN SCIENCE AND CAREER & TECHNOLOGY

Purpose of the Study

The main idea behind this study is to develop efficient learning units integrated between science and career & technology subjects on "properties of matter" and "design and technology" for high school students. Furthermore, it is to identify completely learning essential components of the learning units such as problems and needs of learning unit,

goals of learning unit, principle of learning unit, objectives of learning unit, matter of learning unit, teaching-learning activities, teaching-learning materials, measurement and evaluation.

The purposes of this study are summarized as follows:

1. To develop learning units integrated between science and career & technology subjects on "Properties of Matter" and "Design and Technology" at the high school level
2. To assess students' achievement and performance on the concepts and process of science and technology
3. To assess teachers' opinions toward integrated learning units
4. To assess students' opinions toward integrated learning units.

Research Questions

This study organizes the data collection and analysis around the following four questions:

1. How well have "Designing and Technology" and "Properties of Matter" been integrated?
2. What are the students' achievement on the concepts and process of science and technology?
3. What are the students' opinions toward the learning units?
4. What are the teachers' opinions toward the learning units?

Significance of the Study

This study attempts to acquire the learning units integrated between science and career and technology subjects on "properties of matter" and "design and technology" at the high school level. The results of this study should assist teachers and students to have good opinions toward the integrated learning units and to extend the outcome of research and learning unit development to other subjects.

Limitations of the Study

Population

The population of this study consists of science and career & technology teachers and students in grade ten at Key Stage 4 (Mathayom Suksa 4).

Samples

The subjects were 83 students of the science program in grade ten at Key Stage 4 who were studying in the second semester of the academic year 2004 at Surasakmontri School in Bangkok Thailand.

Variables of the Study

The integrated approach to problem-based learning in science and career & technology is the only independent variable. The dependent variables, on the other hand are composed of the following factors.

1. Achievement, cognition and application
2. Teachers' opinion
3. Students' opinion

Subject content

1. Science learning units

The content consists of learning materials which is based on standards for the MOE's Science learning unit for grade ten: "Students will be able to observe, investigate, discuss and explain chemical reactions that are involved in daily life including products from chemical reactions which affect life and environment".

2. Career and technology units

The content of this unit is described. "Students will be able to understand the nature and process of technology, to think systematically of knowledge and imagination in designing, creating, developing and improving the inventions. Students will be able to use these technologies in their future professional or vocational life." The learning unit is an integrated unit covering both "Designing and Technology" and "Properties of Matter".

Definition of terms

1. **The development of integrated learning unit** means an approach of science

teaching-learning development in high school by integrating science and career & technology learning units according to curriculum development process that consists of the following:

1) Basic data for diagnosis of needs

2) The development of learning unit outline

3) The examination of learning unit outline

4) Pilot study

5) Field experiment of integrated learning units

6) Evaluation and improvement

2. **Integration** means a construction of learning units as the following:

1) To bring together scattered topics that are related

2) To encourage students to think critically and apply experience, ability and skills

3) To improve students' attitude about the study

4) To eliminate repetition in the subject content

5) To encourage students to work together and report on an environment and society.

In this research, an integration between science subject content and technological process using problem-based learning in teaching learning activity is studied.

3. **Technological process** means problem solving methods in response to human needs. It consists of seven steps.

1) Identify the problem, need or want

2) Collection of useful information to develop possible solutions

3) Selection the best possible solution

4) Planning of detail design and conduct

5) Testing to see if it works

6) Modification and improvement

7) Assessment the product

4. **Design** means the thought and imaginary process to the steps that are brought to the problem solving plan (MOE.2001).

5. **Teaching learning classroom activity** covers the following:

1) Any student-centered learning activity that is congruent with the aims of learning units, the study purpose and the scope of the contents.

2) Goals for students which are integrated scientific knowledge with process of technology to be used in daily life and scientific career.

3) Teaching learning activity for the students is outlined.

3.1 Problem solving activities that link scientific knowledge to teaching-learning methods is problem-based learning. The problem is used to encourage students to practice critical thinking skill.

3.2 Unit subjects of technological contents are analyzed and used to promote progress of technology.

6. **Parallel model** means a parallel model of integration in which integrated learning units of science and career & technology using properties of matter core content as a unifying theme is employed. The parallel model of integration in this study is characterized as follows:

1) Teachers use problem situations from scientific knowledge to effect integration between the two subjects, to plan together and emphasize the teaching of theme / concept / problem.

2) Teachers collaborate to make decisions about theme / concept / problem for each subject.

3) Teachers implement the theme / concept / problem together.

Hypotheses

1. The efficiency of the learning units integrated between science "Properties of Matter" and career and technology "Design and Technology" had efficiency according to the criterion.

2. The achievement mean scores of science and career & technology of students after the experiment of the integrated learning units are higher than the achievement mean scores of the same samples before the experiment.

3. The opinion mean scores toward integrated learning units of teachers after the experimental implementation of learning units are higher than the opinion mean scores of the same samples before the experiment. .

4. The opinion mean scores toward integrated learning units of students after the experimental implementation of learning units are higher than the opinion mean scores of the same samples before the experiment. .

CHAPTER 2
REVIEW OF THE LITERATURE

This chapter focuses on the exploration of educational literature and research related to this research project. The related five main topics and some subtopics are as follows:

1. The Integration:
   - 1.1 Concepts of integration
   - 1.2 Integrated curriculum category
   - 1.3 Integrated curriculum model
2. Career and technology:
   - 2.1 Concept of career and technology
   - 2.2 Learning substance of career and technology
   - 2.3 Design and technology
3. Problem-based learning:
   - 3.1 Concept of problem-based learning
   - 3.2 Assessment within problem-based learning
   - 3.3 Problem-based learning assessment instrument
4. Research related to integration to science and career and technology
5. Research related to problem-based learning

1. The Integration

1.1 Concept of integration

In this section a discussion of how the notion of integration has been conceptualized by researchers and educators will be reviewed. Researchers in the United States have written about the notion of an integrated curriculum. Thai educators have drawn upon some of this research but have also expanded upon this research and applied it to their local student needs.

From various concepts and definitions of integration expressed by both Thai and Western educators, conclusion for the concept of integration is that it is a learning process

that links many subject matters together to be complete and holistic. It makes students gain the experiences and development (Tyler. 1949: 85; Taba. 1962: 298; Jacobs. 1989: 27; ThongYoo Kaeosaiha. 2000: 4; Tirachai Pooranachote. 2000: 13).

The reason for promotion of integration is that all things in real life are not limited to be related only to any special subject matter. Instructional provision of integration will help connect the concepts of many subjects and help the transfer of learning. Integrated curriculum helps reduce repeated subject matters. Therefore, it responds to learners' various abilities in several aspects and is suitable for constructivism. Furthermore, there are the needs to learn and link learning across disciplines, strategies and forms of thinking are different within and across the subject matters. Thus there is no only single approach that is suitable for every discipline (Johnsen. 1994: 37; & Tirachai Pooranachote. 2000: 14; & Beane, James A. 2002).

1.2 Integrated curriculum category

In general the word "integrated curriculum" and "interdisciplinary curriculum" are interchangeable. Integration is divided into two kinds by educators; Firstly, single subject integration, learners can apply their skill and knowledge by bringing matter within the same subject to connect to real life. Secondly, it is the integration between two or more subjects with the same theme. This type of integration will help learners gain knowledge and understanding in a holistic way and they could apply their knowledge to solve the problem with deep understanding (Anchalee Sarnratana. 1999: 29; & Teerachai Pooranachote. 2000: 13).

1.3 Integrated curriculum model

Integration is assigned to many models by educators for applying to instruction. In this study the researcher is interested in using the model of curriculum integration that is "Parallel model".

In parallel model at least two teachers from different subject areas must plan together to identify the common elements and determine how the concept, theme and problem will be addressed in each subject area. Parallel model is also referred to as a

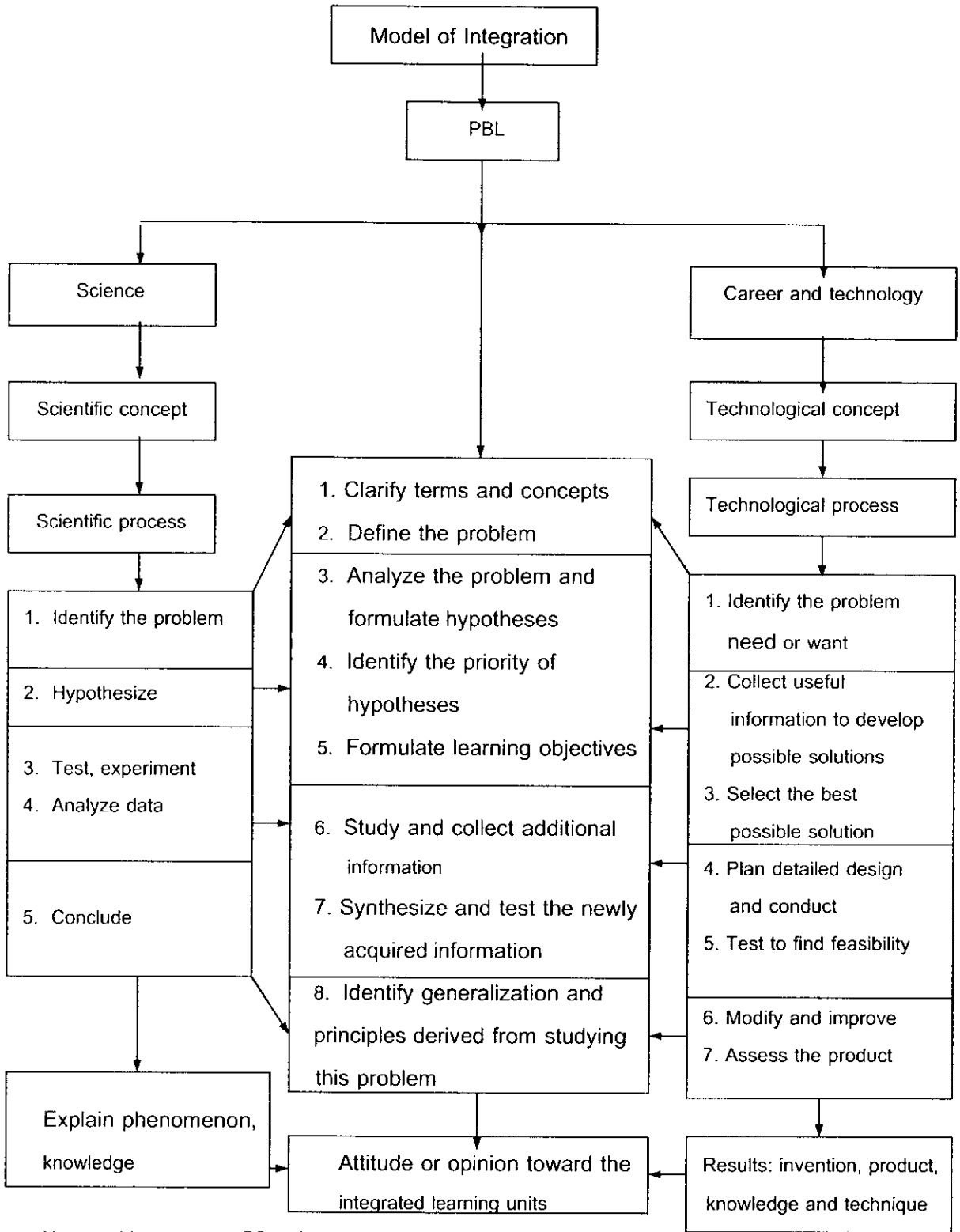
threaded model when each discipline focuses on the same theme or problem during the same time block at school. Homework and assignments commonly vary by subject area, but all reflect the common theme, project, problem, and concept being addressed (Teerachai Pooranachote. 2000: 15-16; Anchalee Sarnratana. 1999: 29-30).

For this study "Parallel model" will be employed in an integrated learning units between science "properties of matter" and career and technology "design and technology" at the high school level by using the core matter of science "properties of matter". It is the integration of both content and instructional process by using problem-based learning (PBL) approach.

Models of "Parallel" include three styles of the following:

First, teachers use the problematic situation from scientific knowledge to integrate between two planned subjects and emphasize theme, concept and problem together. Second, teachers will collaborate to make a decision to identify how to teach the topic, concept and problem in each subject. Third, each teacher will implement the preceding topics, concepts and problems in their class. This type of curriculum integration can be summarized and shown by Figure 2-A

Integration by parallel instruction between science and career and technology by PBL



Use teaching strategy, PBL of two subjects that cover some concepts and processes of science and technology

FIGURE 2-A PARALLEL MODEL OF INTEGRATION

The above figure shows the model of teaching of two subjects being taught along to the process of each subject, but brought to connect for the harmony between scientific process in science course and technological process in career and technology subject by integrating PBL process with scientific process and technological one.

2. Career and technology

2.1 Concept of career and technology

Career and technology is a subject which has a major role in enhancing the development of children to better end, especially in intellectual aspect. In the classroom technology will promote critical thinking, improve writing skill, increase the learning opportunity and performance learning that include expertise in working skill and career. Career and technology is useful for knowledge creation through the process of problem solving. It makes us discover an approach for problem solving. It combines knowledge of many subjects together. Thinking process, design, invention and accumulation of human experiences are the processes that create technology. (Chuangchote Phunthuwech. 1999 : 3 ; & Dillon. 2001)

In the past we were often used to "science and technology", but currently the technological education is assigned to combine with career course; thus resulting in subject in career and technology to keep abreast with the rapidly changing world.

2.2 Learning substance of career and technology

Learning substance and standards, comprising the improvement of life quality of learners after graduation at basic education level. Educational institutions may respond to the need of learners' capacity, aptitude and interest. Details of substance and standards of career and technology are as given below:

1) Living and family life
2) Career
3) Design and technology
4) Information technology
5) Work and career technology

This study emphasizes design and technology in the following:

Understanding the nature of technology and technological procedures; applying knowledge, wisdom, imagination, and systematic thinking to technological strategies and procedures; making creative decisions about technological choices to up-grading life, social activities, environment, work and the professional world. (MOE. 2001 :15, 25-26)

2.3 Design and technology

Over twenty years ago, the U.S., England and Wales first advocated the idea that technology should be part of everyone's basic education because technology has a major role in enhancing to developing children to the better end especially in intellectual ability. In the classroom technology will promote critical thinking, improve writing skill, increase the learning opportunity and performance learning that include expertise in working skill and career.

Technology involves the application of knowledge or the implementation of various science together. It is the integration of many branches of knowledge such as resources, materials, tools and information for solving problem, design, production, and using products, structures (physical and social), and systems to extend human capability to control and modify natural and human-made environment. Technology education leads technologically literate citizens, enables young people to consider a wide range of careers in the high-performance workplace. (Chuangchote Bhunthuvech. 1999:15-16; The National Science Foundation. 1994)

So, technological process is related to solving problem, creative thinking, curriculum design for bringing invention and performance to respond human need. Furthermore, it is to increase the performance efficiency, problem solving method and design including research and development, investigation, invention and design and resource implementation.

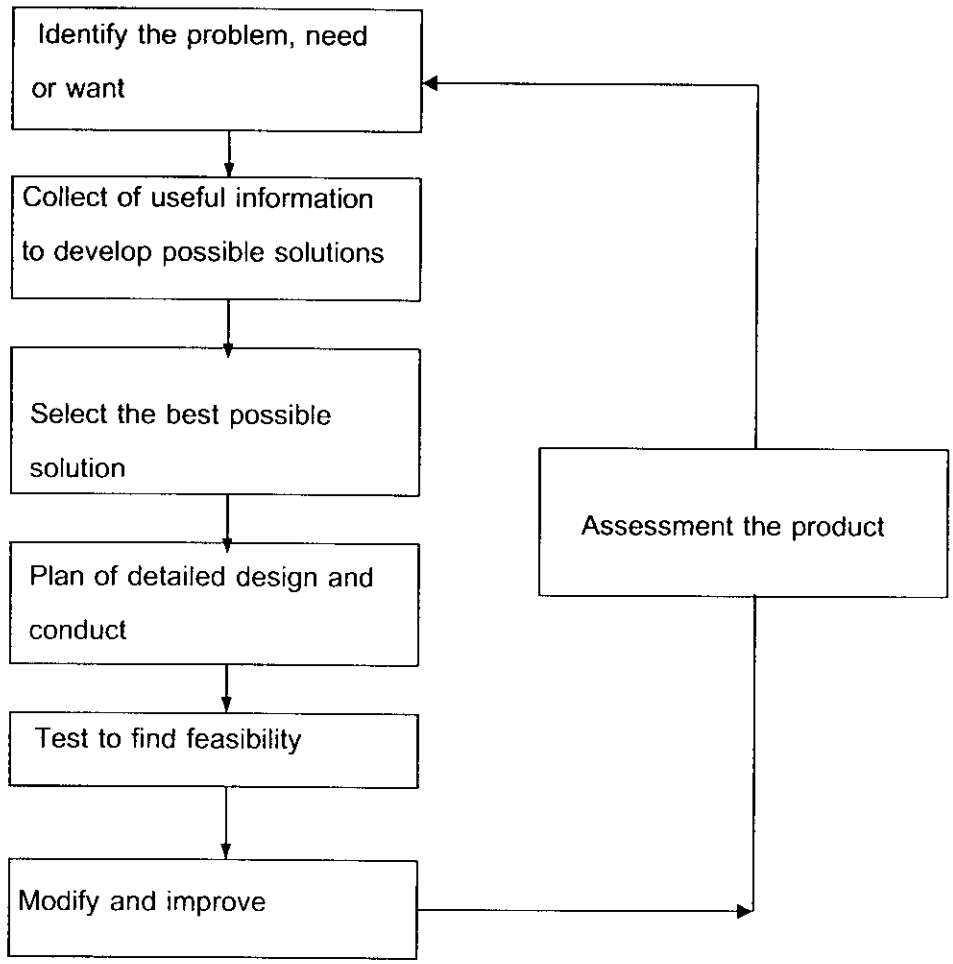


FIGURE 2-B MODEL OF PROBLEM SOLVING PROCESS AND DESIGN

Human beings should have ability and status to apply knowledge, materials, energy, equipment, methodology, and technical skills through problem solving processes and design for use in problem solving and design in order to produce effective performance, benefits, and new products as well as new technological process. Thus, teaching and learning about technology should also use a problem-solving process and design.

Design and technological process is the process of opinion being transferred to form a model, creation for invention, production, and creation of objects and new products that passed through the problem-solving process. So, problem-solving process and design includes seven following steps as shown in Figure 2-B.

1. Identify the problem, need or want, This step starts with studying for understanding, stipulating and identifying the problem from a fixed situation. At the end of the step the components and data for implementing a solution to the problem will be determined.

2. Collect useful information to develop possible solutions, Explore, find, or create various alternative solutions to the problem and bring them to the performance and activity.

3. Select the best possible solution, Bring the data from step 1 and step 2 to select the solution method.

4. Plan of detailed design and conduct, Use the knowledge, theory, concept and solution outline to design the invention.

5. Test to find feasibility, Test the invention for accuracy and examine the efficiency of the invention.

6. Modify and improve, This step is the study of feedback to know defects for improvement before implementation.

7. Assess the product, In this step, students draw conclusions about learning principles and ideas from problem-solving in given situations, which can then be presented and communicated to others.

3. Problem-based learning (PBL)

3.1 Concept of problem-based learning

In this section a summary of how the notion of problem-based learning being conceptualized by educators will be reviewed.

Problem-based learning is an approach to create and develop problem solving skills and teaching/learning strategy for students to acquire skills and knowledge (Barrows; & Stepien. 1985 ; Boud; & Feletti. 1997).

In this research study, problem-based learning will be used as guideline in the teaching-learning arrangement to develop the process of technology as illustrated in Figure 2-C.

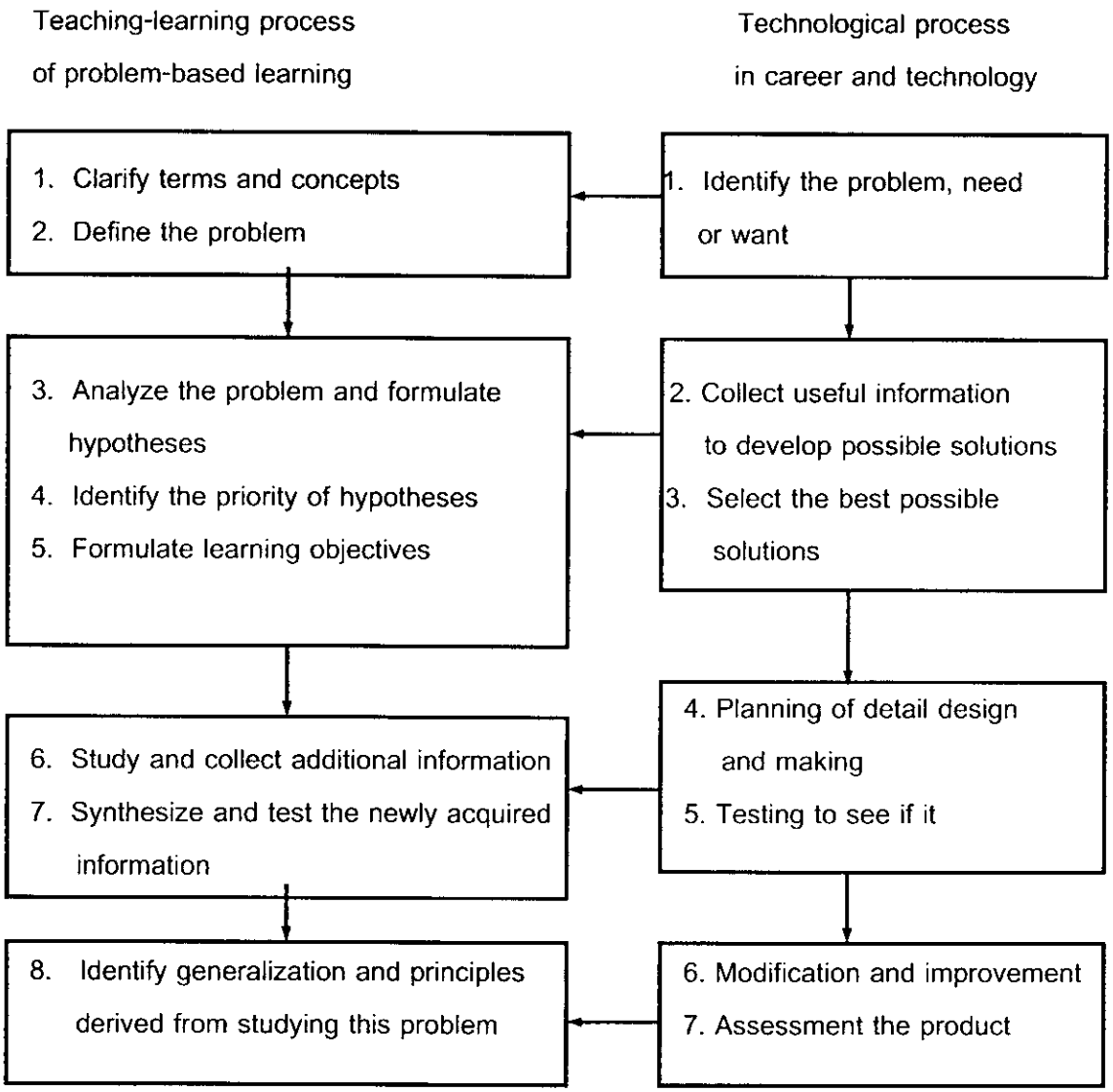


FIGURE 2-C STEPS OF TEACHING-LEARNING ARRANGEMENT OF PBL CONNECT TO TECHNOLOGICAL PROCESS

The figure illustrates the model of teaching two subjects along the process of each subject, but the process of PBL is used to connect the harmony scientific process in science subject and technological process in career and technology subject by integrating PBL process with the scientific process and the technological one. Figure 2-C shows the process of PBL comprising eight steps (Bubpha Makesrithongkum. 2002: 105-106) as follows:

1. Clarify terms and concepts
2. Define the problem

3. Analyze the problem and formulate hypotheses
4. Identify the priority of hypotheses
5. Formulate learning objectives
6. Study and collect additional information
7. Synthesize and test the newly acquired information
8. Identify generalization and principles solving derived from studying this problem

3.2 Assessment In PBL

Assessment In PBL focuses on process variables such as self-directedness, motivation, effort, problem-solving and attitude assessment methods. Process of assessment methods focuses on three kinds as follows:

Tutor, peer and self-ratings generally emphasize assessment of a wide range of skills, including self directed learning, group collaboration and communication skills. Tutor and peer focus on co-workers who evaluate each other. Self-ratings are based upon judging the state of one's own knowledge as an essential element of the learning process. (Swanson et al. 1997 : 271)

3.3 Problem-based learning assessment instrument

The evaluation method should be appropriate with the teaching method and the assessment instruments that are used in the implementation of PBL. There are several types of PBL assessment instruments. They are self-assessment, peer assessment, reports, facilitator / tutor assessment, multiple choice questionnaire (MCQ), modified essay questions (MEQ), triple-jump assessment adjusted from a publication of MacMaster Medical School as shown below:

Multiple Choice Questions (MCQ)

MCQ will be used in this study for evaluating student behavior focussing on higher order thinking and problem-solving which is a part of the achievement assessment. MCQ lessens the risk of student going back to memorizing texts. However some schools provide MCQ to enable students to integrate the knowledge they have learned from many subjects. MCQ has the merit in random use of content extensively, having high reliability,

and unambiguous scoring. (MacMaster Medical School. 2001; Swanson. 1997: 276)

Research related to integration of science and career and technology

The preceding research studies are provided as examples of experiences that can meet the integration of needs to develop career and technology.

Nantanat Jirasuksa. (2001) conducted the thesis on " A Study of Learning Achievement on Substance and It's Change by Using Integrated Teaching Method called Science-Technology-Society for Mathayomsuksa 4 Students." Samples were Mathayomsuksa 4 Students during the first semester of the 2001 academic year at Yothinburana School. The experimental group was selected by simple random sampling and included fifty two students. This group was taught by using Integrated Teaching Method called Science-Technology-Society (STS). The randomized experimental group pretest-posttest design was employed for this experiment. The data was statistically analyzed by t-test for dependent samples. It was found that students who were taught by STS Approach before and after chemistry learning achievement were significantly different at .05 level. In addition, their problem solving abilities on Chemistry before and after treatment were significantly different .05 level.

Ellyn (2002 : Abstract) studied on "Exploratory Art Technology Project at Hadley Junior High School" which was planned to assist middle school students notice the associations between the fine art concepts they have learned and can adapt those concepts to the world of work. To start the project, Hadley Junior High School teachers created partnerships with local businesses that use technologies like photography, desktop publishing, video, laser imaging and computer generated imaging. Students conducted site-visits to these businesses. Employees of these businesses have prepared presentations that exposed the function of technology in contemporary art processes. Teachers associated with the program also developed a curriculum that extended learning beyond the initial site visits. Units of the Exploratory Art Technology curriculum had also been revised to include connections to the Illinois Learning Standards, SCANS, National Professional Teaching Standards for Career and Technical Education, and to use in the place of work.

Peoria (2002 : Abstract) studied "Junior Achievement of Central Illinois (JACI)" that encouraged people to realize the value of free enterprises, businesses and economics. The partnership has developed from an easy array into a chronological learning program that began in Kindergarten and pursued the students through the eighth grade year. The programs together with business volunteers increased the social studies curriculum. JACI's Unique Approach unified program materials, training and support. By supplying this support, JACI had been the flourishing association between education and business. In this association Concordia utilized to organize students for the work for the world of work. The students came in contact volunteers from various diverse career fields and the active contact between volunteers and the students encouraged active learning and brought theory to life. Students at Concordia achieved to study the components of the free enterprise system so they could meet the needs of a fast-paced economy and guarantee their quality of life. Leaders from JACI suggested that the partnership helped motivate a new age group to learn the basics of economics and arrang those students to go into the work world with a stronger educational foundation.

Morris (2002) studied "The Construction Trades Fair" at Grundy Area Vocational Center which was established to offer career opportunities within the creation trades. The eighth grade students were chosen in order to fix the seeds early adequate to be included into the decision-making processes of the young participants former to their selection of a high school course of study. Three hundred students in the area, teachers, administrators and counselors joined the fair. Upon arrival, the participants were positioned into smaller groups of 10-15 each and rotated through as many stations as possible. While rotating through the various stations, participants were laying brick, leveling concrete, wiring circuits, tying rebar, and rotated to other practical activities. Students who were registered to the career and technical training programs were supported the areas demonstrated at the Trades Fair. GAVC instructors were stimulated to view the event as schedules allowed. Due to the success of the first Trades Fair, the 2002 Trades Fair has been stretched to two days in an endeavor to supply the experience for all eighth grade students in the country.

From the aforementioned research, it can be summarized that educators used various strategies to apply for national, state, and local teaching standards. These

approaches will draw eagerness from students due to personal collaboration and purpose gained from the real-world problem-solving method to learning. Students feel involved due to the relevance of the material to their natural circumstance and its usable means to personal, social, and professional goals. Background learning permits for higher expertise in the retention of scientific knowledge.

Research related to Problem-Based learning

Dombrowski, Lynn (2002) studied "Students Generating Web Pages: Implementation of Problem-Based Learning in the Classroom" The research emphasized on high school students registered in a Chemistry Technology class entitled "Chemistry in the Community." An inventory titled Project Teamwork Checklist (PTC) was accustomed to measure student knowledge/skill level. Students assessed items on a Likert scale of 1 (Most like me) to 5 (Least like me). Students contacted the NASA Exploring the Environment (ETE) Web site to learn about environmental issues. They were taught by problem-based learning (PBL) through the internet. The difference between student's pretest and post-test scores on PTC inventory were analyzed for each student based on the items that correlated with each team role. The results of this research showed that high school students cooperated with each other by helping and training other students in the group to carry out complicate unassigned tasks. The Web-based project supplied students with a generative environment that inspired students to research, write, organize, design, and develop their own on-line modules.

Willis; & et al (2002: Abstract) studied "Small-group work and assessment in a PBL curriculum: a qualitative and quantitative evaluation of student perceptions of the process of working in small groups and its assessment." The study explained how to evaluate students' perceptions of both PBL group work and what a group assessment needed to assess. Focus groups and a questionnaire were used to generate the data. The focus group results indicated that students supported PBL group work as a method of learning, and that those groups that work cooperatively were perceived as facilitating the most motivating learning environment. The students felt that it was easy to evaluate. Behavioral skills contributed to maximize motivation of the group process, and cognitive skills related to

the content of the group discussion. The questionnaire results also supported the use of a summative assessment of small-group work discussion.

Penrose, Robert (n.d.). gave the opinion that Problem-Based Learning helped to locate the high school students who had to apply knowledge to a new condition and develop a solution. In the process of developing the solution, students had an opportunity to 1) make their own learning connections to the material, 2) work cooperatively with other students, 3) gain understanding of the importance of the material to real-life, 4) apply cross-curricular skills and knowledge and 5) be creative. Problem Based Learning was found in the research of brain theory. People leaving the workshop had an occasion to summarize and even completely develop a PBL activity that they can utilize when they went back to their classrooms.

Fareed (2001) studied "Problem-Based Learning Variant: Transition phase for a Large Institution" to compare students' test scores and perceptions of problem-based learning (PBL) and lecture-based learning (LBL) by applying a PBL-variant. The method included two hundred forty-nine second year medical students were taught a topic of Biochemistry by the LBL method and then the rest 141 were taught another topic by the PBL-variant. At the conclusion of each topic an MCQ test was given. One week later a 9 item questionnaire was given to the 50 students now attending classes to assess their perceptions of the 2 teaching formats. There was no significant difference in the test scores by PBL or LBL, but PBL received significantly higher student ratings ($p < 0.05$) than LBL in self-study time, library time, number of books and computer consulted, enthusiasm for the topic, group discussion, depth of knowledge and interest taken in the teaching format. But there was no significant difference in students' ratings of the teacher's importance in either PBL or LBL.

In conclusion, PBL strategies affect students' cooperating in groups discussion and in problem solving. Practicing students for the future workforce is the major aroused generating the changes in education. To be prepared, students must be able to collaborate with others, adjust to new technology, and logically think through problems. Teachers provide the tools and take care closely to their students to develop these skills.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter illustrates in details the research and development methodology. Under this main purpose as follows:

1. To develop learning units integrated between science "Properties of Matter" and career & technology "Designing and Technology" at the high school level;
2. To assess the teachers' opinion toward integrated learning units;
3. To assess the students' opinion toward integrated learning units;
4. To assess the students' achievement and performance on the concepts and process of science and technology.

In the first section, the learning unit development model is based on six step model (see Figure 3-A) . The six steps are:

1. Diagnosis of needs for learning units development
2. The development of learning unit outline
3. The examination of learning unit outline
4. Pilot study
5. Field experiment of integrated learning units
6. Evaluation and improvement.

In the first step, diagnosis of needs for learning units "Properties of Matter" and "Design and Technology" development, it was necessary to collect basic subject matter content related to learning units. There were two sub-steps:

(a) A study of documents and research work related to science and career & technology learning units leads to an understanding of problems and basic essential needs that were based on the analyses of these documents and research works.

(b) An outline was created for the combined science and career & technology learning units. Sub step (b), "Created outline" involved a learning unit outline which was developed based on the information in step one, this information was examined for accuracy by experts.

In step two, learning units integrated between "Properties of Matter" and "Design and Technology" were developed.

In the third step, the integrated learning unit outline was examined for accuracy by experts.

In the forth step involved a pilot study for the learning units. The pilot curriculum was evaluated using students pre and post tests, teacher questionnaires, and expert opinions. Based on these evaluations, correlation and revisions were made.

In the fifth major step, the revised curriculum was carried out in the schools. Another evaluation was followed.

In the sixth step, curriculum development was evaluated and improved. In the next section six major steps of the integrated learning unit development model were explained in more detail as they were related to the development of integrated learning units.

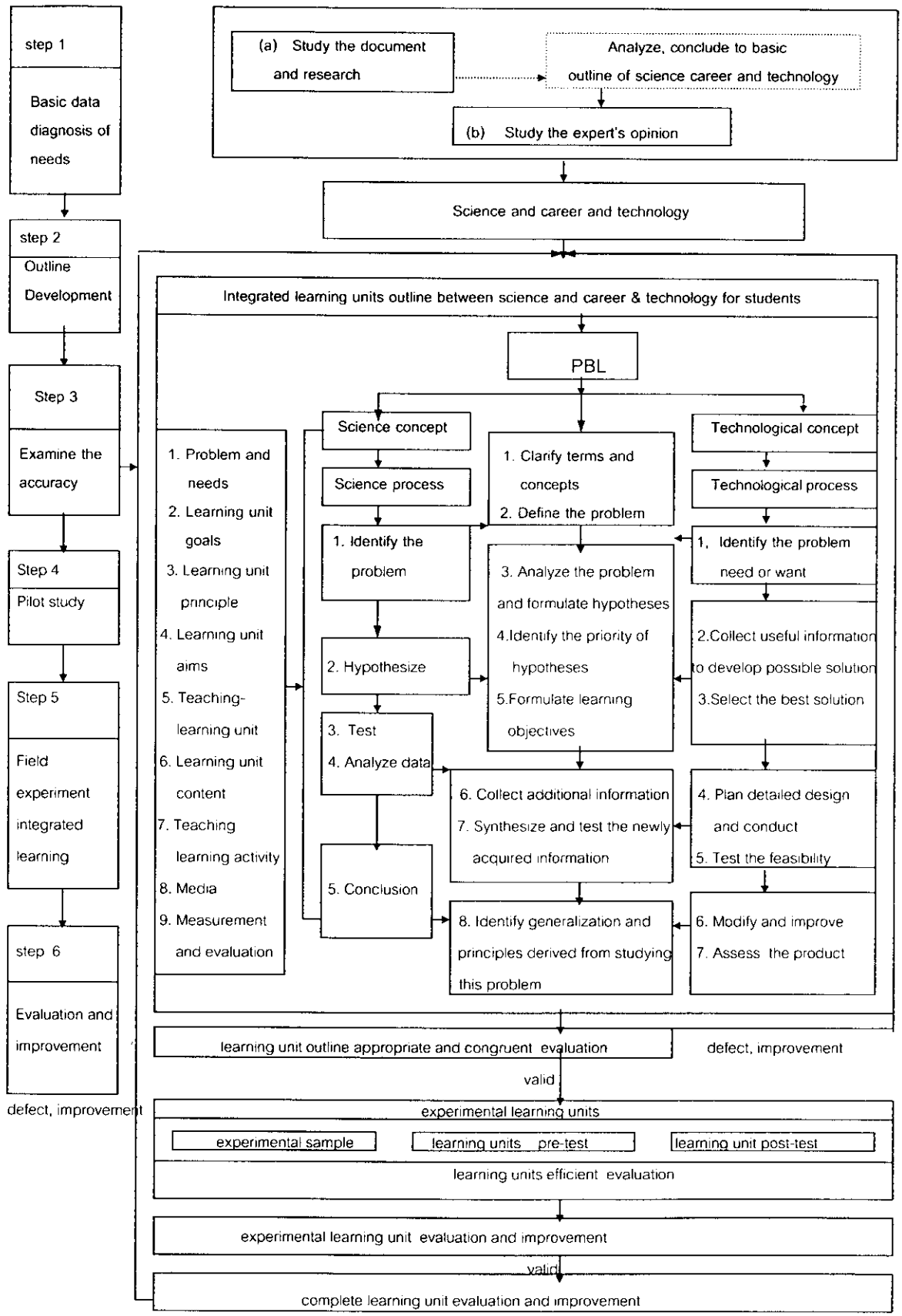


FIGURE 3-A METHODOLOGICAL STEPS OF THE DEVELOPMENT OF INTEGRATED LEARNING UNITS BETWEEN SCIENCE AND CAREER & TECHNOLOGY

Table 1 provided more detailed sketch of the steps involved in the curriculum development model.

TABLE 1 METHODOLOGICAL STEPS FOR THE DEVELOPMENT OF INTEGRATED LEARNING UNITS

steps	objectives	research questions	methods	resources	result
1. Diagnosis of needs	To study integrated science and career, technology learning units at high school level	What is integrated learning units between science and career & technology that can prepare high school students for careers?	1. To study the documents and research related to science, career & technology 2. To study the ideas of experts about integrated learning units	1. The documents and research related to science and career & technology 2. Instructor opinion	To know the content, outline and the process of science subject, career & technology
2. Develop-ment of integrated learning unit outline	To assign learning unit outline to fit with integrated learning units between science and career & technology at high school level	What are the components of an outline for an integrated learning unit between science and career & technology?	Document analyses	The document and research related to science and career & technology	To get the integrated learning unit outline

TABLE 1 (continued)

steps	objectives	research questions	methods	resources	result
3. Outline quality examination	1. The appropriate evaluation of learning unit outline 2. The congruence evaluation of learning unit outline	1. Are the components of learning unit outline appropriate? 2. Are the components of learning unit outline congruent?	Experts' inspection by using learning unit evaluation form of integrated learning units between science and career & technology	Experts in Science, 2 persons; and career & technology, 2 persons	1.To know evaluated result of appropriateness and congruence of learning unit outline 2.To know defects of both appropriateness and congruence of learning unit outline that should be improved.
4. Pilot study	To study the efficiency of learning units	What is the efficiency of learning units integrated between science and career & technology?	Carried out research by using one experimental group and there were pre-test and post-test	14 students in grade 10 who learned science and career & technology subjects	To know the efficiency of learning units integrated between science and career & technology after the experiment with the experimental group
5. Field experiment of the integrated learning units	To experiment the integrated learning units	What is the efficiency of learning units integrated between science and career & technology at high school?	Carried out research by using samples including one experimental group and one control group in science subjects, there is only	83 students in grade 10 who learn science and career & technology subjects	To know the efficiency of learning units integrated between science and career & technology after the experiment with the one experimental and one control group

Table 1 (continued)

steps	objectives	research questions	methods	resources	result
			one experimental group in career and technology and pre-test and post-test		
6. Evaluation and improvement	To evaluate the efficiency of integrated learning units after the experiment	Are the learning units effective?	1. To study learning units principle 2. Suggestion of the experts who evaluated integrated learning units	1. Students in grade 10 who learn science and career & technology 2. The expert who evaluated the learning unit outline.	To get learning units integrated between science and career & technology for students in high school

Methodology

Step one: Diagnosis of needs

The objective was to study learning units integrated between science and career & technology at high school level.

The method was to prepare necessary basic data in designing learning units that were congruent with a real problem situation.

1. Documents and research that related to science, career and technology were studied, data were analyzed then developed a basic outline of the main points of contents and activities for integrating learning units between science and career & technology at high school level. The developed outline was further examined by the experts.

2. The experts' opinions about learning units integrated between science and career & technology subjects were analyzed. In this step the researcher drew conclusions from the documents and research that related to science, career & technology as well as the experts' opinions in order to create a questionnaire. Then, data and ideas were collected for analyses and repetitious statements were excluded.

Step two: Development of integrated learning units outline

Objective was to assign learning unit outline to fit with learning units integrated between science and career & technology subjects at high school level. The learning unit would be based on what was learned from the documents and research in step one above. Furthermore, the appropriateness and congruence of learning unit outline were evaluated.

Method: This step was to analyze the documents and research that related to science and career & technology as the following sequences.

1. Decisions on problem situations and needs would be based on the study of documents and research (step one above) related to science and career & technology including experts' opinions about science and career & technology for assigning the scope of science and career & technology subjects.

2. Learning unit goal was assigned to fit with problem situations and needs of learning units that were developed as learning units integrated between properties of matter and design and technology at high school level as the following:

2.1 To create the cognition and have good opinion toward learning unit integrated between science and career & technology

2.2 To understand basic chemical reactions and some products from the chemical reactions which affect life and environment including technological process, integration of scientific knowledge with technological process and imagination in designing, creating, developing and improving the inventions.

3. Learning unit principle was obtained on broad objectives of the development of learning units integrated between properties of matter and design and technology at high school level as below:

3.1 The developed learning units were integrated learning unit as parallel model between science and career & technology subjects at high school level.

3.2 The developed learning units used teaching- learning activities as problem-based learning. While, science subject used science process and career & technology subject used technological process. Learning process of each subject was one part of problem-based learning emphasize on science content to be the core of basic knowledge. However, the situation of problem was derived from science knowledge in order to stimulate and link to problem solving in technological process of career & technology subject. Therefore, it affected students, to learn their own development, to be able to work as a group together and collaborate solution or respond to need for problem solving by thinking about solution method or produce the product. It was basic way to have a career in the future.

4. Learning unit aim was assigned to fit with the result from step one, with the hope that if it was performed according to learning unit aim, it would achieve its goal. It is outlined below.

4.1 To get the cognition about the basic chemical reactions and some products from the chemical reactions which affected life and environment

4.2 To get the cognition about technological process and imagination in designing, creating, developing and improving the inventions

4.3 To have the good opinion toward learning unit integrated between science and career & technology

4.4 To be able to analyze and solve the problem of the situation using problem-based learning through science and technological process.

5. Learning unit emphasized decision that was consistent with learning unit aim, including science and career & technology learning units. Each subject of science and career & technology consisted of a learning unit that is composed of four teaching plans. Each science subject lasted three periods per one teaching plan. Similarly, each career & technology subject lasted three to four periods per one teaching plan. One period was 50 minutes. Each learning unit consisted of the detail of teaching plans such as learning objectives, scope of the content, teaching-learning activities, teaching-learning materials, measurement and evaluation.

6. Learning unit contents covered all details of the content in each learning

unit of science and career, technology. A science learning unit consists of four teaching plans. The first plan was chemical reaction in daily life. The second plan was iron rust and protection. The third plan was getting rid of rust and the last plan was reaction between fat and base. Career and technology unit consisted of four teaching plans. The first plan was design and technology. The second plan was getting rid of metal gloomy surface. The third plan was getting rid of rust on cloth and the last plan was problem solving of clogged drain pipe.

7. Teaching-learning activity was the activity in whole vision of science and career & technology subjects, including activity of teachers and students. The teaching-learning process that linked scientific knowledge to teaching-learning method was problem-based learning. The problems were used to encourage students to practice critical thinking skill. For science subject five steps of scientific process were used. Teaching-learning activities were divided to three steps such as step of introduction, teaching and conclusion. Identifying problem, hypothesis, test and data collection and analysis were assigned in teaching step. For career & technology subject, seven steps of teaching-learning activities of technological process were assigned.

8. Teaching-learning materials were the medias, used in teaching-learning activity. Teaching-learning materials of science and & technology subjects consists of teachers' guidebook for students and tests of each subject.

9. Measurement and evaluation were measurement and evaluation of science and career & technology subjects. Three steps of the measurement and evaluation were assigned as follows:

9.1 Cognitive measurement and evaluation was the cognition during learning process and achievement test of science and career & technology subjects was 80 % pass rate of the criterion.

9.2 Opinion measurement and evaluation were evaluated by comparing the opinion mean scores toward integrated learning units and the scores must not be lower than 3.50.

Step three: Examination of integrated learning unit outline

The objective was to evaluate the appropriateness and congruence of learning

unit outline.

Method: The purpose was to evaluate the quality of learning unit outline that were developed by using experts' examination for finding defects both in appropriateness and congruence of learning unit outline, so that improvement could be made before the experiment. This step included the following:

The objective of evaluation

1. An appropriateness evaluation was to evaluate each component of the learning unit outline to show that it was appropriate for the student situation as regards:

a) problem and needs, aim, principle, objective, content,

b) teaching-learning activity, teaching-learning media,

The evaluation was performed using a questionnaire with a 5 level rating scale consisting of: 1) outstanding 2) very good 3) average 4) fair 5) poor (see Appendix A). Items on the expert opinion questionnaire was analyzed using descriptive statistics ($\bar{X}$, S.D). If the rating of expert's opinion was more than or equal to 3.5 showing that the learning unit outline was appropriate.

2. Congruence evaluation of the learning unit proposal was the evaluation of each component of the learning unit outline to discover whether it was congruent with student situation. The congruence evaluation of the learning unit outline was carried out using a questionnaire with 3-level rating scale consisting of: 1) congruent 2) not sure 3) not congruent (See Appendix B Expert congruence evaluation form) The items on the congruence evaluation form were analyzed by using Item-Objective Congruence (IOC):

$$IOC = \frac{\sum R}{N}$$

IOC = Item - Objective Congruence

$\sum R$ = Sum of expert's opinion scores

N = number of the experts

Each congruent item will be converted to a scoring system

"Congruent" was assigned a score of +1

"Not sure" was assigned a score of 0

"Not congruent" was assigned a score of -1

If the item - Objective Congruence was more than or equal to 0.50, showing that learning unit item was usable. Then, a pilot curriculum for science and career& technology was developed.

Step four: Pilot study

Objective of the study was to examine the efficiency of integrated learning unit outline before the step of field experiment.

Method: integrated teaching plan efficiency of learning unit was studied according to experimental methodological process. To perform the experiment, a 6-step plan was used, there are the following:

1. The experimental plan used pre-test and post-test for one experimental group design (Kerlinger; Campbell; & Stanley. 1994: 335; 1963: 13).

2. Samples

Samples were three students of a single form and 11 students of a group form of each classroom grade ten of Surasakmontri School.

3. Experimental equipment includes the following:

3.1 Integrated learning units, learning unit documents.

3.1.1 Integrated learning units, contained problem situations and needs, learning unit goal, learning unit principle, learning unit aim, learning units, learning unit content, teaching-learning activity, teaching-learning materials, evaluation and measurement. These were developed by the researcher, after the evaluation form were approved by the experts.

3.1.2 Learning unit documents were teacher's guides covering lesson plans, teaching-learning documents of science and career & technology learning unit.

3.2 Science and career & technology achievement test for measuring students' knowledge in both pre-test and post-test were constructed using the following steps:

3.2.1 Science and career & technology contents of each learning unit were studied.

3.2.2 The obtained data from 3.2.1 were used to create multiple choices achievement test.

3.2.3 The achievement test was submitted to two groups of experts, one consisting of the persons involved in learning unit development, evaluation and measurement of learning unit of science. The other group consisting of the persons involved in learning unit development, evaluation and measurement of career & technology. Improvement of the achievement tests, regarding content validity, language, multiple choices was made in accordance with the experts' suggestions and comments.

3.2.4 Tried out the improved achievement tests in grade ten of Surasakmontri School for clarity of language and determination of achievement test quality for each item were performed. To decide on difficulty and discriminating power, the tests that had the difficulty in each item between 0.20-0.80 and the discriminating power over 0.20 (Prakong Kunnasoot 1995:33) were selected. Finally, determination 30 efficient test items were choosen.

3.2.5 Determination of achievement test quality was carried out using the achievement tests that passed the difficulty and discriminating power criteria to find reliability, calculated by using Kuder- Richardson (KR-20).

3.3 Opinion test toward learning units integrated between science and career & technology subjects was the opinion of teachers and students toward integrated learning units including the appreciate process of technology that affected the development of career. Test of opinions of teachers and students toward the learning units integrated between science and career & technology subjects was administered before and after the experiment. The experiment included the following steps:

3.3.1 To study learning units integrated between science and career & technology subjects from step one of diagnosis of needs detailed in learning unit goals, unit content and learning objective

3.3.2 To create opinion test, using the data from 3.2.1, of Likert's type with 5 levels of the rating scale of both positive and negative statements:

The positive rating scales of agreement

strongly agree	:	5
agree	:	4
uncertain	:	3
disagree	:	2
strongly disagree	:	1

The negative rating scales

strongly agree	:	1
agree	:	2
uncertain	:	3
disagree	:	4
strongly disagree	:	5

Meaning interpretation of mean scores is divided into 5 levels:

strongly agree	:	4.50-5.00
agree	:	3.50-4.49
uncertain	:	2.50-3.49
disagree	:	1.50-2.49
strongly disagree	:	1.00-1.49

3.3.3 The opinion test was submitted to seven experts, one consisting of the persons involved in learning unit development, evaluation and measurement of learning unit of science. The other consisting of the persons in learning unit development, measurement and evaluation of career & technology who inspected content validity and language. The improvement was then made in accordance with the experts' suggestions and comments.

3.3.4 Tried out the corrected opinion test in grade ten of Surasakmontri School for explicit inspection of language and determination of opinion test quality were conducted by finding discriminating power of each item. Analysis by t-test and the statement that had discriminating power more than or equal to 1.75, significant at .05 (Puangrat Thavirat. 1997: 193) were chosen for this study.

3.3.5 Opinion test quality was determined by calculating the opinion test

reliability with α- coefficient of Cronbach's method (Cronbach. 1971: 16). Finally, the experiment included the following:

1) To study each teaching-learning unit component consisting of teaching-learning unit explanation, learning objectives, content scope, teaching-learning activity, teaching-learning medias, measurement and evaluation

2) To use the data from 3.2.1 to create appropriateness evaluation form of integrated learning units concerning opinion questionnaire using five levels rating scale: 1) outstanding 2) very good 3) average 4) fair 5) poor. It covers the components of integrated learning units application. The criteria for appropriateness evaluation were as follows:

outstanding	:	5
very good	:	4
average	:	3
fair	:	2
poor	:	1

Interpretation of weighted mean score was divided into five levels as the following:

outstanding	:	4.50-5.00
very good	:	3.50-4.49
average	:	2.50-3.49
fair	:	1.50-2.49
poor	:	1.00-1.49

3) Appropriateness evaluation form was submitted to the experts, one consisting of the persons in learning unit development, evaluation and measurement of learning unit of science, and the other consisting of the persons in learning unit development, evaluation and measurement of career & technology for inspecting content validity and language. The improvement was made in accordance with the experts' suggestions and comments.

4. Implementation: The experiment used for this study was integrated learning units developed by the researcher, and the samples were pre-tested and post-

tested. The following were performed by the researcher:

4.1 To organize conference for science and career & technology teachers

4.2 To conduct the experimental learning units with the samples including pre and post test

4.3 To test the achievement of science and career & technology, evaluation of activity result, measure opinion toward integrated learning units of teachers and students.

5. Data analysis was carried out as the following:

5.1 To compare score difference of achievement test of science, career & technology, opinion test of teachers and students toward the integrated learning units before and after the experimental implementation of the learning units

5.2 To find learning unit efficiency that included the following:

Comparison of average cognitive scores of science and career & technology between learning process and achievement. The efficiency criteria must not be lower than 80/80 by using E_1/E_2 from these formulas.

$$E_1 = \frac{\overline{X}}{A} \times 100$$

E_1 was teaching-learning efficiency from all learning units.

$\overline{X}$ was mean activity score of samples from all learning units.

A was total activity score from all learning units.

$$E_2 = \frac{\overline{F}}{P} \times 100$$

E_2 was teaching-learning achievement efficiency after the end of learning units.

$\overline{F}$ was mean test score of samples after the end of using learning units.

P was total test score after the end of using learning units.

The process of finding the efficiency of integrated learning unit included three steps (Chaiyong Bhramawong; et al. 1988:88).

1) Single form (1:1) one teacher tests each student (poor, average and smart)

2) Group form (1:10) one teacher tests 6-12 students who had mixed ability (poor, average and smart)

3) Field form (1:100) one teacher tests 30-40 students. This step was similar to the testing administered in real teaching. If it was below the criteria, this step had to be improved and retested.

5.3 Opinion mean score was compared toward the integrated learning units. The efficiency of the criterion must not be lower than 3.50.

6. Consideration of the integrated learning units efficiency was carried out as follows:

6.1 Criteria of consideration of the integrated learning unit efficiency were based on the following:

6.1.1 Students' cognitive achievement and opinions toward the integrated learning unit were considered.

6.1.2 The integrated learning units consisted of integrated learning units efficiency included the following:

1) Cognitive mean scores of science and career & technology were composed between learning process and achievement. The method involved E_1/ E_2 criterion.

2) To compare opinion mean score toward the integrated learning units, the score must not be lower than 3.50.

6.2 The integrated learning units were improved after evaluation by the experts, then, they were further implemented to the students.

Step five: Field experiment of learning units integrated between science and career & technology subjects

Objective: To experiment the improved integrated learning units of science and career & technology.

Method: Integrated teaching plan efficiency according to experimental methodological process was investigated. This step was similar to the step of pilot study, but some parts were different from the pilot study as follows:

1. Samples: The samples in the science subject were 83 students, divided into two classrooms. There were one experimental group and one control group of grade 10 at Surasakmontri School. For career & technology subject, the samples were 38 students of one experimental group.

2. Experimental time in this study was about 9-10 weeks.

Teaching-learning of science and career & technology subjects were scheduled as shown in Table 2.

TABLE 2 TIME TABLE OF TEACHING-LEARNING OF SCIENCE AND CAREER & TECHNOLOGY SUBJECTS

Week	Science	Career & technology
1	Test	Test
2-3	Chemical reactions in everyday life	Design and technology
4-5	Iron rust and protection	Getting rid of metal gloomy surface
6-7	Getting rid of iron rust	Getting rid of iron rust on cloth
8-9	Reaction of fat and base	Problem solving of clogged drain pipe
10	Test	Test

Step six: Evaluation and improvement

Objective: To evaluate the curriculum efficiency after field experiment of the integrated learning units

Method: This step used the results of step five to make a final improvement of the learning unit components as the following:

Learning unit efficiency

1. Students: Cognitive achievement and opinions toward the integrated learning unit were considered.

2. Integrated learning units

The integrated learning unit efficiency included the following:

2.1 To compare cognitive mean scores of science and career & technology between learning process and achievement, Using E_1/E_2 criterion

2.2 To compare opinion mean score toward integrated learning units; the score must not be lower than 3.50.

CHAPTER 4

FINDINGS

Data analysis of the research was offered as five steps of curriculum development including:

1. Basic data for diagnosis of needs
2. The examination of learning unit outline
3. Pilot study
4. The experiment of integrated learning units.
5. Evaluation and improvement.

1. Basic data for diagnosis of needs

The study of experts' opinions about learning units integrated between science and career & technology subjects, 11 and 12 experts in science and in career & technology subjects respectively. The results were shown in Table 3.

TABLE 3 EXPERTS' OPINIONS ABOUT LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY

Experts' opinion	
Science	Career & Technology
Very strong level	Very strong level
7. Content in item 3. can be assigned to situation or problem for getting rid of iron rust on cloth in technological process ($\bar{X}$ = 4.72).	30. Students appreciate the implementation of scientific knowledge in everyday life ($\bar{X}$ = 4.81).
27.Evaluation from test was found to be $\bar{X}$ = 4.71.	15. Students apply work-skill, knowledge and skill in daily life ($\bar{X}$=4.70).

TABLE 3 (continued)

Experts' opinion	
Science	Career & Technology
Very strong level	Very strong level
9. If there is curriculum integration as item 2., teachers should meet or consult cooperatively in teaching-learning process ($\bar{X}$ = 4.55). The experts' opinions were at strong level in 29 items with $\bar{X}$ =3.91-4.45 (see Appendix A).	5. Content and activities from reaction between fat and base to form soap can be integrated with technological process ($\bar{X}$=4.61). 31. Students appreciate the implementation of scientific knowledge in career ($\bar{X}$=4.60). 32. Students can apply the scientific knowledge in career ($\bar{X}$ = 4.60). 28. Evaluation from students' performance was obtained $\bar{X}$ = 4.54.
	Strong level
	The experts' opinions were at strong level in 28 Items with $\bar{X}$=3.81-4.45 (see Appendix B).

Table 3 showed that most of science experts had the opinions about the learning units integrated between science and career & technology at the very strong level such as item 7, 27, 9 respectively ($\bar{X}$ = 4.72-4.55). The experts' opinions were at the strong level in 29 items with $\bar{X}$ =3.91-4.45 (see Appendix A).

Career & technology experts had the opinions about the learning units integrated between science and career & technology at the very strong level such as item 30, 15, 5, 31,32, 28 respectively, $\bar{X}$ = 4.81-4.54. The experts' opinions were at the strong level in 28 items, $\bar{X}$=3.81-4.45 as shown in Appendix B.

The experts' opinions were analyzed in two parts, such as a part of contents, teaching-learning process and a part of measurement and evaluation as outlined in Table 4.

TABLE 4 THE ANALYSIS RESULT OF AVERAGE AND STANDARD DEVIATION OF EXPERTS' OPINIONS OF SCIENCE AND CAREER & TECHNOLOGY TO ASSESS THE APPROPRIATENESS ABOUT CONTENTS AND TEACHING-LEARNING PROCESS AND MEASUREMENT AND EVALUATION

Experts' opinion	Science			Career & Technology		
	$\bar{X}$	S.D.	level of appropriateness	$\bar{X}$	S.D.	level of appropriateness
1. Contents and teaching-learning process	4.24	0.55	strong	4.29	2.83	strong
2. Measurement and evaluation	4.21	0.49	strong	4.37	2.84	strong

Table 4 indicated that science and career & technology experts' opinions of the assessment of appropriateness, possibility and needs of both contents and teaching-learning and measurement and evaluation parts were appropriate at the strong level.

2. The examination of learning unit outline

When the learning unit outline and teaching-learning arrangement plan of science and career & technology subjects were examined by the experts for the components of appropriateness and congruence, the results were as follows:

1. The results of appropriateness of the learning unit outline of science subject according to the experts' opinions were shown in Table 5.

TABLE 5 MEAN AND STANDARD DEVIATION AND APPROPRIATENESS LEVEL OF LEARNING UNIT OUTLINE OF SCIENCE AS THE EXPERTS' OPINION

List of evaluation	$\bar{X}$	S.D.	Level of appropriateness
1. Problems and needs of learning unit outline	4.08	0.50	very good
2. Goals of learning unit outline	4.20	0.89	very good
3. Principle of learning unit outline	4.11	0.58	very good
4. Aim of learning unit outline	4.12	0.55	very good
5. Content of learning unit outline	3.91	0.96	very good
6. Teaching-learning activities	3.83	0.55	very good
7. Teaching-learning materials	3.89	0.58	very good
8. Measurement and evaluation	4.27	0.45	very good
9. Learning unit: plan one; chemical reaction in everyday life	4.16	1.21	very good
10.Learning unit: plan two; iron rust and protection	4.29	1.33	very good
11.Learning unit: plan three; getting rid of iron rust	4.11	0.91	very good
12.Learning unit: plan four; reaction of fat and base	4.13	1.61	very good

Table 5 revealed that the results of appropriateness evaluation of each component of learning unit outline as the experts' opinions had the range of mean scores as ($\bar{X}$) 3.83-4.29 and standard deviation (S.D) 0.50-1.61 the experts perceived that every component of learning unit outline had appropriateness at the high level. Consideration of the standard deviation, It was found that learning unit, plan four, reaction of fat and base was higher than the standard deviation of other components. It showed that the expert's opinions were more different than other components.

2. The results of appropriateness of learning unit outline of career & technology subjects according to the experts' opinions were depicted in Table 6.

TABLE 6 MEAN AND STANDARD DEVIATION AND APPROPRIATENESS LEVEL OF LEARNING UNIT OUTLINE OF CAREER & TECHNOLOGY AS THE EXPERTS' OPINIONS

List of evaluation	$\bar{X}$	S.D.	Level of appropriateness
1. Problems and needs of learning unit outline	4.33	0.82	very good
2. Goals of learning unit outline	4.53	0.55	outstanding
3. Principle of learning unit outline	4.56	0.58	outstanding
4. Aim of learning unit outline	4.53	0.55	outstanding
5. Content of learning unit outline	4.42	0.50	very good
6. Teaching-learning activities	4.67	0.89	outstanding
7. Teaching-learning materials	4.44	0.58	very good
8. Measurement and evaluation	4.73	1.09	outstanding
9. Learning unit: plan one; design and technology	4.69	0.95	outstanding
10.Learning unit: plan two; getting rid of gloomy surface of metal	4.72	0.99	outstanding
11.Learning: plan three; getting rid of iron rust on cloth	4.64	1.34	outstanding
12.Learning: plan four; problem solving of clogged drain pipe	4.69	0.86	outstanding

Table 6 showed that the result of appropriateness evaluation of each component of learning unit outline as the experts' opinions had the range of mean scores as ($\bar{X}$) 4.33-4.73 and standard deviation (S.D) 0.5-1.34. It showed that the experts perceived that components of learning unit outline had the appropriateness at the very good to outstanding level.

3. The result of congruence evaluation of learning unit outline of science subjects as the experts' opinions was shown in Table 7.

TABLE 7 ITEM-OBJECTIVE CONGRUENCE OF LEARNING UNIT OUTLINE OF SCIENCE SUBJECT AS THE EXPERTS' OPINIONS

List of evaluation	Item- Objective Congruence
1. Problems and needs of learning unit outline	1.00
2. Goals and principle of learning unit outline	1.00
3. Principle and objectives of learning unit outline	1.00
4. Aim and content of learning unit outline	1.00
5. Content of learning unit and teaching-learning activities	0.67
6. Teaching-learning activities and teaching-learning materials	0.67
7. Teaching-learning activities and measurement and evaluation	1.00
8. Aim of learning unit and learning objectives of plan1	0.67
9. Aim of learning unit and learning objectives of plan2	0.67
10. Aim of learning unit and learning objectives of plan3	0.67
11. Aim of learning unit and learning objectives of plan4	0.67
12.Congruence inside plan1	0.87
13.Congruence inside plan 2	0.87
14.Congruence inside plan 3	0.80
15.Congruence inside plan 4	0.87

Table 7 indicated that the result of congruence evaluation of each component of learning unit outline as the experts' opinions range had Item-Objective Congruence (IOC) 0.67-1.00 showing that the experts perceived that every component of learning unit outline had the congruence of each other.

4. The result of Item-Objective Congruence (IOC) evaluation of learning unit outline of career & technology subjects as the experts' opinions was shown in Table 8.

TABLE 8 ITEM-OBJECTIVE CONGRUENCE OF LEARNING UNIT OUTLINE OF CAREER & TECHNOLOGY SUBJECT AS THE EXPERTS' OPINIONS

List of evaluation	Item- Objective Congruence
1. Problems and needs of learning unit	0.67
2. Goals and principle of learning unit	1.00
3. Principle and objectives of learning unit	1.00
4. Objectives and content of learning unit	1.00
5. Content of learning unit and teaching-learning activities	0.67
6. Teaching-learning activities and teaching-learning materials	0.67
7. Teaching-learning activities and measurement and evaluation	1.00
8. Objectives of learning unit and learning objectives of plan 1	0.67
9. Objectives of learning unit and learning objectives of plan 2	0.67
10.Objectives of learning unit and learning objectives of plan 3	0.67
11.Objectives of learning unit and learning objectives of plan 4	1.00
12.Congruence of plan 1	0.87
13.Congruence of plan 2	0.80
14.Congruence of plan 3	0.93
15.Congruence of plan 4	0.87

Table 8 indicated that the result of the experts' opinion toward congruence evaluation between the components of learning unit outline with the range of Item-Objective Congruence (IOC) 0.67-1.00. This revealed that the experts perceived every component of the learning unit outline having the congruence of each other.

3. Pilot study

The learning unit outline was analyzed to find efficiency according to experimental

methodological process and experimental equipments such as science and career & technology achievement test, opinion test toward learning units integrated between science and career & technology. In addition, appropriateness evaluation forms of integrated learning units were also tried out to find the efficiency as the criterion.

Furthermore, the researcher tried out integrated learning unit with samples as a single form with three students individually in one classroom in grade ten of Surasakmontri School in semester two of academic year 2003 from January to February 2004. After that the researcher tried out the unit with samples as a group form with 11 students in grade ten of Surasakmontri School in semester one of academic year 2004 from June to August 2004.

The researcher consulted and advised closely the science teacher and career & technology teacher about the development of learning units integrated between science and career & technology subjects. Each teacher was well trained on the teaching-learning process of each subject until one could use each instrument effectively. However, the teacher of each subject could not combine this study to the ordinary subject and could not add the result or scores of the study to the ordinary grade. This was due to the research was conducted with only two classrooms having an experimental group and a control group. Therefore, it was an additional work for teachers and students. Especially, the experimental group must append additional six to seven learning periods per week both in science and career & technology subjects, the teachers asked the students to send only one group report.

The result of pilot study was divided into a single form and a group form as follows. The integrated learning units were used as a single form with three students at grade 10 of Suraskmontri School in semester two from January to February 2004. It was found that achievement mean scores of science and career & technology subjects after the experiment were higher than those before the experiment. Science cognitive mean scores between cognition during learning process and achievement were 86.25 / 62.22 (see Table 28). Career & technology cognitive mean scores between cognition during learning process and achievement were 83.96 / 64.44 (see Table 29). Opinion mean scores toward the learning units integrated between science and career & technology subjects after the experiment were higher than before the experiment (see Table 22). Furthermore, the

experiment as a group form with 11 students at grade 10 of Suraskmontri School in semester two from June to August was conducted. It was found that achievement mean scores of science and career & technology subjects after the experiment were higher than before the experiment. Science cognitive mean scores between cognition during learning process and achievement was 81.30/63.03 (see table 30). Career & technology cognitive mean scores between cognition during learning process and achievement were 82.73 / 75.76 (see Table 31). Opinion mean scores toward learning units integrated between science and career & technology subjects after the experiment were higher than before the experiment (see Table 23).

After trying out, the defects were corrected for more efficiency such as language revision for easier understanding, revision of report writing as the steps of technological process, revision of some items of test for easier understanding but they were still in the first objective theme and language revision of some items of test for easier understanding.

4. Field experiment of learning units integrated between science and career & technology subjects teaching-learning process

The details in each plan of learning units of science and career & technology subjects are summarized as bellows:

Plan one of science learning unit: Chemical reaction in daily life

This plan covered the content of chemical reactions and some uses in daily life. Some compounds in daily life such as sulfuric acid, hydrochloric acid or acid from fruit such as lemon or tamarind, these chemicals could react as acid with some matters and could be applied to daily life. In this plan, chemical reactions of some matters, were studied. Students studied five steps according to the guide-book such as identifying a problem, setting hypothesis, test, analysis and conclusion. The teacher taught as teacher-guide and was strict student in identifying problem and hypothesizing. Students of many groups could not identify the problems and hypothesize from the problems. Many students were seldom active for showing their opinions. Most of the students were activated to join the activity and helped evaluate group members.

Plan two: Iron rust and protection

In this plan, most of the students were interested in doing the activity especially the test of iron rust and protection. Some groups could not do well in the step of identifying problem and setting hypothesis. Some students asked about these steps and they were confused when they answered the questions. Most of the students remained active to join the activity and group members helped evaluate each others. Some groups seldom discussed in the analysis and conclusion.

Plan three: Getting rid of iron rust

In this plan, most of the students were interested in joining the activity for getting rid of iron rust and many groups could identify the problem better but some groups could not identify the problems and hypothesis clearly. Most of the students were still active to join the activity and group members helped evaluate each others. Some groups could discuss in the analysis and conclusion, therefore, the teacher could evaluate from their reports.

Plan four: Reaction of fat and base

Most of the students paid attention to join the activity of the reaction of fat and base, producing bubble substance that was soap. Group members still helped assess group work, but a few students were rather not interested in the activity that the teacher could evaluate from their reports.

Plan one of career & technology learning unit: Design and technology

In this plan the teacher led the discussion about technology and the application of technology in daily life. Most students were interested in joining the activity. The teacher assigned and stimulated all groups to search broadly about the understanding of design, technology and technological process from the guidebook and texts. Most of the students were active to share the opinions in their groups, but few students still did not join this activity. The representative of each group presented the knowledge of technology and technological process. The teacher had to stimulate students to share their opinions to each other. Most of the students helped evaluate their group members well.

Plan two: getting rid of gloomy surface of metal

The teacher led discussion about gloomy surface of metal and asked the background knowledge of protection and solution of gloomy surface of metal that students

had learned from science. Then teacher asked problem solving of gloomy surface of metal such as brass or aluminum and assigned students to identify this problem and perform as the steps of technological process that teacher had often emphasized. The teacher suggested students to study more from the guidebook and search broadly from many sources before designing and performing. Some groups had not searched for this step so teacher could observe from their performance. However, they could perform in this step because they got the background knowledge from science. The representative of each group presented as the steps of technological process that most of the students were interested, but they still did not share extensively their opinions in the discussion. Most of the students helped evaluate their group members well.

Plan three: Getting rid of iron rust on cloth

In this plan, most of the students could identify the problem and perform as the step of technological process because the students had background knowledge from science subject that made them know the substance used to get rid of iron rust. Many groups were able to choose suitable substance and method for getting rid of iron rust on cloth but some groups were confused to perform according to the steps of technological process. So the teacher had to emphasize these steps and suggested students to study in the guidebook. Students could share their opinions as their representative and discussed the performing as technological process.

Plan four: problem solving of clogged drain pipe

Many groups could perform well as the step of technological process, but some students did not pay attention to join the activity that the teacher could evaluate from their performance and reports. Most of the students helped evaluate their group members well.

In the test, all students cooperated well to do the achievement test, teaching-learning process, group-learning evaluation, the opinion test and appropriateness evaluation of application learning units. Unfortunately, in the examination of learning unit efficiency in the second and the third times not all students showed up for the tests. There were three students missing in the second and four missing in the third time.

From teaching-learning process, we could conclude that most of the students were

interested in joining the activities, but, there were few students who were not interested.

The field experiment of learning units could be presented in these steps as follows:

1. The results of learning unit experiment consisted of the basic data analysis of mean ($\bar{X}$), standard deviation (S.D.) of cognition as learning process, achievement test of science and career & technology subjects before and after the experiment, the analysis of the opinion of teachers and students toward the integrated learning units before and after the experiment and the analysis of science and career & technology achievement, the opinions toward integrated learning units before the experiment, the analysis of science and career & technology achievement, activity and the opinion toward the integrated learning units after the experiment.

2. The results of appropriateness evaluation of learning unit experiment

3. Analysis of the cognition between learning process, achievement and the opinions toward integrated learning units after the experiment with the criteria.

4. Conclusion of the experiment.

However, the researcher perceived that there were still some problems to conclude as follows:

1) Some students were not active to join well some activities as to what were proper.

2) Some students did not identify problems and hypothesize correctly.

3) Some students were still confused to perform properly in some steps of technological process. Explanation about the above problems were discussed in chapter 5.

1. The results of learning unit experiment

The results of learning unit experiment consisted of the basic data analysis of mean ($\bar{X}$), standard deviation (S.D.) of cognition during learning process, achievement of science and career & technology subjects before and after the experiment as shown in Table 9.

TABLE 9 THE COMPARISON OF SCIENCE AND CAREER & TECHNOLOGY ACHIEVEMENT AND THE OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE THE EXPERIMENT OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Teaching-learning process	Full scores	experimental group		control group			
		$\bar{X}$	S.D.	$\bar{X}$	S.D.	t	p
Science							
Achievement part	30	11.26	2.73	12.59	2.27	0.262	0.795
Career & technology							
Achievement part	30	10.89	4.76	-	-	-	-
Opinion part	295	231.79	13.04	216.30	18.62	3.851	0.000*

* $p < .05$

From Table 9, the result of science achievement before experiment of the control group was not significantly higher than the experimental group. Students' opinions toward learning units integrated between science and career & technology subjects before the experiment of the experimental group was significantly higher than the control group, at the.05 level.

TABLE 10 THE COMPARISON OF COGNITION DURING LEARNING PROCESS, ACHIEVEMENT AND THE OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Teaching-learning process	Full scores	before experiment		after experiment			
		$\bar{X}$	S.D.	$\bar{X}$	S.D.	t	p
Science							
Experimental group							
Achievement	30	11.26	2.73	25.38	6.86	10.163	0.000*
Cognition during learning	123	-	-	99.97	5.85	-	-
Control group							
Achievement	30	12.59	2.27	17.86	4.08	0.114	0.910
Cognition during learning	123	-	-	94.65	7.69	-	-
Career & technology							
Experimental group							
Achievement	30	10.89	4.76	24.03	6.25	11.995	0.000*
Cognition during learning	180	-	-	151.97	9.29	-	-
Opinion							
Teachers	295	230.50	8.37	256.50	10.75	4.949	0.000*
Experimental group	295	231.79	13.04	237.97	13.92	0.684	0.497
Control group	295	216.30	18.62	227.23	14.72	3.456	0.001*

* $p < .05$

From Table 10, the result of science achievement after the experiment of the experimental group was significantly higher than before the experiment at the .05 level.

Students' opinions toward the integrated learning units after the experiment of the experimental group were not significantly higher than before the experiment. Science achievement after the experiment of the control group was not significantly higher than before the experiment. Students' opinions toward the integrated learning units after the experiment of the control group were significantly higher than before the experiment at the .05 level. Teachers' opinions toward integrated learning units after the experiment were significantly higher than before the experiment at the .05 level.

TABLE 11 THE COMPARISON OF ACHIEVEMENT AND THE OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Teaching-learning process of each subject	experimental group $\bar{X}$	S.D.	control group. $\bar{X}$	S.D.	t	p
Science						
Achievement part	25.38	6.86	17.86	4.08	9.961	0.000*
Career & technology						
Achievement part	24.03	6.25	-	-	-	-
Opinion part	237.97	13.92	227.23	14.72	11.192	0.000*

* $p < .05$

From Table 11, the results of science achievement after the experiment of the experimental group was significantly higher than the control group at the .05 level. The students' opinions toward integrated learning units after the experiment of the experimental group were significantly higher than the control group at the .05 level.

2. The results of appropriateness evaluation of learning unit experiment

The appropriateness evaluation of the experiment of learning unit integrated

between science and career & technology subjects of students was shown in Table 12.

TABLE 12 THE RESULTS OF MEAN, STANDARD DEVIATION AND APPROPRIATENESS LEVEL OF LEARNING UNIT EXPERIMENT

Item	Evaluation statement	N = 37		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content part			
1.	Items of the content are appropriate.	4.14	0.69	very good
2.	Content arrangement is appropriate.	4.03	0.67	very good
3.	Content difficulty is appropriate.	3.87	0.65	very good
4.	Content covers vital things for students.	3.81	0.64	very good
5.	Content is congruent with learning objectives.	4.11	0.68	very good
6.	Content is congruent with time.	3.67	0.62	very good
7.	Content is useful to students' learning.	4.11	0.68	very good
8.	Integrated learning units that use theme / concept / problem as a core for decreasing the repetition of content in each subject.	3.87	0.65	very good
9.	Content integration between different subjects enables students to review other contents, to learn from other subjects.	3.76	0.64	very good
10.	Integrated learning units help decrease the learning-time of each content.	3.92	0.66	very good
11.	Students can transfer knowledge from learning-content to apply in new situation.	3.97	0.66	very good
	Teaching-learning activities			
12.	Teaching-learning activities are appropriate to the content.	3.92	0.65	very good
13.	Teaching-learning activities are appropriate to time.	3.38	0.57	average

TABLE 12 (continued)

Item	Evaluation statement	N = 37		Level of appropriate-ness
		$\bar{X}$	S.D	
	Teaching-learning activities			
14.	Teaching-learning activities promote and help students solve the problems by themselves.	4.11	0.68	very good
15.	Teaching-learning activities make students get the chance to cooperate.	4.22	0.72	very good
16.	Teaching-learning activities make students get the chance to share their opinions fully.	4.19	0.69	very good
17.	Teaching-learning activities promote students to work as a group.	4.32	0.72	very good
18.	Teaching-learning activities promote students to apply knowledge in daily life.	4.08	0.68	very good
19.	Teaching-learning activities help students to apply the skills in future.	3.86	0.65	very good
20.	Teaching-learning activities help students study from many sources such as library or internet..	3.76	0.63	very good
	Teaching-learning materials			
21.	Teaching-learning materials are congruent with learning objectives.	4.08	0.68	very good
22.	Teaching-learning materials are congruent with content.	3.84	0.64	very good
23.	Teaching-learning materials are congruent with teaching-learning activities.	4.00	0.67	very good

TABLE 12 (continued)

	Evaluation statement	N= 37		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Teaching-learning materials			
24.	Teaching-learning materials promote students to study from many sources.	3.78	0.63	very good
25.	There is regular use of materials in teaching-learning.	3.92	0.66	very good
	Measurement and evaluation			
26.	Measurement and evaluation are congruent with the learning objectives	3.98	0.65	very good
27.	Measurement and evaluation are congruent with content.	3.86	0.64	very good
28.	Measurement and evaluation are congruent with teaching-learning activities.	3.92	0.65	very good
29.	Measurement and evaluation are appropriate.	3.81	0.63	very good
30.	Evaluation was achieved from performance, presentation and report in front of the classroom.	3.94	0.66	very good
31.	Measurement and evaluation before learning are congruent.	3.62	0.54	very good
32.	Measurement and evaluation while learning are congruent.	3.95	0.59	very good
33.	Measurement and evaluation after learning are congruent.	3.78	0.58	very good
34.	Measurement and evaluation of students against each other are congruent.	3.84	0.64	very good
35.	Measurement and evaluation cover knowledge, skill and attitude.	4.03	0.67	very good

TABLE 12 (continued)

Item	Evaluation statement	N = 37		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Behavior and teaching method of teachers			
36.	Teachers teach by using teachers' guide and teaching documents.	3.92	0.59	very good
37.	Teachers help students to solve problems by themselves.	4.14	0.65	very good
38.	Teaching methods of teachers help develop thinking process.	4.03	0.61	very good
39.	Teachers promote students to use problem solving skill.	4.19	0.69	very good
40.	Teachers give the chance to students to cooperate in discussion and ask the problems.	4.35	0.72	very good
41.	Teaching methods of teachers help promote cooperation among teachers.	4.14	0.69	very good

From Table 12, the overall view of appropriateness of learning unit experiment was at the very good level. The means range is among 3.38-4.35. Upon consideration of each item, it was found that only one item was at the average level that was teaching-learning activities being appropriate with time, its mean was 3.38.

3. Analysis of the cognition between learning process, achievement and the opinions toward learning units integrated between science and career & technology subjects after the experiment with the criteria

The comparison of cognition during learning process, achievement and the opinions toward integrated learning units of science and career & technology subjects after the experiment with the criteria of each part was shown in Table 13.

TABLE 13 THE COMPARISON OF COGNITION DURING LEARNING PROCESS, ACHIEVEMENT AND THE OPINIONS TOWARD INTEGRATED LEARNING UNITS OF THE EXPERIMENTAL GROUP AFTER THE EXPERIMENT WITH THE CRITERIA

Teaching-learning process	Total scores	Mean	The criteria	Meaning
Science				
Experimental group				
1. Cognition part				
1.1 During learning	123	98.58 (80.15)	E_1 = 80	higher than the criterion
1.2 Achievement	30	25.38 (84.61)	E_2 = 80	higher than the criterion
Career & technology				
1. Cognition part				
1.1 During learning	180	150.61 (83.67)	E_1 = 80	higher than the criterion
1.2 Achievement	30	24.03 (80.09)	E_2 = 80	higher than the criterion
2. Opinion part				
2.1 Students' opinion	295	4.003	3.5	higher than the criterion
2.2 Teachers' opinion	295	4.350	3.5	higher than the criterion

From Table 13, the results of the mean scores of cognition during learning and achievement of both science and career & technology subjects, teachers and students' opinions toward learning units integrated between science and career & technology subjects after the experiment was higher than the criteria.

4. Conclusions of the experiment

The results of the study are summarized as the following criteria.

1. Student part

1.1 The comparison of science cognition before the experiment of the

experimental group and the control group was not significantly different. Students' opinions toward learning units integrated between science and career & technology subjects before the experiment between the experimental group and the control group was significantly different at the .05 level.

1.2 The comparison of cognition and opinions toward learning units integrated between science and career & technology subjects before and after the learning units of the experimental group and the control group showed that students in the experimental group who learned both science and career & technology subjects had the cognition after the experiment significantly higher than before the experiment at the .05 level. After the students in the control group who experimented only science subjects, it was found that they had science cognition after the experiment not significantly higher than before the experiment. Furthermore, students' opinions toward learning unit integrated between science and career & technology subjects after the experiment of the experimental group were not significantly higher than before the experiment. Students' opinions toward learning units integrated between science and career & technology subjects after the experiment of the control group were significantly higher than before the experiment at the .05 level.

1.3 In this study the students of the experimental group learned both science and career & technology subjects but those in the control group learned only science subject. The comparison of cognition and opinion toward learning units integrated between science and career & technology subjects after the experiment of the experimental group and the control group was studied. It revealed that the students of the experimental group had science cognition after the experiment significantly higher than the control group at the .05 level. In addition, students' opinions toward learning units integrated between science and career & technology subjects after the experiment of the experimental group were significantly higher than the control group at the .05 level.

2. Teacher part

Both science and career & technology teachers' opinions toward learning units integrated between science and career & technology subjects after the experiment were significantly higher than before the experiment at the .05 level.

3. Learning unit part

3.1 The mean score of appropriateness of the learning unit experiment was 3.96 indicating the very good level and higher than the criteria.

3.2 Learning unit efficiency after the experiment was as the following:

3.2.1 The mean scores of science cognition between cognition during learning process and achievement were 80.15 / 84.61 and higher than the criterion (E_1 / E_2 must not be lower than 80 / 80). The mean scores of career & technology cognition between cognition during learning process and achievement were 80.098 / 83.67 and higher than the criterion (E_1 / E_2 must not be lower than 80 / 80).

3.2.2 The mean score of students' opinions toward learning units integrated between science and career & technology subjects was at the very good level that was 4.003 and higher than the criterion (must not be lower than 3.50).

3.2.3 The mean score of teachers' opinions toward learning units integrated between science and career & technology subjects was at the very good level that was 4.35 and higher than the criterion (must not be lower than 3.50).

5. The result of evaluation and improvement

The evaluation and an the improvement of the integrated learning units after the experiment are the following:

Learning unit evaluation

Learning unit evaluation consisted of the details as given below:

1. Evaluation for efficiency of the learning units after the experiment was performed.

2. The criteria used to evaluate the learning units.

2.1 Student part was composed of the following details:

2.1.1 The mean score of science cognition after the experiment of the experimental group was significantly higher than before the experiment at the .05 level.

2.1.2 The mean score of career & technology cognition after the experiment of the experimental group was significantly higher than before the experiment at

the .05 level.

2.1.3 The mean score of science cognition after the experiment of the experimental group was significantly higher than the control group at the .05 level.

2.2 Learning unit part consisted of these given details.

2.2.1 Appropriateness of learning unit experiment of students was not lower than the average level. (It must not be lower than 2.50.)

2.2.2 Learning unit efficiency after the experiment was as the following:

2.2.2.1 The mean scores of science cognition between cognition during the learning process and achievement used E_1/E_2 criterion that must not be lower than 80 / 80.

2.2.2.2 The mean scores of career & technology cognition between cognition during learning process and achievement used E_1/E_2 criterion that must not be lower than 80 / 80.

2.2.2.3 Opinion mean score toward integrated learning units was at the very good level that must not be lower than 3.50.

3. The result of evaluation

The conclusion of evaluation result from the consideration of basic statistic and the test of statistical significance was as follows:

3.1 The consideration of learning unit efficiency of student part found that the mean score of science and career & technology achievement after the experiment of the experimental group was significantly higher than before the experiment at the .05 level.
The mean of science achievement after the experiment of the control group was not significantly higher than before the experiment.

Furthermore, the overall views of appropriateness of the learning unit experiment was at the very good level. Its mean score was 3.96 and higher than the criterion (It must not be lower than 3.50). The learning unit efficiency after the experiment showed that the mean scores of science cognition between cognition during the learning process and achievement were 80.15 / 84.61 and higher than the criterion (E_1 / E_2 must not be lower than 80 / 80). Mean scores of career & technology cognition between cognition during learning process and achievement was 83.67 / 80.098. It showed that integrated

learning units had higher efficiency than the criterion, and could be further applied. Additionally, the difference between E_1 / E_2 was not higher than ± 5 so it was not error. (Wanida Chatwirakom. 2004:104; citing Chaiyong Bhramawong. 2004: interviewed) The mean score of students' opinions toward learning units integrated between science and career & technology subjects was at the very good level that was 4.003 and higher than the criterion (It must not be lower than 3.50). The mean score of teachers' opinions toward learning units integrated between science and career & technology subjects was at the very good level that was 4.35 and higher than the criterion (It must not be lower than 3.50).

3.2 Some details of the suggested by the experts learning unit components such as content of the learning units, teaching-learning activities, measurement and evaluation of learning unit were improved in order to make them clear and appropriate. The obtained results of these components were evaluated and indicated that indicated that this research had efficiency based on the criteria and could be applied in a real life.

The above improvement included the given detailed.

1. Learning unit contents

The researcher improved and reduced some details of contents so that they were easier and appropriate to time.

2. Teaching-learning activities

Some steps of teaching-learning activities were improved to make them appropriate and complete.

3. Measurement and evaluation

The researcher improved the evaluation methods in order to make the condition of the learning process clear and appropriate.

When the science and career & technology learning units were improved the complete volume of learning units integrated between science and career & technology subjects will be used in schools.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

This chapter describes the summary of the study as the following outlines.

Summary

In this study the researcher assigned the purpose as below:

1. To develop learning units integrated between science and career & technology subjects on "Properties of Matter" and "Design and Technology" for high school students.

2. To assess students' achievement and performance on the concepts and process of science and technology

3. To assess teachers' opinions toward integrated learning units

4. To assess students' opinions toward integrated learning units.

Hypotheses

1. The efficiency of learning units integrated between science "Properties of Matter" and career and technology "Design and Technology" was evaluated according to the criterion.

2. The achievement mean scores of science and career & technology of students after the experiment of integrated learning units are higher than the achievement mean scores of the same samples before the experiment.

3. The opinion mean scores toward integrated learning units of teachers after the experimental implementation of learning units are higher than the opinion mean scores of the same samples before the experiment. .

4. The opinion mean scores toward integrated learning units of students after the experimental implementation of learning units are higher than the opinion mean scores of the same samples before the experiment.

Research Methodology

The research methodology on the development of integrated learning units were composed of six steps as fallows:

Step one: Diagnosis of the needs for learning unit development

This step involved the study of basic subject matter and related materials to form the learning units that were consistent with problems and needs. In doing so, the study of documents and research literatures regarding the integration between science and career & technology subjects was performed. Further, data analysis gave the conclusions and the main points to create a questionnaire. Then data and ideas were collected from 11 science and 12 career & technology experts who were the teaching specialists with more than five years experience of science and career & technology subjects respectively. After the data analysis, the results were presented as a mean and a standard deviation.

Step two: Development of integrated learning unit outline

In this step, the result of study and basic data analysis from step one was developed to be the components of the learning unit outline such as problems and needs of learning unit outline, goals of learning unit outline, principles of learning unit outline, aims of learning unit outline, matters of learning unit outline, teaching-learning activities, teaching-learning materials, including measurement and evaluation.

Step three: The examination of learning unit outline

In the third step, learning unit outline was examined by seven experts, consisting of the persons in learning unit development, evaluation and measurement of science and career & technology to achieve appropriateness and congruence of components of learning unit outline in the evaluation form of learning unit outline integrated between science and career & technology subjects for high school level. The result of data analysis was presented as mean, standard deviation and Item – Objective Congruence. After that the obtained result from the evaluation was improved to provide more complete learning unit outline.

Step four: Pilot study

This step the efficiency evaluation of the developed learning unit outline was evaluated by the experimentation integrated learning units with three students, a single form in grade ten of Surasakmontri School in January, February and May2004 and a group

form with 11 students, starting from the end of May to July 2004. After that the defects were corrected to get integrated learning units for a real experiment in the next steps.

Step five: The experiment of integrated learning units

In this step the developed and completely improved learning units were experimented for finding the learning unit efficiency. This was experimented with 83 students in two classrooms in grade ten of Surasakmontri School starting from the end of July to September of the second semester of the academic year 2004. Random sampling was used both in the experimental group and the control group. The experimental group took a pre-test and a post-test. The experimental group had to take science and career & technology achievement test before the integrated learning unit experiment, then students' opinions toward learning units integrated between science and career & technology subjects were measured. On the other hand, the control group took only science achievement, and students' opinions toward learning units integrated between science and career & technology subjects were measured. After that the experiment was assigned to the experimental group to learn both science and career & technology subjects, but the control group learned only science subject. After the integrated learning unit experiment was assigned, both the experimental group and the control group took the same achievement test, and students' opinions toward learning units integrated between science and career & technology subjects were measured as before the experiment. The experimental group evaluated integrated learning units using appropriateness evaluation form of the integrated learning unit experiment.

The data of the experimental group were analyzed by comparing mean scores of cognition during learning process and achievement of science and career & technology subjects, then students' opinions toward integrated learning units were measured. The mean scores of cognition during learning process, achievement of science subject, and students' opinions towards learning units integrated between science and career & technology subjects of the control group were analyzed by using t-test. In addition, the appropriateness of integrated learning units of the experimental group was evaluated by mean scores and standard deviation. Besides the comparison of mean scores of cognition during learning process with achievement, students' opinions toward integrated learning

units after the learning unit experiment were also compared, based on the criterion.

Step six: Evaluation and improvement

In this step, efficiency of integrated learning units after integrated learning units was evaluated according to the criteria in two aspects as follows:

The student aspect, from the mean scores of cognition during learning process and achievement of science and career & technology subjects it was found that the experimental group had significantly higher mean scores of cognition during learning process and the achievement of science and career & technology subjects after integrated learning unit experiment than before the learning unit experiment at the .05 level. The mean scores of cognition during learning process and achievement of science subject after integrated learning units of the experimental group were significantly higher than the mean scores of cognition during the learning process and science achievement of the control group at the .05 level.

After the integrated learning unit aspect, the appropriateness evaluation of integrated learning units of learner ought to be at the average level and not be lower than 2.50. The integrated learning unit efficiency that consisted of mean scores of cognition during learning process and achievement was E_1 / E_2 and must not be lower than 80 / 80. The mean scores of opinions toward learning units integrated between science and career & technology subjects were at the very good level (It must not be lower than 3.50).

In addition, the units were improved in details according to the experts' suggestion. Finally, the efficient integrated learning units and were implemented in a real situation.

Conclusions

The findings from this study were agree with the process and were summarized as the following:

1. Learning units integrated between science and career & technology subjects on "properties and matter" and "design and technology" had efficiency according to the criterion that consisted of mean scores of cognition between cognition during the learning process and achievement, E_1 / E_2 = 80.15 / 84.61, 83.67 / 80.098 repectively.

2. The result of students' achievement of learning units integrated between science and career & technology subjects after the experiment was higher than before the experiment, significantly at the .05 level. Furthermore, students' science achievement of the experimental group was higher than that of the control group, significantly at the .05 level.

3. Students showed better opinions toward learning units integrated between science and career & technology subjects. Additionally, students' opinions toward integrated learning units of the experimental group was higher than that of the control group, significantly at the .05 level.

4. Teachers showed better opinions toward learning units integrated between science and career & technology subjects.

Discussions

1. Diagnosis of needs

Diagnosis of needs was data collection from the documents and research related to learning units integrated between science and career & technology subjects of students at grade 10 being congruent with the real situation of problem and needs including study of experts' opinions on curriculum development, teaching- learning measurement and evaluation, specialists' opinion evaluation of science and career & technology teaching. Studying curriculum of educational technology from kindergarten to high school (K-12), it was found that the curriculum of educational technology should integrate technology to other subjects in both content and technological process such as design and problem solving method (Raizen; et al. 1995:14). National Science Foundation promoted the activity of the Man-Made-World that integrated science, mathematics and technology to be the main part of the curriculum (Raizen; et al. 1995:20) by adding basic engineering activities to secondary school curriculum that was congruent with experts' opinions of science and career & technology teaching. In this study it was found that Basic Education Curriculum B.E. 2544-curriculum in career & technology could be integrated with science subject group in substance 3: design and technology (mean = 4.09), content in substance 3: design and technology could be integrated with both content and activities with science subject group (mean = 4.00).

2. The development of learning unit outline

The development of learning unit outline using the result of studying documents, research and experts' opinions in step one to fix to the learning unit outline as curriculum components that consisted of problem situations and needs, learning unit goal, learning unit principle, learning unit aim, learning units, learning unit content, teaching-learning activity, teaching-learning materials, evaluation and measurement, was congruent with the curriculum developed by Tyler & Taba (Tyler. 1949 : 414-416; Taba. 1962 : 422-425). Each subject was composed of one learning unit, divided into four teaching plans learning objectives, scope of the subject matter were matched with the learning unit aim. The scope of subject matter of all teaching plans integrated between science and career & technology, emphasized science subject matter mainly. Management of teaching-learning activity involved problem-based learning method by using problems to lead the study according to technological process. Both science process and career & technology process were overlapped with problem-based learning. Learning objectives, scope of subject matter, teaching-learning activity and teaching-learning materials were assigned to cover all parts of knowledge, skill, attitude including measurement and evaluation based on the learning unit aim.

3. The examination of learning unit outline

This learning unit was developed by the researcher and used in teaching-learning by integrating between two subjects, science and career & technology in parallel model. Although each subject was taught separately and had different teaching-learning process and work, all subjects reflected the same theme / concept / problem. (MOE. 2001: 29; Teerachai Pooranachote. 2000 : 15-16 ; Anchalee Sarnratana. 1999: 29-30). Learners would study and summarize knowledge from science subject to be foundation for finding continually solution method of technological process that overlapped with problem-based learning.

The learning unit efficiency was evaluated from the experts' opinion measurement. Appropriateness evaluation of science learning unit components showed appropriateness at the average level to the very good level (mean =3.38-4.32) and appropriateness evaluation of career & technology learning unit components showed appropriateness at the

average level to the very good level (average =4.33-4.73). Congruence evaluation of science learning unit outline showed Item-Objective Congruence equal to 0.67-1.00 and congruence evaluation of career & technology learning unit outline showed Item-Objective Congruence equal to 0.67-1.00, higher than the required criterion that was 0.50. It meant that all components of the learning unit outline were congruent with each other.

4. Field experiment of integrated learning units

4.1 The integrated learning units were used with grade 10 students of Surasakmontri School during the second semester of academic year 2004 and the result of performance agreed with the plan of learning management. The result of the comparison of mean scores difference of cognition during learning process with achievement before and after learning unit experiment of the experimental group showed that the experimental group students who learned both science and career & technology had the cognition after learning unit experiment significantly higher than before the learning unit experiment at the .05 level. The developed learning units were effectively used so students could succeed both in studying cognition from scientific process and taking the cognition to be basic cognition for linking and applying to solution of technological process as problem-based learning that was congruent with the study outcome of Willis, & et al. (Willis, & et al. 2002) who found that students supporting PBL group work as a method of learning, working cooperatively and facilitating the most motivating learning environment. The students felt that it was easier to measure behavioral skills contributing to maximizing motivation of the group process, and cognitive skills relating to the content of the group discussion. Robert (Delisle, Robert. 1997:5) mentioned that from the research and teachers' experience it showed that teaching methods of PBL could stimulate students who were bored and increased the students' understanding and achievement. It was because of the learning unit components and another part was the outcome of the emphasis of problem-based learning management. It was the process that emphasized students to use problem sought knowledge by linking problems to the knowledge, reasonable ideas leading to problem solving. Besides problem-based learning management affected to students' collaboration in group discussion and solving the problem, students had the opportunity to add working power in the future that was the creation of force to educational changes for preparing

students to work cooperatively with others and adjust to new technology and reasonable thinking through problems. Teacher arranged equipment and took care closely of students to develop completely these skills that were congruent with Penrose, Robert (n.d.). Problem-based learning helped place the high school students in the position where they had to apply knowledge to a new situation and to develop problem solving. In the process of developing the solution, students got an opportunity to 1) make their own learning connections to the material, 2) work cooperatively with other students, 3) gain an understanding of the importance of the material to real-life, 4) apply cross-curricular skills and knowledge and 5) be creative. Problem-based learning was found in the research of brain theory. People who got workshop would have a chance to draw up and even completely develop a problem-based learning activity.

However, the researcher perceived from the learning unit experiment that there were still some problems as follows:

1. Some students did not pay attention to join well some activities as they should.

2. Some students did not identify problems and hypothesize correctly.

3. Some students were still confused to do properly in some steps of technological process.

The details of the above problems are the following:

1. Some students did not pay attention to join well some activities as they should. Because the teachers of each subject could not combine this study to the ordinary subject especially science subject, the research experimented with only two classroom for the experimental group and the control group, so it added much work for the students. Especially the experimental group had additional five periods per week of both science and career & technology subjects and most students had to learn in leisure time for entrance examination and the school had many extra activities. So sometimes students had not much time for this study and they were too tired to learn. Besides measurement and evaluation scores from this learning unit, the experiment did not evaluate common scores of science and career & technology subjects. Thus, some students did not realize the significance of joining the research because it did not affect their academic report.

2. Some students could not identify problems and hypothesize correctly. To solve the problems, the students were assigned to join the discussion and review the identification and hypothesis in the next time. Due to limited time that the students had to study all of four learning units and study all of three stages as a single form, a group form and field experiment, the time in each stage lasted about two months. So the teacher assigned the students to review the questions for the discussion after action and review in students' guidebook, and discuss and review in the next time.

3. Some students still confused to do properly in some steps of technological process. Teacher solved this problems by emphasizing these steps many times and advising students to study more from the guidebook and search from many materials. Group representatives presented the outcome and joined the discussion and answered questions as steps of technological process.

The results of difference in comparison of students' opinions toward learning units integrated between science and career & technology subjects after the experiment of the experimental group were not significantly higher than before the experiment. It was the outcome of the developed learning unit efficiency and teaching-learning process that most students of the experimental group realized the use and outcome. The outcome to students' development was able to solve problems together and have work power in the future. Students' opinions toward learning units integrated between science and career & technology subjects after the experiment of the experimental group was significantly higher than the control group at the .05 level. It was because the students of the experimental group learning both science and career & technology subjects saw the overview of the use from linking continued knowledge. So they had the opinions toward learning units that differed from the control group who learned only science subject that did not lead to students' development as the aim of real learning unit integration. So students of the control group did not realize the use and outcome. Students' opinions toward learning units integrated between science and career & technology subjects after the experiment of the experimental group were not significantly higher than before the experiment at the .05 level. Because students of the experimental group were science students who were interested and willing to take new strange knowledge, they showed their opinions toward integrated

learning units before the experiment at the very good level. When they joined this study the experiment of each subject could not combine this study to the ordinary subject especially science subject because the research used only two classrooms. The experimental group and the control group, so the students had additional works. Especially the experimental group had additional five periods per week of both science and career & technology subjects and most students had to learn in their free time for preparing the entrance examination and the school had many extra activities. So sometimes students had not much time for this study and they were too tired to learn. These causes might affect to the opinions toward integrated learning units more or less. So it made the evaluated outcome after the experiment not higher than it should be.

4.2 The results of the comparison of teachers' opinions toward learning units integrated between science and career & technology subjects after the experiment was significantly higher than before the experiment at the .05 level. Two teachers who were sincerely interested in joining this study for teaching-learning development, so they cooperate in the long experiment, starting from the pilot study to find the efficiency of learning unit outline, in both two steps of the experiment such as single form and group form until field experiment of learning units. Also because the two teachers who joined the research were interested and endured to collaborate teaching-learning development that started from meeting and consulting about experiment operation of learning units integrated between science and career & technology subjects by explaining the concept, method, teaching-learning process, measurement and evaluation of each subject. They could use each equipment well, including close suggestion throughout the study period. As the experiment of each subject could not combine this study to the ordinary subject especially science subject because the research involved only two classrooms for experimental group and control group, the teachers had additional work. Although teachers had more ordinary teaching work and extra work, they had to be responsible for the experiment until it succeeded. In addition the teachers might realize the importance and the use in applying it to teaching-learning development of the national education.

4.3 The result of appropriateness evaluation of learning unit experiment as students' opinions showed that appropriateness mean score of learning unit experiment

equals to 3.96 and was higher than the criterion (It must not be lower than 2.50). When It was evaluated separately in each part such as subject matter, teaching-learning activities, teaching-learning materials, measurement and evaluation, behavior and teachers' teaching method, it was found that appropriateness all in parts was at the very good level. It showed that students were interested and satisfied to join in learning activities of developed learning unit. Considering teaching-learning activities in each item, teaching-learning activities were appropriate with time, and appropriateness was at the average level. The teachers of each subject could not combine this study to the ordinary subject especially science subject because the research experiment involved only two classrooms of the experimental group and the control group, the students had additional work.. Especially the experimental group had additional five periods per week, of both science and career & technology subjects and most students had to learn in their free time for preparing for the entrance examination and the school had many extra activities. For science subject it had additional two-three periods per week, but for career & technology subject it had one or two periods added. Also most students had to learn in their free time for preparing for the entrance examination and the school had many extra activities. So sometimes students had not much time for this study as it should be and they were too tired to learn. These causes might affect to the opinions toward integrated learning units in teaching-learning activities being suitable with time.

4.4 The results of efficiency evaluation of learning unit after the experiment (learning unit experiment) showed that the mean scores of science cognition between cognition during learning process and achievement were 80.15 / 84.61, higher than the criteria (E_1 / E_2 must not be lower than 80 / 80). The mean scores of career & technology cognition between cognition during learning process and achievement were 83.67 / 80.098 that were higher than the criteria (E_1 / E_2 must not be lower than 80 / 80). The mean score of students' opinions toward learning units integrated between science and career & technology subjects was in very good level that was 4.003, higher than the criterion (It must not be lower than 3.50). The mean score of teachers' opinions toward learning units integrated between science and career & technology subjects was at the very good level that was 4.003, higher than the criterion. (It must not be lower than 3.50). It showed that the developed learning unit had the efficiency as the required criterion.

5. Evaluation and improvement

After conducting the integrated learning unit experiment, the next step was outcome evaluation from experiment as efficiency evaluation criteria of learning unit including experts' suggestion and teachers who joined the experiment, then the learning unit was approved as the suggestion above. Finally, the complete learning units integrated between science and career & technology subjects was used in teaching-learning process.

Recommendations

The finding suggested recommendations as follows:

1. Policy recommendations

1.1 Success of development or learning unit used in school was realized by the administrators who saw the needs to carry and promote the use including personnel who realized the importance of using the learning unit development.

1.2 This research found that learning unit management as learning unit that integrated between two different subjects affected learning of students in both two subjects and carried the relationship between teachers both two subjects. So the development of integrated learning units among all subjects and stages should be promoted for the development of teaching and
learning.

1.3 There should be a policy on research and curriculum development or integrated learning units in school at all level.

2. Recommendations of integrated learning unit application

2.1 The developed integrated learning units were the integration between science and career & technology subjects in form of parallel model by using problem-based learning. Although each subject was taught separately and fixed teaching-learning process including work assigned to students were different, all subjects should reflect to the theme ,concept and problem together. So teacher in each subject should consult together for exchanging the opinion and experience in part of content, related period of teaching, preparing of data sources for learners' promptness to learn including problem, advantage and disadvantage teaching-learning process. It should take several ideas and more

understanding in the form of this teaching-learning management for being able to perform teaching-learning activities and correct the defects during teaching-learning to develop in better way.

2.2. Before learning unit application, teachers should study this learning units for understanding and realizing clearly to over views of all learning unit components that would affect the teaching-learning management to achieve the learning unit objectives.

3. Recommendations of the next research

3.1 Research for curriculum or integrated learning unit development by using problem-based learning between science subject and others or between career & technology subject and others to take a variety of teaching-learning development should be studied further.

3.2 As the curriculum or learning unit integration has many models such as integration among subjects and within the same subject, linking form or curriculum or learning unit integration by using projects and so on, then should be a study and research for curriculum or integrated learning unit development in the same subject by using problem-based learning such as integration within science subject or career & technology subject or others by integration between different learning substance. Examples of integration within science subject by integration between learning substances are 3) Properties of matter and 2) Life and environment or 3) Properties of matter and 8) Nature of science and technology or 2) Life and environment and 8) Nature of science and technology or 5) Energy and 8) Nature of science and technology such as content about ester could be integrated with aromatherapy in spa business or the principle of temperature and relative humidity in soundna business or electrostatics potential therapy that used electrostatics potential in physical therapy or content of properties of matter could apply to OTOP. Besides it could be integrated in other forms to the curriculum or integrated learning unit development in many forms that should be useful to teaching-learning from this time. Furthermore, If it could develop science teachers to know both fields of science and career & technology subjects it would be the advantage of further learning. Teacher can apply this knowledge of this matter in solving environmental problems.

3.3 There should be a research and development of the curriculum or integrated learning units by designing that the control group studied science and career & technology like the experimental group but at the different time. For instance, the experimental group studied science at the same time as career & technology, but the control group studied career & technology after finishing studying science in order to compare the difference of time schedule. That is to see whether different time will cause different effect or not.

3.4 There should be a research and development of the curriculum or integrated learning units for students at all stages.

BIBLIOGRAPHY

Barrows; et al. (1985). Problem-Based Learning: Rationale and Description. *Medical Education* 17:11-16 (Online). Available: http://www.ln.edu.hk/tlc/learning matters /05-2001-242001.pdf. Retrieved April 12, 2003.

Beane, James A. (2002, Fall). Curriculum Matters: Organizing the Middle School Curriculum. National Middle School Association. (Online). Available: http://www Untitled Article.htm. Retrieved May 21, 2003.

Boud, D. & Feletti, G.I. (1997). The challenge of problem-based learning, London: Kogan Page.

Camp, W.G.; & Doolittle, E. Peter (1999, Fall). Constructivism: the Career and Technical Education Perspective. Virginia Polytechnic Institute & State University. (Online). Available: http://scholar.lib.vt.edu/ejournals/JVTE/v16n1/doolittle.html Retrieved April 18, 2003.

Dillon, Michael (2001, April). Smart Alecs: The role of technology in children's lives is growing, but is it making our kids more intelligent? *Texas Technology*: 33-35. (Online). Available: http://hisd2.harlandale.k12.tx.us/MOL/students/pbarcenez /6303-%20technology/Lierature%20Review%202.doc. Retrieved April 21, 2003.

Dombrowski, Lynn. (2002, January 1) "Students Generating Web Pages: Implementation of Problem-Based Learning in the Classroom" (Online). Available: http://www. tech LEARNING com Technology & Learning – The Resource for Education Technology Leaders.htm. Retrieved June 20, 2003.

Delisle, Robert. (1997). How to use problem-based learning in the classroom. The United States of America.

Ellyn. (2002). Exploratory Art Technology Hadley Junior High School 240 Hawthorne Blvd. (Online). Available: http://www.isbe.net/wpp/MSSAMPLE ACT.pdf. Retrieved April 21, 2003.

Fareed, A. (2001, August 20). Problem-Based Learning Variant: Transition phase for a Large Institution. 51 (No. 8) Department of Biochemistry, Dow Medical College, Department of Marketing Statistics, Aga Khan University Hospital, Karachi. (Online). Available: http://jpma.org.pk/new/main/full.asp?article NO=V51N8P0271.

Retrieved April 12, 2003.

Hall; Henson; & T. Kenneth. (2001). Curriculum Planning: Integrating Multiculturalism, Constructivism, Colorado School Mediation Project (CSMP). (2002) and Education Reform. New York: McGraw-Hill.

Humphreys, A.; & Post, T.; & Ellis, A. (1981). Interdisciplinary Methods: A Thematic Approach. Santa Monica, CA: Goodyear Publishing.

Jacobs, H. H. (Ed.). (1989) Interdisciplinary curriculum: Design and implementation. Alexandria, VA: Association for Supervision and Curriculum Development.

Johnsen. (1994, May / June 37). Figuring out Interdisciplinary Curriculum: *Gifted Child Today* 1: 37-39.

Layman W. John; et al. (1996). Realizing Science Standards in the Classroom. *Inquiry and Learning*. New York: USA.

MacMaster Medical School. (2001). McMaster University (Online). Available: http://www.grian.com/pblpage/pbl8.html Retrieved April 10, 2003.

Morris (2002) "The Construction Trades Fair " (Online). Available: http://www.inderscience.com /ejournal/t/ijtm/ijtm2001/ijtm2001v22n78.html Retrieved June 18, 2003.

Penrose, Robert (n.d.). *Developing Problem Based Learning Activities.* Biology / Environmental Studies Teacher. United High School. (Online). Available: http://k12s.phast.umass.edu/~stemtec/pathways/Proceedings/abstract/ Penrose.doc. Retrieved April 10, 2003.

Peoria (2002). (Online). Available: http://www.isbe.net/wpp/MSSAMPLEACT.pdf Retrieved April 10, 2003.

Raizen A. Senta; et al. (1995). *Technology Education in the Classroom: Understanding the Designed World,* Jossey Bass Publishers San Francisco.

Swanson; et al. (1997). *Strategies for Students Assessment.* The Challenge of Problem-Based Learning. 271-276. 2 nd ed. London:Kogan Page.

Taba, H. (1962). *Curriculum Development: Theory and Practice.* New York, NY: Harcourt, Brace & World.

The National Science Foundation (1994). *Project Update /TEI (Teacher Enhancement Initiative),* No. 94-73. Arlington, VA.: National Science Foundation.

Tyler, R. W. (1949). Basic Principles of Curriculum and Instruction. Chicago, IL: The University of Chicago Press.

Willis, S.C.; & Jones, A.; & Bundy, C.; & Burdett, K.; & Whitehouse, C.R.; & O'Neill, P.A. (2002: *Abstract*). Small Group Work and Assessment in a PBL Curriculum: Qualitative and Quantitative Evaluation of Student Perceptions of the Process of Working in Small Groups and its Assessment. *Medical Teacher* 24 (5). (Online). Available: http://library.mtroyal.ca/instruction/0203/pbiblio.htm Retrieved April 20, 2003.

Department of Education. (2001). *Learning Assignment of Career and Technology Content*. Bangkok.

Aunchalee Sarnratana. (1999: December, 29). Integrative Education. *Education*. 2(12): 29-30.

Bubpha, Makesrithongkum. (2002). *A Curricular Development to Enhance the Ethical Decision-Making Process in Jouralistic Profession for Journalism Students.* Doctoral Dissertation. Bangkok: Graduate School, Srinakarinwirot University.

Chaiyong Bhramawong; et al. (1978). *Workbook for Chula Plan.* Bangkok: Chulalongkorn University Press.

Chuangchote Bhuntuvech. (1999). *Technology Education.* Bangkok: Kurusapha Press.

IPST. (2002). *Learning Assignment of Scientific learning Content*. Bangkok: Kurusapha Press.

MOE (2001:15, 25-26). Basic Education Curriculum B.E. 2544 (A.D. 2001). Bangkok: The Express Transportation Organization of Thailand. (ETO) Press.

Informal Educational Department. (2001). *Interesting Articles of Teaching Learning Integration*. Bangkok: Graduate College.

Nantanat Jirasuksa. (2001). *"A Study of Learning Achievement on substance and it's Change by Using Integrated Teaching Method called Science-Technology Society for Mathayomsuksa 4 Students"*. Master thesis, Bangkok: Graduate School, Srinakarinwirot University.

Panya Srichan; et al (2003). *Learning Matter of Career and Technology*. Educational Reform of Basic Educational Curriculum B.E. 2544. Bangkok: Prasarnmitr Press.

Prakong Kanasoot. (1986). *Applied Statistics for Teachers*. Bangkok: Thaiwatanaphanich Press.

ThongYoo Kaeosaiha. (2000). Concept of Integrated Learning Management for Informal Educational Department. In *Joined Articles of Matters of Teaching Learning Integration*. Amphan Cheapsatayakorn, & Pravene Rodkheao. 4-7. 1st ed. Bangkok: Kurusapha Press.

Teerachai Pooranachote. (2000). Integrated Teaching. In *Joined Articles of Matters of Teaching Learning Integration*. Amphan Cheapsatayakorn, & Pravene Rodkheao. 13-16. 1st ed. Bangkok: Kurusapha Press.

Wanida Chatwirakom. (2004). *Development of a Science Instructional Model Focusing On Students' Construction of Knowledge for Matayomsuksa 1 on Ecosystem*. Doctoral Dissertation. Bangkok: Graduate School, Srinakarinwirot University.

APPENDIX

Questionnaire for research (Science)

Science experts' opinion questionnaire toward the development of learning units integrated between science and career & technology subjects for high school students according to the basic educational curriculum B.E. 2544

Explanation: 1. This questionnaire is useful to the development of integrated learning units between science and career & technology for high school students. The purpose for knowing appropriateness, possibility and needs to the integrated learning units between science and career & technology in many cases such as the parameter of teaching-learning, substance, teaching-learning process, measurement, evaluation and achievement.

2. The opinion questionnaire has three sections.

2.1 Data about status of the informant

2.2 Status and parameter in teaching-learning

2.3 Suggestions

Section one: Data about status of the informant

Explanation: Please fill in the blank and put ✓ in ( ) in front of the real statement

1. Your status (answer only one choice)

( ) The expert of curriculum development

( ) The teaching-learning expert of science

( ) The teaching-learning expert of career & technology

( ) The specialist of curriculum development

( ) The teaching-learning specialist of science

( ) The teaching-learning specialist of career & technology

2. Your work experience ..... years

Section one: Status and parameter in teaching-learning

Explanation: Please decide on each statement and put ✓ in back of the statement.

Strength of this topic in curriculum or the performance on this competence.

Very Strong ___|___|___|___|___ Very Weak

Item	Status of problem and teaching-learning process affects to the development of integrated learning units of science.	N = 11		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
1.	From basic educational curriculum 2001, Content of career and technology course in substance 3: design and technology can be integrated with science in substance 3: properties of matter.	4.36	2.59	strong
2.	Content in substance 3: Design and technology (understand the nature and process of technology, and use knowledge to imagine, think systematically and solve the problem or situation that may produce the products) can be integrated with both content and activities with science course.	4.09	2.48	strong
3.	Content and activities of metal corrosion, metal gloomy surface and rust that occurs from reaction between metal and many effects such as oxygen or water or acid can be integrated with technological process.	4.36	2.59	strong
4.	Content and activities of reaction of getting rid of iron rust can be integrated with technological process.	4.45	3.03	strong
5.	Content and activities from reaction between fat and base to form soap can be integrated with technological process.	4.36	3.19	very strong

Item	Status of problem and teaching-learning process affects to the development of integrated learning units.	N = 11		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
6.	Content in item 3. can be assigned to situation or problem for solution of metal gloomy surface in technological process.	4.27	2.68	strong
7.	Content in item 3. can be assigned to situation or problem for solution of iron rust on cloth in technological process.	4.36	2.59	strong
8.	Content in item 5. can be assigned to situation or problem for solution of clogged water pipe in technological process.	4.27	2.68	strong
9.	If the curriculum is integrated as item 2., teachers should meet or consult cooperatively in teaching-learning process.	4.55	2.95	strong
10.	Integrated learning units that use theme / concept / problem to be the core decreases the repetition of content in each course.	4.45	2.68	strong
11.	Content integration between different subjects affects students to review other contents, learned from other subjects.	4.09	3.35	strong
12.	Example situations cause students to solve and to create or invent something for problem solving.	4.27	3.49	strong

Items	Status of problem and teaching-learning process affects to the development of integrated learning units.	N = 11		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
13.	Help decrease the learning-time in each content.	4.18	3.89	strong
14.	Students apply the knowledge in daily life.	4.18	3.89	strong
15.	Students have working skills and apply them in daily life.	4.09	4.38	very strong
16.	Students study the knowledge from many sources such as internet.	3.91	3.35	strong
17.	Students get the chance to act by themselves.	4.00	2.86	strong
18.	Link the knowledge from learning-content to use in new situation.	4.18	3.89	strong
19.	Students get the chance to show creative thinking.	4.18	3.89	very strong
20.	Demonstrate necessarily action-skill to students before real performance.	4.09	3.35	strong
21.	Conduct and suggest students to correct defects as performing..	4.18	2.95	strong
22.	Promote students to apply local materials.	4.36	3.19	strong
	Measurement, evaluation and learning-result.			
23.	If the curriculum is integrated as item 2, the achievement of science subject should be evaluated.	4.00	1.79	strong
24.	The achievement of career and technology subjects should be evaluated.	4.09	2.17	strong
25.	Let students participate in evaluation.	4.45	2.68	strong
26.	Students assess each other.	4.45	2.95	strong

Items	Status of problem and teaching-learning process affects to the development of integrated learning units.	N=11		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Measurement, evaluation and learning-result			
27.	Evaluate the test.	3.72	2.77	strong
28.	Evaluate the students' performance.	4.18	3.89	very strong
29.	From item 28., the measurement of the attitude or opinion toward integrated learning units should be evaluated.	4.18	3.89	strong
30.	Students appreciate implementation of scientific knowledge in everyday life.	4.45	3.03	very strong
31.	Students appreciate implementation of scientific knowledge in career.	4.45	3.03	very strong
32.	Students can apply scientific knowledge in career.	4.45	3.03	very strong

Section 3: Suggestion as appropriateness, possibility and needs to the integrated learning units between science and career & technology in many cases.

Explanation: Please give the suggestion in these cases.

1. Content.....

.....

2. Teaching-learning process.....

.....

3. Measurement, evaluation and learning-result.....

.....

Evaluator.....( )

Appendix B

Questionnaire for research (career & technology)

Career & technology experts' opinion questionnaire about the development of learning units integrated between science and career & technology subjects for high school students according to the basic educational curriculum B.E. 2544

Explanation: 1. This questionnaire is useful to the development of integrated learning units between science and career & technology for high school students. The purpose for knowing appropriateness, possibility and needs to the integrated learning units between science and career & technology in many cases such as the parameter of teaching-learning, substance, teaching-learning process, measurement, evaluation and achievement.

2. The opinion questionnaire has three sections.

2.4 Data about status of the informant

2.5 Status and parameter in teaching-learning

2.6 Suggestion

Section one: Data about status of the informant

Explanation: Please fill in the blank and put ✓ in ( ) in front of the real statement

1. Your status (answer only one choice)

( ) The expert of curriculum development

( ) The teaching-learning expert of science

( ) The teaching-learning expert of career & technology

( ) The specialist of curriculum development

( ) The teaching-learning specialist of science

( ) The teaching-learning specialist of career & technology

2. Your work experience ..... years

Section one: Status and parameter in teaching-learning

Explanation: Please decide on each statement and put ✓ in back of the statement.

Strength of this topic in curriculum or the performance on this competence.

Very Strong ___|___|___|___|___ Very Weak

Item	Status of problem and teaching-learning process affects to the development of integrated learning units of career & technology:	N = 12		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
1.	From basic educational curriculum 2001, Content of career and technology course in substance 3: design and technology can be integrated with science in substance 3: properties of matter.	4.09	2.92	strong
2.	Content in substance 3: Design and technology (understand the nature and process of technology, and use knowledge to imagine, think systematically and solve the problem or situation that may produce the products) can be integrated with both content and activities with science course.	4.0	3.21	strong
3.	Content and activities of metal corrosion, metal gloomy surface and rust that occur from reaction between metal and many effects such as oxygen or water or acid can be integrated with technological process.	4.36	3.89	strong
4.	Content and activities of reaction of getting rid of iron rust can be integrated with technological process.	4.18	3.83	strong
5.	Content and activities from reaction between fat and base to form soap can be integrated with technological process.	4.61	2.17	very strong

Item	Status of problem and teaching-learning process affects to the development of integrated learning units:	N = 12		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
6.	Content in item 3. can be assigned to situation or problem for solution of metal gloomy surface in technological process.	4.18	2.77	strong
7.	Content in item 3. can be assigned to situation or problem for getting rid off iron rust on cloth in technological process.	4.18	2.28	strong
8.	Content in item 5. can be assigned to situation or problem for solution of clogged drain pipe in technological process.	4.00	2.77	strong
9.	If the curriculum is integrated as item 2., teachers should meet or consult cooperatively in teaching-learning process.	4.36	2.49	strong
10.	Integrated learning units that use theme / concept / problem to be the core decreases the repeat of content in each subject.	4.45	3.19	strong
11.	Content integration between different subjects affects students to review other contents, learned from other subjects.	4.27	2.49	strong
12.	Example situations cause students to solve and to create or invent something for problem solving.	4.18	2.49	strong

Items	Status of problem and teaching-learning process affects to the development of integrated learning units:	N = 12		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Content and teaching-learning process			
13.	Help decrease the learning-time in each content.	4.36	2.49	strong
14.	Students apply the knowledge in daily life.	4.36	2.28	strong
15.	Students have working skills and apply them in daily life.	4.71	2.95	very strong
16.	Students study the knowledge from many sources such as internet.	4.45	2.59	strong
17.	Students get the chance to act by themselves.	4.36	3.08	strong
18.	Link the knowledge from learning-content to use in new situation.	4.00	2.12	strong
19.	Students get the chance to show creative thinking.	4.54	2.74	very strong
20.	Demonstrate necessarily action-skill to students before real performance.	4.45	2.83	strong
21.	Conduct and suggest students to correct defects as performing.	4.27	3.46	strong
22.	Promote students to used local materials to apply.	4.45	2.83	strong
	Measurement, evaluation and learning-result			
23.	If there are curriculum integration as item 2.,It should evaluate the achievement of science course.	3.81	2.35	strong
24.	It should evaluate the achievement of career and technology course.	4.00	2.35	strong
25.	Students participate in evaluation.	4.18	2.77	strong
26.	Students assess each other.	4.27	2.35	strong

Item	Status of problem and teaching-learning process affects to the development of integrated learning units.	N = 12		Level of appropriate-ness
		$\bar{X}$	S.D.	
	Measurement, evaluation and learning-result			
27.	Evaluate the test.	4.27	2.55	strong
28.	Evaluate the students' performance.	4.54	2.74	very strong
29.	From item 28, the measurement of the attitude or opinion toward integrated learning units should be evaluated.	4.45	2.35	strong
30.	Students appreciate implementation of scientific knowledge in everyday life.	4.81	3.49	very strong
31.	Students appreciate implementation of scientific knowledge in career.	4.60	2.68	very strong
32.	Students can apply scientific knowledge in career.	4.60	2.68	very strong

Section 3: Suggestion as appropriateness, possibility and needs to the integrated learning units between science and career & technology in many cases.

Explanation: Please give the suggestion in these cases.

1. Content.....

.....

2. Teaching-learning process.....

.....

3. Measurement, evaluation and learning-result.....

.....

Evaluator.....( )

Appendix C

Evaluation form of science learning unit outline

This evaluation form is the evaluation form of science learning unit outline used to evaluate appropriateness and congruence among various components of science curriculum

This evaluation form is divided to two parts as below:

1. Appropriate evaluation form of learning unit outline
2. Congruent evaluation form of learning unit outline

Could experts consider appropriateness and congruence among various components of science learning unit, please?

Step 1. Appropriate evaluation form of learning unit outline is consideration how various components of learning unit outline that is appropriate among these components are:

1. Problems and needs of learning unit
2. Goals of learning unit
3. Principle of learning unit
4. Objectives of learning unit
5. Content of learning unit
6. Teaching-learning activities
7. Teaching-learning materials
8. Measurement and evaluation
9. Learning units

Explanation check this mark / in "level of appropriateness" as your opinion

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
1. Problems and needs of learning unit					
1.1 needs of learning unit development					
1.2 reason of learning unit development					
1.3 appropriateness of solution outline					
1.4 possibility of solution outline					
2. Goals of learning unit					
2.1 congruence with educational goal					
2.2 appropriateness to students					
2.3 benefit to career foundation					
2.4 assign explicitly the developed objects					
2.5 congruence with educational policy					
3. Principle of learning unit					
3.1 clearness					
3.2 appropriateness					
3.3 possibility					
4. Objectives of learning unit					
4.1 clearness					
4.2 appropriateness to students					
4.3 congruence with educational policy					
4.4 possibility					
4.5 cover the developed objects					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
5. Content of learning unit					
5.1 response of curriculum objectives					
5.2 arrangement of content					
5.3 appropriateness of item fixation					
5.4 cover essential content for students					
6. Teaching-learning activities					
6.1 congruence with subject matter					
6.2 appropriateness of teaching learning activities					
6.3 promote learners' analytical thinking					
6.4 use suitable technological materials					
6.5 implementation of teaching					
6.6 accomplish to objectives of the learning unit					
7. Teaching-learning materials					
7.1 congruence with teaching-learning activities					
7.2 appropriate with students					
7.3 support arrangement of activity to achieve learning objectives					
8. Measurement and evaluation					
8.1 appropriateness of measured apparatus					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
8.2 possibility of measurement					
8.3 examine the achievement learning objectives					
8.4 measure directly learning objectives					
8.5 identify explicitly measured action					
9. Learning unit: chemical reaction in in everyday life					
9.1 clearness of learning unit explanation					
9.2 clearness of learning objectives					
9.3 appropriateness of learning objectives					
9.4 appropriateness of learning matter scope					
9.5 learning matter scope affects the achievement of learning objectives					
9.6 appropriateness of teaching-learning activities					
9.7 implementation of teaching-learning activities					
9.8 teaching-learning activities affects the achievement of learning objectives					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
9.9 appropriateness of teaching-learning materials					
9.10 teaching-learning materials affect the achievement of learning objectives					
9.11 appropriateness of the apparatus for measurement and evaluation					
9.12 possibility of measurement and evaluation					
9.13 achievement of learning unit objectives is examined by measurement and evaluation					
10. Learning unit: iron rust and protection					
10.1 clearness of learning unit explanation					
10.2 clearness of learning objectives					
10.3 appropriateness of learning objectives					
10.4 appropriateness of learning matter scope					
10.5 learning matter scope affects the achievement of learning objectives					
10.6 appropriateness of teaching-learning activities					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
10.7 implementation of teaching learning activities					
10.8 teaching learning activities affects the achievement of learning objectives					
10.9 appropriateness of teaching-learning materials					
10.10 teaching -learning materials affects the achievement of learning objectives					
10.11 appropriateness of apparatus for measurement and evaluation					
10.12 possibility of measurement and evaluation					
10.13 achievement of learning unit objectives is examined by measurement and evaluation					
11. Learning unit: getting rid of iron rust					
11.1 clearness of learning unit explanation					
11.2 clearness of learning objectives					
11.3 appropriateness of learning objectives					
11.4 appropriateness of learning matter scope					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
11.5 learning matter scope affects the achievement of learning objectives					
11.6 appropriateness of teaching-learning activities					
11.7 implementation of teaching learning activities					
11.8 teaching learning activities affects the achievement of learning objectives					
11.9 appropriateness of teaching-learning materials					
11.10 teaching -learning materials affects to achievement of learning objectives					
11.11 appropriateness of apparatus for measurement and evaluation					
11.12 possibility of measurement and evaluation					
11.13 achievement of learning unit objectives is examined by measurement and evaluation					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
12. Learning unit: reaction between fat and base					
12.1 clearness of learning unit explanation					
12.2 clearness of learning objectives					
12.3 appropriateness of learning objectives					
12.4 appropriateness of learning					
12.5 learning matter scope affects the achievement of learning objectives					
12.6 appropriateness of teaching-learning activities					
12.7 implementation of teaching learning activities					
12.8 teaching learning activities affects the achievement of learning objectives					
12.9 appropriateness of teaching-learning materials					
12.10 teaching -learning materials affects the achievement of learning objectives					
12.11 appropriateness of apparatus for measurement and evaluation					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
12.12 possibility of measurement and evaluation					
12.13 achievement of learning unit objectives is examined by measurement and evaluation					

Step 2 congruent evaluation form of learning unit outline is under consideration, Are various components of curriculum outline congruent among these components?:

1. Problem, needs and goals of learning unit
2. Goals of learning unit and principle of learning unit
3. Principle of learning unit and objectives of learning unit
4. Objectives of learning unit and content of learning unit
5. Content of learning unit and teaching-learning activities
6. Teaching-learning activities and teaching-learning materials
7. Teaching-learning activities and measurement and evaluation
8. Objectives of learning unit and learning objectives of each learning unit
9. Congruence inside each learning unit is congruence between these components as the following:
   - 9.1 Learning unit explanation and learning objectives
   - 9.2 Learning objectives and scope of subject content
   - 9.3 Scope of subject matter and teaching-learning activities
   - 9.4 Teaching-learning activities and teaching-learning materials
   - 9.5 Learning objectives and measurement and evaluation

Explanation check this mark / in "level of congruence" as your opinion

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
1. Problems and needs of curriculum			
2. Goals of curriculum and principle of curriculum			
3. Principle of curriculum and objectives of curriculum			
4. Objectives of curriculum and content of curriculum			
5. Content of curriculum and teaching-learning activities			
6. Teaching-learning activities and teaching learning materials			
7. Teaching-learning activities and measurement and evaluation			
8. Objectives of learning unit and learning objectives in plan 1.			
9. Objectives of learning unit and learning objectives in plan 2.			
10. Objectives of learning unit and learning objectives in plan 3.			
11. Objectives of learning unit and learning objectives in plan 4.			
12. Congruence inside plan 1.			
12.1 learning unit explanation and learning objectives			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
12.2 learning objectives and scope of learning matter			
12.3 scope of learning matter and teaching learning activities			
12.4 teaching-learning activities and teaching-learning materials			
12.5 learning objectives and measurement and evaluation			
13.Congruence inside plan 2.			
13.1 learning unit explanation and learning objectives			
13.2 learning objectives and scope of learning matter			
13.3 scope of learning matter and teaching learning activities			
13.4 teaching-learning activities and teaching-learning materials			
13.5 learning objectives and measurement and evaluation			
14.Congruence inside plan 3.			
14.1 learning unit explanation and learning objectives			
14.2 learning objectives and scope of learning matter			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
14.3 scope of learning matter and teaching learning activities			
14.4 teaching-learning activities and teaching-learning materials			
14.5 learning objectives and measurement and evaluation			
15.Congruence inside plan 3.			
15.1 learning unit explanation and learning objectives			
15.2 learning objectives and scope of learning matter			
15.3 scope of learning matter and teaching learning activities			
15.4 teaching-learning activities and teaching-learning materials			
15.5 learning objectives and measurement and evaluation			
16.Congruence inside plan 4.			
16.1 learning unit explanation and learning objectives			
16.2 learning objectives and scope of subject matter			
16.3 scope of subject matter and teaching learning activities			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
16.4 teaching-learning activities and teaching-learning materials			
16.5 learning objectives and measurement and evaluation			

These evaluation form is adapted from the evaluation form of Bubpha, Makesrithongkum. (2002).

Suggestion.....

.....

.....

Evaluator.....( )

Appendix D

Evaluation form of learning unit outline of career and technology

This evaluation form is the evaluation form of learning unit outline of career and technology used to evaluate appropriateness and congruence among various components of curriculum of career and technology.

This evaluation form is divided to two parts as below:

1. Appropriate evaluation form of learning unit outline
2. Congruent evaluation form of learning unit outline

Could experts consider appropriateness and congruence among various components of learning unit of career and technology, please?

Step 1. Appropriate evaluation form of learning unit outline is under consideration how various components of learning unit outline that is appropriate among these components are:

1. Problems and needs of learning unit
2. Goals of learning unit
3. Principle of learning unit
4. Objectives of learning unit
5. Content of learning unit
6. Teaching-learning activities
7. Teaching-learning materials
8. Measurement and evaluation
9. Learning units

Explanation check this mark / in "level of appropriateness" as your opinion

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
1. Problems and needs of learning unit					
1.1 needs of learning unit development					
1.2 reason of learning unit development					
1.3 appropriateness of solution outline					
1.4 possibility of solution outline					
2. Goals of learning unit					
2.1 appropriateness with students					
2.2 benefit to career foundation					
2.3 congruence with social needs					
2.4 assign explicitly the developed objects					
2.5 congruence with educational policy					
3. Principle of learning unit					
3.1 clearness					
3.2 appropriateness					
3.3 possibility					
4. Objectives of learning unit					
4.1 clearness					
4.2 appropriateness with students					
4.3 congruence with educational policy					
4.4 possibility					
4.5 cover the developed objects					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
5. Matter of learning unit					
5.1 response of curriculum objectives					
5.2 arrangement of matter					
5.3 appropriateness of item fixation					
5.4 cover essential matter for students					
6. Teaching-learning activities					
6.1 congruence with subject matter					
6.2 appropriateness of teaching learning activities					
6.3 promote learners' analytical thinking					
6.4 use suitable technological materials					
6.5 implementation of teaching					
6.6 accomplish to objectives of learning unit					
7. Teaching-learning materials					
7.1 congruence with teaching-learning activities					
7.2 appropriate with students					
7.3 support arrangement of activity to achieve learning objectives					
8. Measurement and evaluation					
8.1 appropriateness of measured apparatus					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
8.5 possibility of measurement					
8.6 examine to achieve learning objectives					
8.7 measure directly learning objectives					
8.8 identify explicitly measured action					
9. Learning unit: Design and technology					
9.1 clearness of learning unit explanation					
9.2 clearness of learning objectives					
9.3 appropriateness of learning objectives					
9.4 appropriateness of learning matter scope					
9.5 learning matter scope affects the achievement of learning objectives					
9.6 appropriateness of teaching-learning activities					
9.7 implementation of teaching-learning activities					
9.8 teaching-learning activities affects the achievement of learning objectives					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
9.9 appropriateness of teaching-learning materials					
9.10 teaching-learning materials affect the achievement of learning objectives					
9.11 appropriateness of apparatus for measurement and evaluation					
9.12 possibility of measurement and evaluation					
9.13 achievement of learning unit objectives is examined by measurement and evaluation					
10. Learning unit: getting rid of metal gloomy surface					
10.1 clearness of learning unit explanation					
10.2 clearness of learning objectives					
10.3 appropriateness of learning objectives					
10.4 appropriateness of learning matter scope					
10.5 learning matter scope affects the achievement of learning objectives					
10.6 appropriateness of teaching-learning activities					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
10.7 implementation of teaching learning activities					
10.8 teaching learning activities affects the achievement of learning objectives					
10.9 appropriateness of teaching-learning materials					
10.10 teaching -learning materials affects the achievement of learning objectives					
10.11 appropriateness of apparatus for measurement and evaluation					
10.12 possibility of measurement and evaluation					
10.13 achievement of learning unit objectives is examined by measurement and evaluation					
11. Learning unit: getting rid of iron rust on cloth					
11.1 clearness of learning unit explanation					
11.2 clearness of learning objectives					
11.3 appropriateness of learning objectives					
11.4 appropriateness of learning matter scope					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
11.5 learning matter scope affects the achievement of learning objectives					
11.6 appropriateness of teaching-learning activities					
11.7 implementation of teaching learning activities					
11.8 teaching learning activities affects the achievement of learning objectives					
11.9 appropriateness of teaching-learning materials					
11.10 teaching -learning materials affects the achievement of learning objectives					
11.11 appropriateness of apparatus for measurement and evaluation					
11.12 possibility of measurement and evaluation					
11.13 achievement of learning unit objectives is examined by measurement and evaluation					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
12. Learning unit: problem solving of clogged drain pipe					
12.1 clearness of learning unit explanation					
12.2 clearness of learning objectives					
12.3 appropriateness of learning objectives					
12.4 appropriateness of learning					
12.5 learning matter scope affects the achievement of learning objectives					
12.6 appropriateness of teaching-learning activities					
12.7 implementation of teaching learning activities					
12.8 teaching learning activities affects the achievement of learning objectives					
12.9 appropriateness of teaching-learning materials					
12.10 teaching -learning materials affects the achievement of learning objectives					
12.11appropriateness of apparatus for measurement and evaluation					

List of evaluation	Level of appropriateness				
	out standing	very good	average	fair	poor
12.12 possibility of measurement and evaluation					
12.13 achievement of learning unit objectives is examined by measurement and evaluation					

Step 2 congruent evaluation form of learning unit outline is under consideration, are various components of curriculum outline congruent among these components?:

1. Problem, needs and goals of learning unit
2. Goals of learning unit and principle of learning unit
3. Principle of learning unit and objectives of learning unit
4. Objectives of learning unit and content of learning unit
5. Content of learning unit and teaching-learning activities
6. Teaching-learning activities and teaching-learning materials
7. Teaching-learning activities and measurement and evaluation
8. Objectives of learning unit and learning objectives of each learning unit
9. Congruence inside each learning unit is congruence between these components as the following:

9.1 Learning unit explanation and learning objectives

9.2 Learning objectives and scope of subject matter

9.3 Scope of subject matter and teaching-learning activities

9.4 Teaching-learning activities and teaching-learning materials

9.5 Learning objectives and measurement and evaluation

Explanation check this mark / in "level of congruence" as your opinion

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
1. Problems and needs of curriculum			
2. Goals of curriculum and principle of curriculum			
3. Principle of curriculum and objectives curriculum			
4. Objectives of curriculum and content of curriculum			
5. Content of curriculum and teaching-learning activities			
6. Teaching-learning activities and teaching-learning materials			
7. Teaching-learning activities and measurement and evaluation			
8. Objectives of learning unit and learning objectives in plan 1.			
9. Objectives of learning unit and learning objectives in plan 2.			
10.Objectives of learning unit and learning objectives in plan 3.			
11.Objectives of learning unit and learning objectives in plan 4.			
12.Congruence inside plan 1.			
12.1 learning unit explanation and learning objectives			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
12.5 learning objectives and scope of learning matter			
12.6 scope of learning matter and teaching learning activities			
12.7 teaching-learning activities and teaching-learning materials			
12.8 learning objectives and measurement and evaluation			
13.Congruence inside plan 2.			
13.1 learning unit explanation and learning objectives			
13.2 learning objectives and scope of learning matter			
13.3 scope of learning matter and teaching learning activities			
13.4 teaching-learning activities and teaching-learning materials			
13.5 learning objectives and measurement and evaluation			
14.Congruence inside plan 3.			
14.1 learning unit explanation and learning objectives			
14.2 learning objectives and scope of learning matter			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
14.3 scope of learning matter and teaching learning activities			
14.4 teaching-learning activities and teaching-learning materials			
14.5 learning objectives and measurement and evaluation			
15.Congruence inside plan 3.			
15.1 learning unit explanation and learning objectives			
15.2 learning objectives and scope of learning matter			
15.3 scope of learning matter and teaching learning activities			
15.4 teaching-learning activities and teaching-learning materials			
15.5 learning objectives and measurement and evaluation			
16.Congruence inside plan 4.			
16.1 learning unit explanation and learning objectives			
16.2 learning objectives and scope of subject matter			
16.3 scope of subject matter and teaching learning activities			

List of evaluation	Level of congruence		
	congruence	not sure	no congruence
16.4 teaching-learning activities and teaching-learning materials 16.5 learning objectives and measurement and evaluation			

These evaluation form is adapted from the evaluation form of Bubpha, Makesrithongkum. (2002).

Suggestion.....

.....

.....

Evaluator.....( )

Appendix E

Opinions toward learning units integrated between science and career & technology subjects

Explanation: please consider statements in the left then mark X in answer sheet as your opinion.

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affects to these general feeling ?					
1. Have the aspiration and enthusiasm in technological design	.....	.....	.....	.....	.....
2. Appreciate the value and usefulness of science and technology.	.....	.....	.....	.....	.....
3. At school students least study a lot of science and technology.	.....	.....	.....	.....	.....
4. Students don't like science subject.	.....	.....	.....	.....	.....
5. Students don't like career & technology subject.	.....	.....	.....	.....	.....
6. It is possible that students will choose a job in science and technology.	.....	.....	.....	.....	.....
7. Promote students to get new knowledge.	.....	.....	.....	.....	.....
8. Promote students to be reasonable people.	.....	.....	.....	.....	.....
9. Appreciate in the result of science and technology.	.....	.....	.....	.....	.....
10. Be satisfied in learning experience about integrated learning units.	.....	.....	.....	.....	.....

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affect to these general feeling ?					
11. Cause lack of collaboration.	.....	.....	.....	.....	.....
12. Be satisfied in learning experience of science and technology.	.....	.....	.....	.....	.....
13. Get knowledge from many resources.	.....	.....	.....	.....	.....
14. Having motivation for continued learning.	.....	.....	.....	.....	.....
15. Students like to learn more about science and technology at school.	.....	.....	.....	.....	.....
16. Students lack learning interest and intention in performing.	.....	.....	.....	.....	.....
17. Students think of career subject less than academic subject.	.....	.....	.....	.....	.....
18. Appreciate implementation of integrated scientific knowledge and technology in everyday life.	.....	.....	.....	.....	.....
19. Think of having job in technology on some days.	.....	.....	.....	.....	.....
20. Cause lack self-confidence.	.....	.....	.....	.....	.....
21. Cause not dare to show.	.....	.....	.....	.....	.....
22. Science causes competition.	.....	.....	.....	.....	.....

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affect these general feeling ?					
23. Promote creative thinking.	.....	.....	.....	.....	.....
24. Think that technology causes unemployment.	.....	.....	.....	.....	.....
25. Technology does not depend on a lot of science.	.....	.....	.....	.....	.....
26. Technology is only for bright people.	.....	.....	.....	.....	.....
27. There are connections to real life situations.	.....	.....	.....	.....	.....
28. When new thing is discovered, I want to know more details immediately.	.....	.....	.....	.....	.....
29. Think that there are few TV and radio programs about technology.	.....	.....	.....	.....	.....
30. Appreciate the implementation of scientific knowledge and technology in career.	.....	.....	.....	.....	.....
How do integrated learning units between science and career & technology affect these general activities ?					
31. Cause to think about creation or invention of the methods or products.	.....	.....	.....	.....	.....

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affect these general activities ?					
32. Choose the suitable problem solving method.	.....	.....	.....	.....	.....
33. Be willing to find knowledge from many medias.	.....	.....	.....	.....	.....
34. Help identify the problem or need.	.....	.....	.....	.....	.....
35. Plan and design the products or methods for problem solving or need.	.....	.....	.....	.....	.....
36. Arrange related learning activities.	.....	.....	.....	.....	.....
37. Perform along to the steps that are designed.	.....	.....	.....	.....	.....
38. Students don't intend to learn science.	.....	.....	.....	.....	.....
39. Students don't intend to learn career and technology.	.....	.....	.....	.....	.....
40. Assess the performance of each other.	.....	.....	.....	.....	.....
41. Test and evaluate the process, method for improvement.	.....	.....	.....	.....	.....
42. Have worked with hobbies related to science.	.....	.....	.....	.....	.....

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affect to these general activities ?					
43. Have worked with hobbies related to technology.	.....	.....	.....	.....	.....
44. Evaluate satisfaction of the result.	.....	.....	.....	.....	.....
45. Handle or arrange with technology tools.	.....	.....	.....	.....	.....
46. People who study technology have to be smart.	.....	.....	.....	.....	.....
47. People who study technology have to be talented.	.....	.....	.....	.....	.....
48. People who study technology have only to be good at both mathematics and science.	.....	.....	.....	.....	.....
49. To understand Technology people have to take technology training course.	.....	.....	.....	.....	.....
50. Relate process skills to everyday problem solving and higher order thinking skills	.....	.....	.....	.....	.....
51. Integrated learning units that use theme concept and problem to be the core help eliminate repetition in the subject content.	.....	.....	.....	.....	.....
52. Help reduce learning time of each content.	.....	.....	.....	.....	.....

Statement	Strongly agree (A)	Agree (B)	Neutral (C)	Dis-agree (D)	Strongly Dis-Agree (E)
How do integrated learning units between science and career & technology affect to these general activities ?					
53. Content integration between different subjects makes learners have a chance to review the content that is learned from other subject.	.....	.....	.....	.....	.....
54. Help apply knowledge in daily life better.	.....	.....	.....	.....	.....
55. Apply knowledge and working skill in career.	.....	.....	.....	.....	.....
56. Link the content between subjects to continue and link well.	.....	.....	.....	.....	.....
57. Activities are congruent with content.	.....	.....	.....	.....	.....
58. Present work.	.....	.....	.....	.....	.....
59. Evaluate correctly as learning objectives.	.....	.....	.....	.....	.....

Appendix F

Example of science learning management plan

Plan one

Science content group

Item: Chemical reaction in daily life Three hours

Learning standard: 3.2

Learning objectives

1. Explain the meaning of chemical reaction
2. Examine the occurrence of some chemical reactions
3. Write chemical equations from some chemical reactions
4. Explain and give an example of chemical reaction.

Learning content

1. The meaning of chemical reaction
2. Examination of the occurrence of some chemical reactions
3. Writing of chemical equations from some chemical reactions
4. Chemical reaction in daily life

The arrangement of learning activities

Guide step

1. Students test the knowledge and opinion of integrated learning unit before learning

2. Teacher guides to discuss about chemical reaction in daily life. Many chemical reaction may cause advantages and disadvantages in life and environment such as the combustion of fuel, photosynthesis, decomposition of some food, iron rust and corrosion of building. Furthermore, there are related the chemical processes occur in our body. Therefore, food digestion reaction inlife and photosynthesis have the vital and need for life.

- When we eat food, if the digestion process was wrong. What is the consequence? (The food that is not digested makes flatulence and the body does not receive the energy from digestion process.)
- If the plant can not do the photosynthesis, how and does it affect life and

environment. (The photosynthesis in plants produce starch and sugar that are the food for life. In addition, it brings carbon dioxide to decrease the air pollution and release oxygen for respiration of life.

3. Teacher asks students to join the discussion about the status in daily life and several activities of human being related to animals, plants, environment and the occurrence of the chemical reactions.

4. Teacher tells the item and learning objectives to students.

Teaching step

1. Teacher assigns students to search for the meaning of chemical reactions in knowledge sheet, texts, internet and journals.

2. What will happen when burning of wood, coal, gasoline, and other fuels or the tarnishing of a silver spoon or the rusting of a nail? (The burning of wood, coal, gasoline, and other fuels produces light, heat, CO_2, H_2O. For the tarnishing of a silver spoon produces new substance on silver surface and the rusting of a nail produces the rust layer on nail surface.

3. Teacher assigns students to do activity of daily life chemical reactions which some reactions may affect the life and environment.

4. Students record the data for discussion and conclusion of the activity.

5. Students join the discussion about collecting and analyzing data from the activity.

6. Teacher begins to discuss about the questions after doing the activities leading to data analysis and conclusion.

7. Students conclude the results of the activity to cover the hypothesis.

8. Teacher examines the results of student's conclusion and make complete correction.

9. Teacher asks questions; What do we call when a starting substance changes to a new substance which having different properties from the starting substance?

10. What do we call the substance that is changed in item 9?

11. What is the product deriving from the reaction of sodium metal with chlorine gas?

12. Teacher leads the discussion about the type of reactions concerning with the energy change as shown in the learning material.

13. Students join the discussion about writing the principle of chemical equations. This is performed by initiating the students to participate in answers and questions. The activity also includes an example of chemical reaction in daily life.

14. Teacher suggests and warns students about safety process, harm of chemical substances before the experiment including safety and protection such as eye glasses or others.

15. Students works in pairs and practice to write the chemical equations in daily life. This activity take about 5-10 minutes.

16. Students are asked to answer the questions to test the understanding of some chemical reactions.

17. Teacher leads the discussion about the questions after doing the activities.

18. Teacher examines the result of student's conclusion and correct the mistakes.

Conclusion step

1. Students study the guide book and do the activity leading to the cognition that should be concluded as below:

Chemical reaction is the change of matter to the new matter having different chemical properties from the original matter such as color, forming gas or sediment. The matter that was changed, known as "starting substance" and the new matter, known as "product".

2. Students raise doubtful questions until understanding clearly.

3. Students write the report of the activity outcome.

Learning materials

1. Learning unit
2. Experiment apparatuses of metal gloomy surface and protection

Measurement and evaluation

Measurement and evaluation methods

1. To evaluate from discussion and answering question
2. To evaluate from students' working skills

3. To evaluate learning activity outcome from learners' group
4. To evaluate learning activity outcome from the teacher
5. Doing report

Equipment

1. Evaluation form of learning acting outcome from learners' group
2. Evaluation form of learning acting outcome from the teacher
3. Work sheet
4. Report

Learning sources

1. Science library
2. School library
3. Internet

Worksheet Matter: Chemical reaction in daily life

Subject: Science Grade: 10 Three hours

Explanation

1. Students study and do activity of chemical reaction in daily life.
2. Students record data for the discussion and conclusion of this activity.
3. Students answer questions after doing activity, then analysis and conclusion.
4. Students conclude the experimental results covering the hypothesis.
5. Students write the report of activity outcome.

Appendix G

Learning management plan

Plan two

Science substance group

Matter: Gloomy corrosion rust of metal and protection Four hours

---

Learning standard: 3.2

Learning objectives:

1. Explain the meaning of metal corrosion and metal rust and can write equation of reactions.

2. Tell the condition of metal corrosion and metal rust that occurs from reaction of metal and oxygen.

3. Experiment to collect and analyze the data about metal corrosion that occurs from reaction of metal and oxygen.

4. Explain the protection method of metal corrosion that occurs from reaction of metal and oxygen.

Learning substance:

1. Meaning of metal corrosion

2. Metal corrosion that occurs from the reaction of metal and oxygen.

3. Experiment and metal corrosion that occurs from the reaction of metal and oxygen.

4. Protection method of metal corrosion that occurs from the reaction of metal and oxygen.

Teaching-learning management

Guide step:

1. Students are assigned to review the outcome of the reaction of metal and environment.

2. Study and search the meaning of metal corrosion from handbooks, internet, textbooks and related documents

3. Explore and tell the difference of surface condition of metal surface or metal instruments such as aluminum, copper, zinc when they are placed for a long time and how

they are different from new metal instruments.

4. Different condition of metal surface or metal instruments such as aluminum, copper, zinc, placed for a long time and different from new metal instruments whether they create problem or not.

5. Teacher announces learning items and learning objectives.

Teaching step

Steps of scientific process:

1. Identify problem is to set the aim from this experiment.

2. Hypothesis is to guess something that still does not happen and to make students need to prove whether it is true or not.

3. Experimental design is working plan for proving hypothesis.

4. Experiment is to prove that hypothesis is true or false.

5. Record of the experimental result is to record for quoting problem and hypothesis.

6. Conclusion is to add the outcome, problem, hypothesis, design, record together for convenience to study.

7. Assign students to study many variables to use in experiment from a guide book for more understanding the experiment.

8. Assign students to tell causes of metal gloomy surface or rust or corrosion when they are placed for a long time.

9. Metal gloomy surface or rust, when they are placed for a long time is effect of chemical reaction or not if it is effect of chemical reaction, metal should react with any substance

10. Students study problem of metal surface when they are placed for a long time from a guide book.

11. Students study and brainstorm to find out the answer for the hypothesis.

12. Students study whether when metal react with oxygen will change or not. Students study from activity.

13. What is the problem that needs to be solved?

14. What is the hypothesis from problem of this activity?

15. What is the independent variable of this activity?

16. What is the dependent variable of this activity?

17. What is the control variable of this activity?

18. Teacher suggests students about safety process before the experiment by warning about harm from chemical substances and instruments including using safety instruments such as eye glasses or others.

19. Students record data to use in discussion and conclusion of this activity.

20. Students discuss collection and analysis from doing activity.

21. Teacher leads the discussion about questions after activity for analysis and conclusion.

22. Students conclude the experiment to cover hypothesis.

23. Teacher examines experimental conclusion of students and correct until completion.

Conclusion step:

1. Students conclude the cognition together, getting from the guide book and doing activity that should conclude as below: Metal corrosion is chemical reaction, occurring from metal and environment that are humidity (H_2O) and oxygen (O_2) or water and the air, acid or other oxidizing agent. Iron rust causes oxygen in the air that combines with iron and water and helps oxygen and iron combine easier, so in damp or wet place the rust occurs easier and protection methods are oil paint or coated matter to prevent the air and water to combine together.

2. Students raise doubtful questions until understanding clearly.

3. Students write the report of activity outcome.

Learning materials

1. Learning plan

2. Experiment apparatuses of metal gloomy surface and protection

Measurement and evaluation

Measurement and evaluation methods

1. Evaluate from discussion and answering question

2. Evaluate from students' working skills

3. Evaluate learning acting outcome from learners' group

4. Evaluate learning acting outcome from the teacher
5. Doing report

Equipment

1. Evaluation form of learning acting outcome from learners' group
2. Evaluation form of learning acting outcome from the teacher
3. Work sheet
4. Report

Learning sources

1. Science library
2. School library
3. Internet such as:

* http://www.GCSE_Coursework_Chemistry_Thermal_Decomposition_of_Metal Oxide.htm
* http://www.bbc.co.uk/education/ks3bitesize/science/metals/metali2rb.shtml
* http://www.lbl.gov/LBL-Science-Articles/Archive/metal-libraries.html
* http://www.wpbschoolhouse.btinternet.co.uk/page23/page23.htm
* http://www.bnl.gov/community/link/LL_05_01.pdf
* http://www.ceramics.rutgers.edu/directory/jjx.html
* http://www.fcv-bcn.org/eng/sch_eng.htm

Worksheet Matter Gloomy corrosion rust of metal and protection

Subject: science grade: 10 three hours

Explanation

1. Students study and do activity of gloomy corrosion rust of metal and protection.
2. Students record data for the discussion and conclusion of this activity.
3. Students answer questions after doing activity, analyzing and concluding.
4. Students conclude the result of experiment to cover hypothesis.
1. Students write the report of activity outcome.

Appendix H

Career & technology learning management plan

Plan two

Career & technology substance group

Matter: problem solving of metal gloomy surface Four hours

Learning standard: 3.1.2, 3.1.3

Learning objectives:

1. Explain problem solving process of gloomy surface of aluminum or brass vessel

2. Design problem solving method of gloomy surface of aluminum or brass vessel.

Learning substance:

1. Use technological process, design problem solving method, create or product to solve the problem of gloomy surface of aluminum or brass vessel worthily, economically, properly, conveniently and safely

2. Problem solving method of gloomy surface of aluminum or brass vessel.

Teaching-learning management

Identify problem step

Teacher and learners join the discussion and raise questions as below:

1. Learners discuss and tell the difference of surface status of metal implement or pretty metal vessel such as aluminum, copper, zinc and iron when we place for a long time and how it differs from new vessel.

2. How does metal gloomy surface or rust or corrosion cause problems?

3. Are there other metals that are placed a long time to make metal surface gloomy or rust or corrode?

4. How can science and technology be related to metal gloomy surface?

5. How do we solve the problem of metal gloomy surface?

6. What do we do if we need to solve the problem of metal gloomy surface?

7. Teacher assign learners to identify the problem that they need to solve.

Step of collection of useful information to develop possible solution

1. Join the discussion about problem solving of gloomy surface of aluminum or brass vessel

2. Assign learners to collect data and knowledge to look for problem solving method of gloomy surface of aluminum or brass vessel

3. Decide together the ways of problem solving.

Step of selection the best possible solution

In this attribute assigning, one group of learners might choose one method as follows for problem solving such as paint, plastic glaze, oil paint, metal glaze and elimination of gloomy surface of metal. In selection, an attribute is needed to be considered from sub item 1.2 figure C. Compare the solution methods or create all products that are chosen. Then plan and identify details of design for solution methods or creating products.

1. Learners choose together proper solution methods of gloomy surface of aluminum or brass vessel that is comfortable, fast, economic worthy, efficient and satisfied to users.

Step of planning of detail design and making

1. Learners plan together and design solution methods of gloomy surface of aluminum or brass vessel.

Example[1] Design solution methods or create all products of gloomy surface of aluminum or brass vessel that occur from reaction between metal and oxygen.

Problem identification and needs to design for looking for solution methods or creating all products of gloomy surface of aluminum or brass vessel that occur from reaction between metal and oxygen.

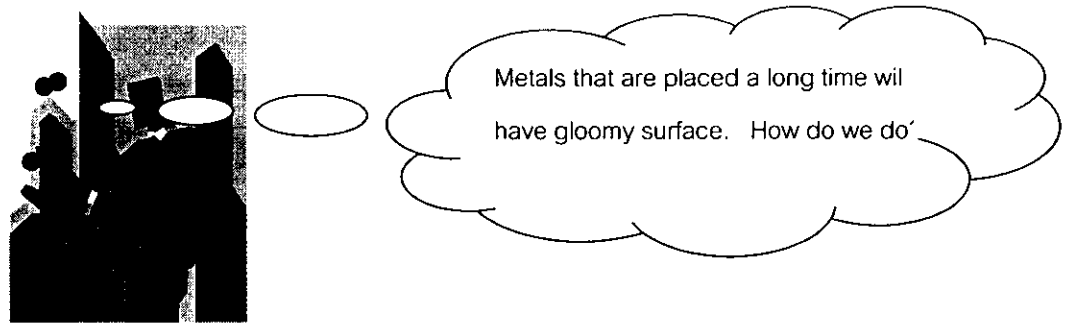


Figure A. Identify the problem, need or want

- Collection of useful information to develop possible solutions by asking questions

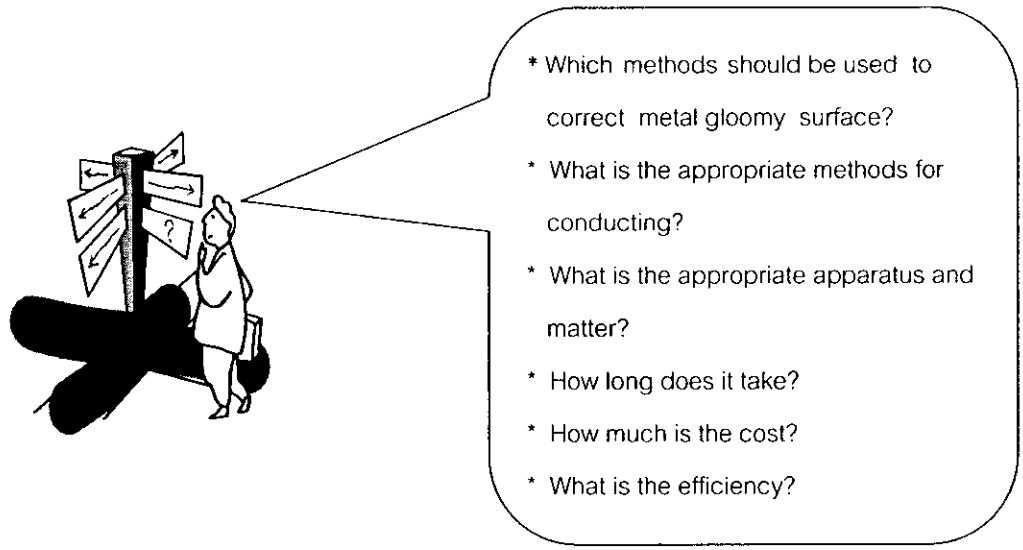


Figure B. Putting questions to look for need attributes

---

[1]Adapted from Panya Srichan; et al (2003). Educational Reform of Basic Educational Curriculum B.E. 2544. Learning Matter of Career and Technology of substance 3 stage 4

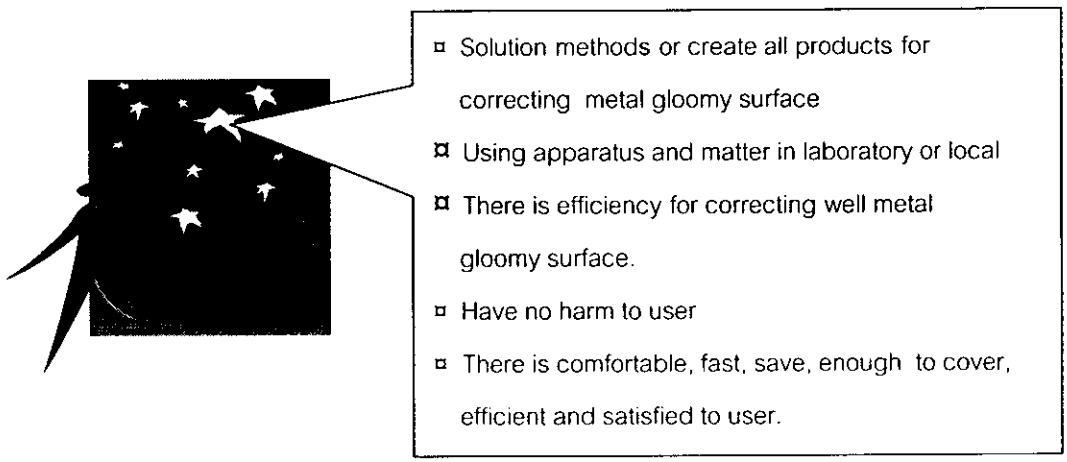


Figure C. Attribute identification and needs of solution methods or create all products

1.1 Selection the best possible solution or products for design

In this attribute, one group of students might choose one method as follows for problem solving such as paint, plastic glaze, oil paint, metal glaze and elimination of gloomy surface of metal. In selection an attribute in needed to be considered from sub item 1.2 figure C. Comparing the solution methods or create all products that are chosen. Then plan and identify details of design for solution methods or creating products.

1.2 Planning of detailed design of solution methods or products

After we select the appropriate method, we have to assign details of apparatus and matter that we study or apply.

Making solution or creating products by explaining all details:

1. Learners assign what the apparatus and matter that need to make solution of gloomy surface of aluminum or brass vessel are.

2. Teacher assign learners to write the method as designed for metal solution that occurs from reaction between metal and oxygen.

3. Learners experiment together according to the plan and design for solution of gloomy surface of aluminum or brass vessel.

4. What are apparatus and matter, used for solution of gloomy surface of aluminum or brass vessel?

5. Learners write the method as design for metal solution of gloomy surface of aluminum or brass vessel as the agreement of group.

6. Learners conduct as design and how to record the outcome.

7. Teacher assign learners to collect and analyze data from the activity.

8. Teacher suggest students about safety process before the experiment by warning about harm from chemical substances and instruments including using safety instruments such as eye glasses or others.

9. Learners join the discussion about collecting and analyzing data from the activity.

10. Learners conclude the outcome.

11. Learners answer the questions from the results of the performance.

Step of testing for feasibility

This testing is to test the efficiency of solution method or creating product whether it is useful comfortable, fast, economic, worthy, efficient and satisfied to users.

1. How do students test the efficiency of solution method or create product?

Step of modification and improvement

1. One group of students might choose one method for problem solving such as paint, plastic glaze, oil paint, metal glaze and elimination of gloomy surface of metal that is not appropriate with vessel, used to touch with food, then assign students to join the discussion of group performance to know about feed back and look for lines to help solution efficiently, fast, comfortably, worthy, Use data to improve and develop group performance. For other groups that have practical work, they should prevent their ideas to increase the efficiency of solution method or creating products.

2. Teacher assign learners in group to propose other ideas for better increasing the efficiency of solution method or creating products.

3. How do students improve methods of solution method or creating products to be more efficient?

Step of evaluation

1. Learners conclude the outcome by identifying whether the method could solve the problem or respond to needs or not. How is it better than the first method? Is it

enough to cover the cost? Is it economical? and How?

2. Teacher and students join the discussion about the conclusion of the outcome and how it is related to daily life.

3. Teacher and students the discussion for integrating scientific knowledge that is related to technology.

4. Learners combine cognition getting from the performance and discussion to answer the questions in question activity.

5. Teacher hands out group evaluation form to learners.

6. Group representative present the performance and cognition to others in front of class.

7. Teacher evaluates learners in each group.

8. Teacher and learners join the discussion and summarize what each group presents.

Learning materials

1. Learning plan
2. Apparatuses of activity

Measurement and evaluation

Measurement and evaluation methods

1. To evaluate from discussion and answering question
2. To evaluate from students' working skills
3. To evaluate learning acting outcome from learners' group
4. To evaluate learning acting outcome from the teacher
5. To do the report.

Equipment

1. Evaluation form of learning acting outcome from learners' group.
2. Evaluation form of learning acting outcome from the teacher.
3. Work sheet.
4. Report

Learning resources

3. Science library
4. School library

5. Internet:

* http://www.GCSE Coursework Chemistry Thermal Decomposition of Metal Oxide.htm
* http://www.bbc.co.uk/education/ks3bitesize/science/metals/metali2rb.shtml
* http://www.lbl.gov/LBL-Science-Articles/Archive/metal-libraries.html
* http://www.wpbschoolhouse.btinternet.co.uk/page23/page23.htm
* http://www.bnl.gov/community/link/LL_05_01.pdf
* http://www.ceramics.rutgers.edu/directory/jjx.html
* http://www.fcv-bcn.org/eng/sch_eng.htm

Worksheet Matter: Getting rid of metal gloomy surface

Subject career & technology grade 10 four hours

Explanation

1. Students select the best possible solution of metal gloomy surface
2. Students design and select apparatus and matter, used for problem solving of gloomy surface by recording in thee form.
3. Students conduct of problem solving of metal gloomy surface.
4. Students present the performance.
5. Students assess the performance and improvement.

Appendix I

Examples of science achievement test

Explanation: Choose the correct answer by putting sign x on the choice in the answer sheet.

1. Which of these represents a chemical change?
   a. Bubbles occurs while eggs are beaten.
   b. Sugar is soluble in water.
   c. Water is frozen.
   d. Bubbles occurs while dissolving sodium bicarbonate in lemon juice.
2. Which of these do not occur in chemical reaction?
   a. Iron is transformed to rust.
   b. Boiling water changes to vapor.
   c. Zinc corrosion occurs in hydrochloric acid.
   d. Combusion of fuels produces water and carbon dioxide.
6. Which of these do not represent metal corrosion?
   a. Metal contacts with air.
   b. Metal contacts with fat.
   c. Metal contacts with water and air.
   d. Copper is changed to rust
12. Which of these equations represents reaction between magnesium (Mg) and hydrochloric acid (HCl)?
   a. $Mg(s) + HCl(aq) \longrightarrow MgH_2(aq) + Cl_2(g)$
   b. $Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$
   c. $Mg(s) + HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$
   d. $Mg(s) + 2HCl(aq) \longrightarrow MgH_2(aq) + Cl_2(g)$
27. Compounds A,B,C and D are added into iron rust, Compound B does not react with iron rust, but, the reaction of Compounds A, C and D can eliminate the iron rust. Which of the following choices is corresponded to the reaction?
   a. sulfuric acid, oxalic acid, lemon and soap
   b. soap, sulfuric acid, lemon and tea
   c. sulfuric acid, mortar, oxalic acid and lemon

d. lemon, oxalic acid, soap and mortar

29. What is substance A in the following equation?

glycerol + A $\longrightarrow$ triglyceride + water

a. base

b. metal

c. water

d. fatty acid

30. In which condition can we solve the problem by "saponification" reaction?

a. cleaning

b. clogged drain pipe

c. get rid of rust

d. both a. and b.

Appendix J

Examples of career & technology achievement

Explanation: Choose correct answer by putting sign x on the choice in the answer sheet.

1. When we use brass implement or pretty metal vessel such as brass spoon, brass tray, coin, or other vessel for a long time as month or year, we will find that there is problem, what's the problem?

   a. implements break up
   b. implements have bad smell
   c. implements have gloomy surface
   d. implements limpid

2. In what is step as technological process in question 1. is?

   a. identification of the problem
   b. selection the best possible solution
   c. planning detailed design and conducting
   d. collection of useful information to develop possible solutions

3. What is step that students should perform in choosing suitable problem solving method?

   a. identification of the problem
   b. modification and improvement
   c. testing to see the feasibility
   d. collection of useful information to develop possible solutions

7. If you want to solve the problem of brass gloomy surface, what principle should be used under consideration?

   a. It can solve the problem, be fast and worthy.
   b. It is valid, economical and satisfied.
   c. It is efficient, worthy, fast and satisfied.
   d. It can solve the problem and be efficient, fast, economical, worthy and satisfied.

8. If the product or solution method does not work or could not be used, what should be done?

   a. assessment the product
   b. modification and improvement
   c. testing to see the feasibility
   d. planning detailed design and conducting

TABLE 14 THE COMPARISON THE DIFFERENCE OF SCIENCE ACHIEVEMENT BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP

	science achievement (30 scores)		
number	before experiment (n=38)	after experiment (n=34)	difference
1	15	7	-
2	13	29	+[2]
3	10	28	+
4	11	-	
5	16	28	+
6	14	27	+
7	12	30	+
8	7	30	+
9	12	26	+
10	12	24	+
11	7	26	+
12	14	-	
13	9	25	+
14	11	24	+
15	10	5	+
16	10	28	+
17	15	15	+
18	12	7	+
19	4	28	+
20	12	28	+
21	8	27	+
22	10	28	+

[2] + mean difference of achievement after the experiment, higher than before the experiment

TABLE 14 (continued)

	science achievement (30 scores)		
number	before experiment (n=38)	after experiment (n=34)	difference
23	10	-	
24	8	28	+
25	9	16	+
26	16	26	+
27	13	29	+
28	13	30	+
29	12	28	+
30	17	28	+
31	11	29	+
32	12	29	+
33	11	16	-
34	12	-	
35	10	28	+
36	11	27	+
37	11	26	+
38	8	26	+

TABLE 15 THE COMPARISON OF THE DIFFERENCE OF CAREER & TECHNOLOGY ACHIEVEMENT BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP

career & technology achievement (30)			
number	before experiment (n=38)	after experiment (n=34)	difference
1	5	14	+
2	6	28	+
3	9	28	+
4	11	-	+
5	8	29	+
6	11	30	+
7	11	30	+
8	20	29	+
9	11	27	+
10	9	24	+
11	21	29	+
12	7	-	*
13	9	28	+
14	21	22	+
15	11	4	-
16	13	27	+
17	7	29	+
18	10	7	+
19	6	30	+
20	11	29	+
21	17	29	+

TABLE 15 (continued)

career & technology achievement (30)			
number	before experiment (n=38)	after experiment (n=34)	difference
22	12	30	+
23	18	-	
24	4	30	+
25	7	20	+
26	6	29	+
27	8	30	+
28	7	29	+
29	7	29	+
30	10	29	+
31	20	30	+
32	15	29	+
33	15	25	+
34	18	-	
35	7	27	+
36	8	30	+
37	9	26	+
38	9	25	+

TABLE 16 THE COMPARISON OF THE DIFFERENCE OF SCIENCE ACHIEVEMENT BEFORE AND AFTER THE EXPERIMENT OF THE CONTROL GROUP

	science achievement (30 scores)		
number	before experiment (n=38)	after experiment (n=34)	difference
1	-	17	
2	12	19	+
3	11	20	+
4	12	12	-
5	12	17	+
6	11	14	+
7	12	15	+
8	18	27	+
9	14	13	-
10	13	15	+
11	10	-	
12	13	22	+
13	11	9	-
14	10	15	+
15	14	12	-
16	8	20	+
17	11	14	+
18	12	12	+
19	12	23	+
20	-	16	+
21	12	12	+
22	-	21	+

TABLE 16 (continued)

science achievement (30 scores)			
number	before experiment (n=38)	after experiment (n=34)	difference
23	14	22	+
24	16	23	+
25	14	15	+
26	9	15	+
27	13	21	+
28	14	23	+
29	13	18	+
30	13	19	+
31	14	-	
32	10	11	+
33	17	20	+
34	14	18	+
35	11	17	+
36	14	16	+
37	14	23	+
38	14	19	+
39	11	17	+
40	14	22	+
41	14	22	+
42	14	18	+
43	8	21	+
44	9	22	+
45	17	21	+

TABLE 17 THE FREQUENCY OF THE STUDENTS' OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP

item	before experiment (n=38)					after experiment (n=37)				
	5	4	3	2	1	5	4	3	2	1
1	7	27	4			9	27	1		
2	10	24	4			16	18	3		
3		3	18	14	3	2	3	9	17	6
4		3	7	16	12	3	-	6	12	16
5		2	8	22	6		7	6	16	8
6	8	19	10	1		7	10	19	1	
7	16	18	3	1		20	15	2		
8	11	22	5			11	19	7		
9	2	25	10	1		2	24	7	4	
10	4	25	8	1		11	19	5	2	
11	1	2	4	23	8	1	2	7	13	14
12	7	24	7			8	22	7		
13	16	17	5			19	13	2	3	
14	6	22	8	2		4	24	7	2	
15	10	17	8	3		13	12	8	4	
16			7	22	9	2	2	7	17	9
17	2	2	14	13	7		3	8	14	12
18	12	23	3			23	12	1	1	
19	10	18	10			9	22	6		
20		1	9	16	12	2	6	6	14	15
21	3		6	16	13	1	4	4	6	22
22		5	7	11	15	3	2	4	8	

TABLE 17 (continued)

item	before experiment (n=38)					after experiment (n=37)				
	5	4	3	2	1	5	4	3	2	1
23	20	16	1	1		20	14	2	1	
24	1	7	14	8	8	2	3	11	10	10
25		3	3	14	18		6	1	18	12
26		1	4	18	15	1	6	2	8	20
27	6	28	4			8	24	4	1	
28	7	23	8			11	18	8		
29	2	3	17	14	2	2	7	18	4	6
30	6	29	1	2		17	11	9		
31	8	24	6			20	16	1		
32	7	28	2	1		7	27	3		
33	9	25	4			6	27	4		
34	5	25	7	1		16	20	1		
35	11	23	4			13	23	1		
36	11	16	9	2		10	21	6		
37	12	14	9	3		3	24	8	1	
38		3	4	18	13	1	4	2	10	20
39		1	6	19	12		4	4	10	19
40	4	21	12			15	15	5	2	
41	2	28	8			7	23	5	2	
42	5	15	14	2	1	7	18	9	3	
43	8	14	11	2	2	2	13	20	2	

TABLE 17 (continued)

items	before experiment (n=38)					after experiment (n=37)				
	5	4	3	2	1	5	4	3	2	1
44	8	19	10	1		8	27	2		
45	4	20	11	3		11	13	8	2	4
46	1	4	9	19	5	3	7	5	9	13
47	1	2	7	19	9	4	3	11	9	10
48		4	6	13	15		5	10	11	12
49	2	8	16	8	4	4	10	11	8	4
50	1	14	21	2		1	14	16	5	1
51	3	16	19			5	28	3	1	
52	3	9	19	6	1	5	13	8	11	
53	6	18	12	2		4	27	4	2	
54	8	22	7	1		18	19			
55	8	23	7			16	19	2		
56	9	17	12			16	10	11		
57	6	24	7	1		9	24	4		
58	11	20	5	2		15	18	4		
59	14	14	10			21	13	3		

TABLE 18 THE FREQUENCY OF THE STUDENTS' OPINIONS TOWARD THE LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT OF THE CONTROL GROUP

items	before experiment (n=43)					after experiment (n=43)				
	5	4	3	2	1	5	4	3	2	1
1	5	26	11	1		11	23	7	2	
2	9	28	6			16	23	4		
3	1	6	13	18	5	2	12	21	8	
4		2	13	15	13			8	20	15
5	1	7	21	10	4		5	15	17	6
6	7	12	22	1	1	6	18	17	2	
7	19	21	4			22	20	1		
8	13	26				19	18	6		
9	6	25	11	1		5	22	14	2	
10	5	24	14			7	25	9	2	
11	1	3	9	20	10	1		5	20	17
12	3	30	8	1	1	9	23	11		
13	1	19	8	3		10	24	5	4	
14	6	24	12	1		10	23	10		
15	8	19	16			6	22	12	3	
16	1		14	14	4		1	8	22	12
17		8	18	12	5	2	8	17	13	3
18	9	26	7	1		13	23	5	1	1
19	7	17	17	2		6	27	9	1	
20	1		8	16	18	1	1	1	22	18
21		4	2	20	17		1	4	20	18
22	3	10	5	16	9	2	6	7	13	15

TABLE 18 (continued)

items	before experiment (n=43)					after experiment (n=43)				
	5	4	3	2	1	5	4	3	2	1
23	21	18	3	2		24	16	3		
24	2	6	20	10	5	2	4	15	13	9
25		2	10	17	14	1	2	8	20	12
26	1		8	21	13	1	2	8	15	16
27	10	20	13			9	27	6	1	
28	13	20	9	1		9	27	6	1	
29	1	10	17	14	1	4	9	17	10	3
30	10	21	12			10	24	8		
31	11	18	13	1		12	21	10		
32	8	32	3			12	26	4	1	
33	13	21	8			11	24	8		
34	6	26	10	1		7	26	9	1	
35	8	24	10	1		6	23	13	1	
36	7	22	12	2		11	18	10	3	1
37	6	19	15	3		7	21	11	2	2
38		2	13	13	15	1	1	6	16	19
39		4	15	13	10	2	6	6	14	15
40						9	24	7	2	1
41	5	24	14			7	25	11		
42	6	14	14	7	2	5	21	12	3	2
43	10	9	18	4	2	5	16	17	4	1

TABLE 18 (continued)

item	before experiment (n=43)					after experiment (n=43)				
	5	4	3	2	1	5	4	3	2	1
44	7	20	13	3		8	29	6		
45	9	18	11	4	1	4	22	10	4	3
46	2	3	6	19	13			5	11	18
47	3	3	10	13	14	1	5	10	13	14
48	1	7	12	15	5	1	10	7	14	11
49	1	14	13	7	8	4	12	12	12	3
50	3	23	11	5	1	4	20	19		
51	6	18	16	3		10	20	12	1	
52	2	13	21	6	1	6	18	14	4	1
53	5	22	14	2		11	25	5	2	
54	11	26	5	1		13	25	3	2	
55	10	27	5	1		8	29	5	1	
56	5	17	19	2		6	25	8		
57	5	22	15	1		11	24	5	3	
58	12	18	10	3		7	20	11	4	1
59	12	23	7	1		13	24	6		

TABLE 19 THE FREQUENCY OF THE TEACHERS' OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT

items	before experiment (n=2)					after experiment (n=2)				
	5	4	3	2	1	5	4	3	2	1
1	1	1				2				
2		2				2				
3		1		1					1	1
4		1	1				2			
5		1		1			1		1	
6		2					1	1		
7	1	1				1	1			
8	2					2				
9	1	1				2				
10		2				1	1			
11		2				1	1			
12		2				1	1			
13	2					2				
14	2					2				
15		1	1			1	1			
16		1		1			1		1	
17				2			1		1	
18	1	1				1	1			
19	1	1				1	1			
20		2					2			
21	1			1		1		1		
22	1			1		1		1		

TABLE 19 (continued)

items	before experiment (n=2)					after experiment (n=2)				
	5	4	3	2	1	5	4	3	2	1
23	1	1				2				
24		1	1				1	1		
25		2					2			
26		2					2			
27	1	1				2				
28	1	1				2				
29	1	1				1	1			
30	1	1				2				
31	1	1				2				
32	1	1				2				
33	1	1				2				
34	1	1				1	1			
35	1	1				1	1			
36	1	1				1	1			
37	1	1				2				
38		1		1			1		1	
39		1		1			1		1	
40		2					2			
41	1	1				1	1			
42		2					2			
43		2					2			

TABLE 19 (continued)

items	before experiment (n=2)					after experiment (n=2)				
	5	4	3	2	1	5	4	3	2	1
44	1	1				2				
45	1	1				2				
46		2					2			
47		1	1				1	1		
48		1	1				1	1		
49		2					2			
50		2				1	1			
51	1	1				2				
52		2				1	1			
53		2				1	1			
54		2				1	1			
55	1	1				2				
56	1	1				2				
57	1	1				1	1			
58	1	1				1	1			
59	1	1				2				

TABLE 20 SCIENCE ACHIEVEMENT BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

scores	experimental group		control group	
(full 30)	before experiment	after experiment	before experiment	after experiment
1	-	-	-	-
2	–	-	-	-
3	–	-	-	-
4	1	-	-	-
5	–	1	-	-
6	–	-	-	-
7	2	2	-	-
8	3	-	2	-
9	2	-	2	-
10	6	-	3	-
11	6	-	6	1
12	8	-	7	4
13	3	-	5	1
14	2	-	13	2
15	2	1	0	5
16	2	2	1	0
17	1	-	2	4
18	–	-	1	3
19	–	-	-	3
20	–	-	-	3
21	–	-	-	4
22	–	-	-	5
23	-	-	-	4

TABLE 20 (continued)

scores	experimental group		control group	
(full 30)	before experiment	after experiment	before experiment	after experiment
24	-	2	-	0
25	–	1	-	0
26	–	5	-	0
27	-	3	-	1
28	–	10	-	-
29	–	4	-	-
30	-	3	-	-
Total	38	34	42	43
Average	418/38 =11	863/34=25.38235	529/42=12.59524	768/43=17.86047

TABLE 21 CAREER & TECHNOLOGY ACHIEVEMENT BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP

scores (full 30)	experimental group	
	before experiment	after experiment
1	-	-
2	-	-
3	-	-
4	1	1
5	1	-
6	3	-
7	6	1
8	3	-
9	5	-
10	2	-
11	6	-
12	1	-
13	1	-
14	-	1
15	2	-
16	-	-
17	1	-
18	2	-
19	-	-
20	2	1
21	2	-
22	-	1
23	-	-

TABLE 21 (continued)

scores (full 30)	experimental group	
	before experiment	after experiment
24	-	1
25	–	2
26	–	1
27	–	3
28	-	3
29	–	11
30	–	8
total	38	34
average	394/38=10.36842	817/34 =24.02941

TABLE 22 THE FREQUENCY OF THE STUDENTS' OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT OF SINGLE FORM

item	before experiment (n=3)					after experiment (n=3)				
	5	4	3	2	1	5	4	3	2	1
1		3				2	1			
2	1	2				1	2			
3			3					1	2	
4				3					3	
5			1	2			1	1	1	
6	1	1	1			1	1		1	
7	1	2				2	1			
8	1	1	1			2	1			
9	1	2				2	1			
10		2	1			2		1		
11			1	2					2	1
12		3				2	1			
13		3				2	1			
14	1	1	1			1	2			
15	1	1	1			1	1	1		
16			3						2	1
17		1	2						2	1
18	3					2	1			
19	1	1	1			2	1			
20			2	1				1	1	1

TABLE 22 (continued)

item	before experiment					after experiment				
	5	4	3	2	1	5	4	3	2	1
21			1	2				1	1	1
22		1		2				1	1	1
23		1	2			2	1			
24		1	2					2	1	
25			2	1				1	1	1
26				1	2				2	1
27	2	1				2	1			
28	1	2				2	1			
29	1	1		1		1	1	1		
30	1	2				1	1	1		
31	1	2				1	2			
32	1	2				1	2			
33	2	1				1		2		
34	1	2				1	1		1	
35	1		2			2	1			
36	1	2				1	1			1
38				3				1	1	1
39				3		1			1	1
40		3				1	1		1	
41	1	1	1			2	1			
42	1	1	1			2			1	
43	1	1	1			2			1	

TABLE 22 (continued)

item	before experimenting learning unit					after experimenting learning unit				
	5	4	3	2	1	5	4	3	2	1
44	2	1				1	1		1	
45	1	1	1			1	1		1	
46				2	1				2	1
47			1	1	1			1	1	1
48			1	2					2	1
49			1	2					2	1
50		2		1		1		2		
51		2	1			1	1	1		
52		2	1			1		2		
53		2	1			1	2			
54		2	1			1	2			
55	1	1	1			1	1	1		
56		2	1			1	1	1		
57		2	1			1	2			
58		2	1			1	1	1		
59		2	1			1	1	1		
average = 228.333 (3.86)						average = 240.333 (4.07)				

TABLE 23 THE FREQUENCY OF THE STUDENTS' OPINIONS TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS BEFORE AND AFTER THE EXPERIMENT OF THE EXPERIMENTAL GROUP OF GROUP FORM (N=11)

items	before experiment					after experiment				
	5	4	3	2	1	5	4	3	2	1
1	4	4	3			2	8	1		
2	2	9				5	6			
3			5	6			2	5	3	1
4			6	5					5	6
5		2	7	2					7	4
6	1	5	5			1	3	7		
7	8	3				5	6			
8	7	3	1			4	7			
9	1	7	3			4	3	4		
10	1	7	3			2	8	1		
11			2	9					5	6
12	4	6	1				10	1		
13	5	5	1			1	9	1		
14	5	4	2		4	4	3			
15	4	6	1		1	2	8			
16			1	5	5				9	2
17		1	2	5	3	1	1	3	5	1
18	3	7	1			5	6			
19	2	5	4			1	4	6		
20		1		4	6				4	7
21			1	4	6				5	6
22				6	5				5	6

TABLE 23 (continued)

items	before experiment					after experiment				
	5	4	3	2	1	5	4	3	2	1
23	8	3				4	7			
24			2	7	2				9	2
25			1	2	8			2	4	5
26				6	5				3	8
27	2	9				3	8			
28	2	8	1			1	10			
29		2	6	2	1	1	5	4	1	
30	1	10				2	9			
31	3	6	2			3	8			
32	2	9				2	9			
33	2	7	2			1	10			
34		8	3			3	8	1		
35	1	10					10	1		
36	2	5	3	1			10	1		
37	1	5	4	1	1		10	1		
38			1	4	6				8	3
39		2	1	5	4				8	3
40	1	6	3	1		1	9	1		
41		9	2			1	9	1		
42	2	4	4	1		1	4	6		
43		6	3	2		1	3	7		

TABLE 23 (continued)

items	before experiment					after experiment				
	5	4	3	2	1	5	4	3	2	1
44	1	8	2			1	10			
45	1	4	3	3		1	9	1		
46			1	9	1			3	4	7
47			1	9	1		3	1	5	5
48			3	3	5		1	1	4	5
49	2	6	2		1	1	5	2	3	
50	1	6	3	1		1	10			
51	1	5	5			1	7	3		
52	1	7	3			1	6	4		
53	4	5	2			1	7	3		
54	3	8				3	8			
55	4	7				1	10			
56	2	8	1			2	9			
57	2	8	1			2	9			
58	1	9	1			2	8	1		
59	5	5	1			2	8	1		
average = 229.2727 (3.86)						average = 234.8182 (3.98)				

TABLE 24 THE DIFFICULTY, DISCRIMINATING POWER AND RELIABILITY OF SCIENCE TEST FOR INTEGRATED LEARNING UNITS

Items	P	r	Item	P	r
1	0.69	0.63	16	0.50	0.50
2	0.41	0.45	17	0.45	0.91
3	0.36	0.36	18	0.56	0.88
4	0.59	0.45	19	0.77	0.45
5	0.45	0.40	20	0.50	0.82
6	0.77	0.45	21	0.69	0.63
7	0.25	0.30	22	0.73	0.55
8	0.45	0.73	23	0.50	0.20
9	0.55	0.20	24	0.36	0.73
10	0.63	0.50	25	0.36	0.36
11	0.40	0.60	26	0.50	0.27
12	0.59	0.45	27	0.64	0.64
13	0.75	0.30	28	0.50	0.45
14	0.64	0.20	29	0.45	0.36
15	0.44	0.88	30	0.50	0.27

Reliability; Kuder- Richardson (KR-20) =0.692505

TABLE 25 THE DIFFICULTY, DISCRIMINATING POWER AND RELIABILITY OF CAREER & TECHNOLOGY TEST FOR INTEGRATED LEARNING UNITS

Items	P	r	Items	P	r
1	0.41	0.64	16	0.45	0.20
2	0.55	0.55	17	0.50	0.64
3	0.45	0.30	18	0.68	0.55
4	0.59	0.45	19	0.64	0.55
5	0.45	0.50	20	0.77	0.45
6	0.55	0.36	21	0.27	0.36
7	0.59	0.82	22	0.59	0.45
8	0.80	0.20	23	0.45	0.30
9	0.50	0.82	24	0.77	0.45
10	0.73	0.36	25	0.27	0.36
11	0.55	0.50	26	0.50	0.27
12	0.55	0.36	27	0.68	0.64
13	0.50	0.45	28	0.36	0.55
14	0.55	0.91	29	0.41	0.64
15	0.55	0.55	30	0.60	0.60

Reliability; Kuder- Richardson (KR-20) = 0.7835

TABLE 26 THE DISCRIMINATING POWER AND RELIABILITY OF THE OPINION TOWARD LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY

items	t	items	t	items	t
1	4.60	21	3.73	41	1.60
2	5.40	22	2.35	42	2.35
3	3.85	23	6.48	43	3.35
4	3.73	24	2.35	44	2.48
5	3.76	25	4.60	45	3.73
6	2.23	26	3.60	46	2.85
7	5.35	27	5.23	47	3.10
8	6.48	28	5.23	48	3.85
9	2.98	29	3.35	49	2.23
10	4.23	30	6.85	50	2.48
11	3.35	31	5.35	51	4.35
12	3.35	32	4.23	52	4.35
13	4.61	33	5.23	53	2.60
14	3.85	34	6.10	54	3.48
15	2.98	35	4.60	55	5.10
16	3.35	36	4.60	56	5.10
17	3.85	37	3.10	57	4.10
18	6.48	38	3.98	58	3.23
19	2.60	39	3.10	59	2.73
20	3.98	40	4.35	60	3.23

Reliability (α - Coefficient) = 0.97

TABLE 27 ITEM-OBJECTIVE CONGRUENCE OF APPROPRIATENESS EVALUATION FORM OF INTEGRATED LEARNING UNITS

items	IOC	items	IOC	items	IOC
1	1.00	15	1.00	29	0.67
2	1.00	16	1.00	30	1.00
3	1.00	17	1.00	31	0.67
4	0.67	18	1.00	32	1.00
5	0.67	19	1.00	33	0.67
6	0.67	20	1.00	34	1.00
7	1.00	21	0.67	35	0.67
8	1.00	22	0.67	36	1.00
9	1.00	23	1.00	37	1.00
10	1.00	24	1.00	38	1.00
11	1.00	25	0.67	39	1.00
12	1.00	26	0.67	40	0.67
13	0.67	27	1.00	41	0.67
14	1.00	28	1.00		

TABLE 28 SCIENCE COGNITION SCORES DURING LEARNING PROCESS AND SCIENCE ACHIEVEMENT FOR EFFICIENCY EXAMINATION (ONE PERSON TEST OR 1:1)

Number	test scores before experiment	cognition scores during learning process	science achievement after experiment
1.	16	84	17
2.	17	87	22
3.	7	80	17
Total	40	251	56
$\overline{X}$	40/3=13.33	251/3=83.33	56/3=18.67

Calculation for finding the efficiency of "process" (E_1) $E_1 = \overline{X} \times 100 / A$

$\overline{X}$ mean Cognition mean scores during learning process from all learning units = 251/3

A mean Cognition total scores during learning process from all learning units=97

E_1 mean Teaching-learning efficiency from all learning units = 251/3x100/97 =86.25

Calculation for finding the efficiency of "outcome" (E_2) $E_2 = \overline{F} \times 100 / P$

$\overline{F}$ mean Achievement mean scores of after the experiment = 56/3

P mean Total scores = 30

E_2 mean Teaching-learning efficiency after the experiment = 56/3 x100 / 30 = 62.2

E_1 / E_2 = 83.33 / 62.22

(E_2 was low because at test stage of finding teaching-learning efficiency, the students took the summative test and they had no time to review the text.)

TABLE 29 CAREER & TECHNOLOGY COGNITION SCORES DURING LEARNING PROCESS AND CAREER & TECHNOLOGY ACHIEVEMENT FOR EFFICIENCY EXAMINATION (ONE PERSON TEST OR 1:1)

Number	Test scores before experiment	Cognition scores during learning process	Achievement after experiment
1.	16	141	20
2.	19	132	25
3.	15	130	13
Total	40	403	58
$\overline{X}$	40/3=13.33	403 / 3=134.33	58/3=19.33

Calculation for finding the efficiency of "process" (E_1) $E_1 = \overline{X} \times 100 / A$

$\overline{X}$ mean Cognition mean scores during learning process from all learning units = 403/3

A mean Cognition total scores during learning process from all learning units =160

E_1 mean Teaching-learning efficiency from all learning units = 403/3x100/160 = 83.96

Calculation for finding the efficiency of "outcome" (E_2) $E_2 = \overline{F} \times 100 / P$

$\overline{F}$ mean Achievement mean scores of after experiment = 58/3

P mean Total scores = 30

E_2 mean Teaching-learning efficiency after the experiment = 58/3 x100 / 30 = 64.44

E_1 / E_2 = 83.96 / 64.44

(E_2 was low because at test stage of finding teaching-learning efficiency, the students took the summative test and they had no time to review the text.)

TABLE 30 SCIENCE COGNITION SCORES DURING LEARNING PROCESS AND SCIENCE ACHIEVEMENT FOR EFFICIENCY EXAMINATION OF GROUP FORM

Number	Test scores before experiment	Cognition scores during learning process	Achievement after experiment
1.	13	106	20
2.	7	104	15
3.	6	104	17
4.	8	106	16
5.	8	93	21
6.	11	97	22
7.	10	106	20
8.	9	95	19
9.	12	97	18
10.	11	95	16
11.	10	97	23
Total	105	1100	208
$\overline{X}$	105/11=9.55	1100/11=100	208/11=18.8

Calculation for finding the efficiency of "process" (E_1) $E_1 = \overline{X} \times 100 / A$

$\overline{X}$ mean Cognition mean scores during learning process from all learning units = 1100/11=100

A mean Cognition total scores during learning process from all learning units = 123

E_1 mean Teaching-learning efficiency from all learning units = 100x100/123 =81.30

Calculation for finding the efficiency of "outcome" (E_2) $E_2 = \overline{F} \times 100 / P$

$\overline{F}$ mean Achievement mean scores after experiment = 208/11

P mean Total scores = 30

E_2 mean Teaching-learning efficiency after experiment = 208/11x100/30 = 63.03

E_1 / E_2 = 81.30 / 63.03

(E_2 was low because at test stage of finding teaching-learning efficiency, the students took the summative test and they had no time to review the text.)

TABLE 31 CAREER & TECHNOLOGY COGNITION SCORES DURING LEARNING PROCESS AND ACHIEVEMENT FOR EFFICIENCY EXAMINATION OF GROUP FORM

Number	Test scores before experiment	Cognition scores during learning process	Achievement after experiment
1.	13	142	25
2.	13	137	17
3.	13	137	26
4.	9	151	26
5.	15	154	24
6.	13	160	21
7.	16	152	24
8.	12	144	20
9.	13	159	29
10.	12	159	23
11.	14	143	15
รวม	143	1638	250
$\overline{X}$	143/11=13	1638/11=148.91	250/11= 22.73

Calculation for finding the efficiency of "process" (E_1) $E_1 = \overline{X} \times 100 / A$

$\overline{X}$ mean Cognition mean scores during learning process from all learning units = 403/3

A mean Cognition total scores during learning process from all learning units =180

E_1 mean Teaching-learning efficiency from all learning units = 1638/11x100/180 =82.72

Calculation for finding the efficiency of "outcome" (E_2) $E_2 = \overline{F} \times 100 / P$

$\overline{F}$ mean Achievement mean scores of after experiment = 250/11

P mean Total scores = 30

E_2 mean Teaching-learning efficiency after experiment = 250/11x100/30 = 75.75

E_1 / E_2 = 82.73 / 75.76

(E_2 was high because the test was improved then the test for finding the second learning efficiency was conducted for the second time.)

VITAE

VITAE

Name:	Yupadee Senkao
Date of Birth:	April 28 th ,1960
Place of Birth:	Bangkok, Thailand
Address:	59/70 Mhoo 3, Prayasurain Rd, Bangchan Sub-District, Klongsamwa District, Bangkok, 10510, Thailand.
	yupadeesenkao@hotmail.com
Position:	Teacher 2 class 7
Office:	Department of Chemistry, Faculty of Science and Technology Rajabhat Valaya-Alongkorn University. 1 Paholyothin Road, Klongneung, klongluang, Pathoomthani 13180.

Educational Background:

2005	Doctor of Education (Science Education), Srinakharinwirot University.
1989	Master of Education (Science Education), 1989 Chulalongkorn University.
1982	Bachelor of Education (Chemistry), Srinakarinwirot University, (Pathoomwan).
1978	MS 5, Streemahaphruettharam School

THE DEVELOPMENT OF LEARNING UNITS INTEGRATED BETWEEN SCIENCE AND CAREER & TECHNOLOGY SUBJECTS ON "PROPERTIES OF MATTER" AND "DESIGN AND TECHNOLOGY" FOR HIGH SCHOOL STUDENTS IN THAILAND

AN ABSTRACT

BY

YUPADEE SENKAO

Presented in partial fulfillment of the requirements for the

Doctor of Education degree in Science Education

at Srinakharinwirot University

May 2005

Yupadee Senkao (2005). *The Development of Learning Units Integrated between Science and Career & Technology Subjects on "Properties of Matter"and "Design and Technology" for High School Students in Thailand.* Dissertation, Ed.D. (Science Education). Bangkok: Graduate School, Srinakharinwirot University. Advisor Committee: Dr. Manat Boonprakob, Associate Professor Dr. Supaluk Prachayasittikul and Dr. Pramuan Siriphunkaew.

The main aim of this study was to develop learning units integrated between science and career & technology subjects on "properties of matter" and "design and technology" for high school students in Thailand. The purposes of this study were as follows:

1. To measure the effectiveness of the learning units
2. To assess students' achievement and performance on the concepts and process of science and technology
3. To assess students' opinion toward integrated learning units
4. To assess teachers' opinion toward integrated learning units.

The researcher developed learning units integrated between science and career & technology subjects by employing parallel model of integration and problem-based learning process. The developed learning unit was implemented with 83 students of grade ten level at Surasakmontri School during July – September, the second semester of 2004 academic year. Thirty eight students and forty five students were random sampling as experimental group and control group respectively. The experimental group studied both science and career & technology subjects but the control group studied science only. Research instruments were 1) Science achievement test and Career & technology achievement test 2) Opinions toward integrated learning unit test 3) Work performance evaluation form and Report doing 4) Appropriateness evaluation form of learning unit outline. Statistics of research were 1) Mean 2) Standard Deviation 3) t-test.

The findings were as follows:

1. Learning units integrated between science and career & technology subjects had efficiency as the criteria of 80 / 80.

2. The result of students' achievement of learning units integrated between science and career & technology subjects after the experiment was higher than before the experiment, significantly at the .05 level. Furthermore, students' science achievement of the experimental group was higher than that of the control group, significantly at the .05 level.

3. Students had better opinions toward learning units integrated between science and career & technology subjects; the mean score was over3.5. Additionally, students' opinion toward the integrated learning units of experimental group was higher than that of the control group, significantly at the .05 level.

4. Teachers had better opinions toward learning units integrated between science and career & technology subjects; the mean score was over3.5.

การพัฒนาหน่วยการเรียนรู้ที่บูรณาการระหว่างวิชาวิทยาศาสตร์เรื่อง "สารและสมบัติของสาร" กับวิชาการงานอาชีพและเทคโนโลยีเรื่อง "การออกแบบและเทคโนโลยี" สำหรับนักเรียนมัธยมศึกษาตอนปลายในประเทศไทย"

บทคัดย่อ

ของ

ยุพดี เส้นขาว

เสนอต่อบัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ เพื่อเป็นส่วนหนึ่งของการศึกษา

ตามหลักสูตรปริญญาการศึกษาดุษฎีบัณฑิต สาขาวิทยาศาสตรศึกษา

พฤษภาคม 2548

ยุพดี เส้นขาว. (2547) *การพัฒนาหน่วยการเรียนรู้เชิงบูรณาการระหว่างวิชาวิทยาศาสตร์เรื่อง "สารและสมบัติของสาร" กับวิชาการงานอาชีพและเทคโนโลยีเรื่อง "การออกแบบและเทคโนโลยี" สำหรับนักเรียนมัธยมศึกษาตอนปลายในประเทศไทย.* ปริญญานิพนธ์ กศ.ด. (วิทยาศาสตรศึกษา). กรุงเทพฯ: บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ. คณะกรรมการควบคุม: ดร.มนัส บุญประกอบ, รองศาสตราจารย์ ดร.สุภาลักษณ์ ปรัชชญาสิทธิกุล, ดร.ประมวล ศิริผันแก้ว.

การวิจัยครั้งนี้มีจุดมุ่งหมายเพื่อการพัฒนาหน่วยการเรียนรู้เชิงบูรณาการระหว่างวิชาวิทยาศาสตร์เรื่อง "สารและสมบัติของสาร" กับวิชาการงานอาชีพและเทคโนโลยีเรื่อง "การออกแบบและเทคโนโลยี" สำหรับนักเรียนมัธยมศึกษาตอนปลายในประเทศไทย เพื่อศึกษาผลของหน่วยการเรียนรู้เชิงบูรณาการระหว่างวิชาวิทยาศาสตร์กับวิชาการงานอาชีพและเทคโนโลยีในประเด็นต่าง ๆ ดังนี้

1) ประสิทธิภาพของหน่วยการเรียนรู้บูรณาการ
2) ผลสัมฤทธิ์ทางการเรียนของนักเรียน
3) ความคิดเห็นของนักเรียนต่อหน่วยการเรียนรู้บูรณาการ
4) ความคิดเห็นของครูต่อหน่วยการเรียนรู้บูรณาการ

ผู้วิจัยได้พัฒนาหน่วยการเรียนรู้เชิงบูรณาการระหว่างวิชาวิทยาศาสตร์กับวิชาการงานอาชีพและเทคโนโลยี โดยใช้การบูรณาการแบบคู่ขนาน (Parallel model) และใช้กระบวนการเรียนการสอนแบบใช้ปัญหาเป็นหลัก (Problem-based learning) งานวิจัยนี้ได้ทดลองภาคสนามกับ นักเรียนชั้นมัธยมศึกษาปีที่ 4 ของโรงเรียนสุรศักดิ์มนตรี 2 ห้องเรียน จำนวน 83 คน ในช่วงเดือนกรกฎาคม ถึงเดือน กันยายน ของภาคเรียนที่ 2 ปีการศึกษา 2547 โดยสุ่มกลุ่มตัวอย่าง ออกเป็น กลุ่มทดลอง 38 คน และกลุ่มควบคุม 45 คน ในการทดลองให้กลุ่มทดลอง เรียนทั้งวิชาวิทยาศาสตร์ กับวิชาการงานอาชีพและเทคโนโลยี ส่วนกลุ่มควบคุม เรียนเฉพาะวิชาวิทยาศาสตร์ เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลได้แก่ 1) แบบทดสอบวัดผลสัมฤทธิ์ทางการเรียนวิชาวิทยาศาสตร์ และวิชาการงานอาชีพและเทคโนโลยี 2) แบบวัดความคิดเห็นต่อหน่วยการเรียนรู้บูรณาการ 3) แบบประเมินผลการปฏิบัติงาน การจัดทำรายงาน 4) แบบประเมินความเหมาะสมของการใช้ หน่วยการเรียนรู้ สถิติพื้นฐานที่ใช้ในการวิจัย คือ 1) ค่าเฉลี่ย 2) ค่าเบี่ยงเบนมาตรฐาน และ3) t-test

ผลการทดลองพบว่า

1. หน่วยการเรียนรู้เชิงบูรณาการระหว่างวิชาวิทยาศาสตร์เรื่อง" สารและคุณสมบัติของสาร" และวิชาการงานอาชีพและเทคโนโลยีเรื่อง "การออกแบบและเทคโนโลยี" มีประสิทธิภาพ

ตามเกณฑ์ 80 / 80

2. ผลสัมฤทธิ์ทางการเรียนของนักเรียนในการเรียนรู้หน่วยการเรียนเชิงบูรณาการของทั้งสองวิชาคือ วิชาวิทยาศาสตร์และวิชาการงานอาชีพและเทคโนโลยี หลังการทดลองสูงกว่าก่อนการทดลองอย่างมีนัยสำคัญทางสถิติ ที่ระดับ .05 นอกจากนี้ผลสัมฤทธิ์ทางการเรียนวิชาวิทยาศาสตร์ของนักเรียนกลุ่มทดลองสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ที่ระดับ .05

3. นักเรียนมีความคิดเห็นต่อหน่วยการเรียนรู้บูรณการระหว่างวิชาวิทยาศาสตร์กับวิชาการงานอาชีพและเทคโนโลยีดีขึ้น และมีค่าเฉลี่ยมากกว่า 3.5 นอกจากนี้ความคิดเห็นต่อหน่วยการเรียนรู้บูรณการของนักเรียนกลุ่มทดลองสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ที่ระดับ .05

4. ครูมีความคิดเห็นต่อหน่วยการเรียนรู้บูรณาการระหว่างวิชาวิทยาศาสตร์กับวิชาการงานอาชีพและเทคโนโลยีดีขึ้น และมีค่าเฉลี่ยมากกว่า 3.5

This study was financially supported by

The Institute for the Promotion of Teaching Science and Technology (IPST)