THE DEVELOPMENT OF HIGH SCHOOL SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH

A DISSERTATION

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CHAPTER ONE
INTRODUCTION

Background

The educational system in Thailand changed in the year 1999. Due to education reform, the National Education Act of B.E.2542 (1999) was enacted. At the heart of the Act is the principle that "all learners are regarded as being most important" (Office of the National Education Commission, ONEC, 1999: 10). According to a report from Ministry of Education (MOE), it was noted that Thailand's curriculum B.E. 2521 (revised B.E. 2533) used at primary and secondary levels have some limitations and weaknesses. The major limitations identified in the report were: the formulation and the application of curriculum used in school do not encourage learner abilities in thinking and learning skills (MOE, 2002: 1). Numerous student achievement studies conducted by the Department of Curriculum and Instruction Development had provided additional data to support the assertion of the MOE that Thai students were not adequately prepared in science. One national study revealed that at the primary level, the average science score is 50%, and the average science score at the lower secondary level is 45.3%, and at the upper secondary level it is less than 50% (Soydhurum, 2001: 42-43). The results from this study provide a picture of less than adequate science achievement in Thai schools. In addition, a study conducted by the International Association for the Evaluation of Educational Achievement (IEA) has shown that when Thai student achievement was compared to student achievement from other countries, Thai students ranked last in all age-groups: for example, 10 years (primary level), 14 years (lower secondary level), and 18 years (upper secondary level) (Soydhurum, 2001: 44). Because of these and other similar studies, it was the consensus of science educators, scientists, and others involved in the reform effort that science education had to be improved. Therefore Thai education reform is needed particularly in curriculum structure and the teaching-learning process. The expectation is that students will acquire knowledge and the abilities necessary to solve problems by themselves and in collaboration with others. The 1999 National Education Act also includes an additional provision on: "lifelong education for all, continuous development of the bodies of knowledge and learning processes" (ONEC, 1999: 4-5).

Section 24 of the Education Act states that the organization and classroom management of educational institutions shall provide both the substances (content or subject-matter) and well organized learning activities that promote critical thinking (ONEC, 1999). This section also emphasizes that individual student differences should be kept in mind when planning learning activities. In addition, it is expected that these educational institutions will organize activities for learners that draw upon the student life experiences, provide practical work based drills for complete mastery of the subject, and provide opportunities to enable learners to think and work critically (ONEC, 1999: 11).

The 1999 National Education Act recommends that for successful implementation, schools need to make changes in the curriculum and in the teaching practices. Two of these changes deemed important in this study are 1) the incorporation of current and locally relevant environmental-related issues into the curriculum and 2) the use of inquiry-based approaches in the teaching of science. A major problem in implementing the recommendations, as put forth by the 1999 National Education Act, is the fact that the traditional lecture style of teaching is still prevalent today among teachers in Thailand. Many teachers still teach in the traditional lecture style and thus fail to encourage their students to think and solve problems. Moreover, teachers rarely integrate current issues and problems from real-life situations as part of the learning process. Student-centered learning must include learning from real-life situations. It is an interactive process where each student's learning is of primary importance. Therefore, the current learning process is not the same as in real-life situations and is not responsive to a learner's developmental processes. Wasri (2000) has extended this concern by stating that learning by memorizing, or a complete reliance on learning from books does not help students recognize and solve real problems.

To fulfill the goals of the 1999 National Education Act, the learner and the teacher are recognized as important for the teaching–learning process. Classroom management strategies must allow all learners to develop at their own pace and to their highest potential. Cain (2002) posited that good teachers capitalize on children's natural curiosity in order to promote an attitude of discovery. Students are encouraged to "find out for themselves" how and why phenomena occur. In addition, the Institute for the Promotion of Teaching Science and

Technology (IPST, 2000) has stressed that science instruction must help students to construct their own knowledge and include many learning styles, especially inquiry-based approaches.

Many countries in the current era of globalization have been going through a process of change in science education. Several articles have highlighted various aspects of the content of education reform. They show that in different countries, reform efforts share some important characteristics, which are clearly concerned with how science is traditionally taught (Van Driel, Beijaard & Verloop, 2001). In an attempt to change this situation in the United States, the National Science Education Standards (NSES) emphasize that "teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich student understanding of science" (National Research Council, [NRC], 1996: 6) and it also states that "science teaching must involve students in inquiry oriented investigations in which they interact with their teachers and peers,...hands-on activities are not enough, students must also have 'minds-on' experiences." (NRC, 1996: 20) Teachers play a vital role in successful inquiry instruction. Children cannot be turned loose to make discoveries and expect to develop a meaningful grasp of scientific inquiry (Etheredge & Rudnitsky, 2003).

Van Driel, Beijaard and Verloop (2001: 131) also state that one of the aims of science education reform is "to focus on inquiry as a central element of the curriculum, to promote students to actively develop their understanding of scientific concepts, along with reasoning and thinking skills." These goals are similar to reform efforts in the other countries that are described in articles and reports such as a new science curriculum in Australia (Curriculum Corporation, 1994 cited by Van Driel, Beijaard & Verloop, 2001), 'Science, Technology and Society' implemented in Canada (Aikenhead & Ryan, 1992), and also in the United Kingdom and its science education for the future called 'Beyond 2000' (Millar & Osborne, 1998). In the Netherlands the national curriculum of the traditional subjects that contains only physics, chemistry, and biology have been changed to engage the students in active learning activities especially through inquiry (Van Driel, Beijaard & Verloop, 2001).

Different teaching-learning methods in Thailand which are introduced in textbooks and teacher guides were developed by the Institute for the Promotion of Teaching Science and Technology (IPST), tried and later introduced to teachers. Among them is the inquiry method that emphasizes "questioning, answering, collecting information, analyzing and drawing conclusions, as well as problem solving by means of the scientific process" (Soydhurum, 2001). The education system in Thailand has promoted student-centered learning since 1978. It was found that the instructional methods typified by teacher-centered approach in which teachers lecture and students learn by rote lack innovation in teaching style (Thailand Development Research Institute, 1992). The report on the study of science education carried out by the Ministry of Education revealed that school science education in Thailand needed to be improved in both content and scientific process (Soydhurum, 2001: 34). In addition, the Thailand Research Funds (TRF) has also published a book entitled the "Crisis in Thai Science Education in 1998", in which it is stated that "... education in the most part still emphasizes rote learning rather than individual thinking." Students are forced to see science as another boring subject that exists only in the classroom or laboratory rather than as a journey through the world where curiosity and sense reign" (Soydhurum, 2001: 34).

In accordance with the 1999 National Education Act in Thailand and in the reference referred to in goals of education reform in other countries, it is important to use inquiry approaches in the teaching-learning process. Cain (2002) has found that following an inquiry or scientific approach necessitates a change in the traditional roles of both the teacher and the student. Students are no longer to be simply sponges absorbing the information given and the teacher will be supportive as a guide, facilitator, and resource person. Inquiry-based science is concerned with all areas of learning, not just in the memorization of science facts and concepts. Etheredge and Rudnitsky (2003: 6) stated that "all of the organizations that have recently studied and made recommendations for science education-including the National Academy of Science and the American Association for the Advancement of Science–agree that inquiry needs to be a fundamental component of an up-to-date science curriculum."

In the past, Thailand had national science curricula for all schools, which were developed by the Institute for the Promotion of Teaching Science and Technology (IPST). The IPST not only developed science curricula but also developed instructional materials including classroom teaching-learning activities. But now, because of the educational reforms that have followed the 1999 National Education Act, it is expected that academics or schools will develop their own curricula based on the standards stipulated by the Ministry of Education. The successful implementation of the 1999 National Education Act is expected to introduce a reorganization of educational administration and management and a new culture of learning, which depends on the passage of the education reform bills proposed by the Education

Reform Office. However, the organization of the educational system and learning process has already been widely implemented by all parties concerned (ONEC, 2001/2002). The implication for a broadened science curriculum is that, beyond functional and cultural literacy, only critical environmental literacy can result in genuine reflection on teachers' own fundamental modernist/ humanist assumptions (Hart, 2002).

Recent reforms to develop a core curriculum have assisted many schools as they attempt to write curricula in specific content areas. These core curricula have been based on national standards and provide a framework or reference point for the development of the school curriculum. The Basic Education Curriculum B.E. 2544 (2001) is the national core curriculum in Thailand and includes 8 strands and learning standards: Thai Language; Mathematics; Science; Social Studies, Religion and Culture; Health and Physical Education; Art; Career and Technology and Foreign Languages. The science strand includes 8 sub-strands: (1) Living Things and Living Processes; (2) Life and the Environment; (3) Matters and Properties of Matters; (4) Forces and Motion; (5) Energy; (6) Processes that Shapes the Earth; (7) Astronomy and Space; and (8) Nature of Science and Technology.

Within the science strand, the sub-strand of Life and the Environment is selected for this research and the topic of natural resources and environmental pollution is focused on in order to develop science curriculum. The curriculum is concerned with natural resources and environmental pollution, the teaching and learning processes, scientific skills, and attitudes toward science. This curriculum incorporates inquiry approach using real-life issues that are drawn from local and national newspaper articles or current events. Specifically, this research is focused on curricular resources that are available to help teachers plan, organize, and manage inquiry-based science teaching methodologies.

Barnes (2002: 4) stated, "...few people are engaging in real environmental problems at all, and with very limited success in solving any of them." Gigliotti (1995) has also suggested that efforts to address environmental problems have been developing for decades; however, these efforts have not been wholly satisfactory (cited by Barnes, 2002). In addition, environmental educators have long argued that modernist notions of schooling and curriculum, which are organized as subject matter disciplines, are inappropriate for learning about complicated, interdisciplinary social and environmental issues (Robottom, 1987/1988; Elliott, 1994/1999; Posh, 1999 cited by Hart, 2002). Keiny and Zoller (1991) summarized the main environmental education objectives as including: increasing environmental awareness, educating toward responsibility and concern for environmental problems, stimulating the learner's ability and willingness to make a personal contribution, and involving the learner in activities to improve the environment. In an effort to use real-life issues based on inquiry cycle approach to the classroom, this study developed science curriculum and instruction materials with inquiry principles. This dissertation research focused on three categories: water and water pollution; air and air pollution; soil and soil pollution as they are extremely important as educational topics and are also included in the Basic Education Curriculum B.E. 2544 (2001).

It is the intention of this study to apply inquiry cycle approach in learning-teaching process to the topics of water and water pollution, air and air pollution, and soil and soil pollution that are related to real-life issues. The occurrences of environmental problems are reported in newspapers everyday concerning the pollution of water, air and soil. These are environmental problems that occur in many places throughout Thailand and they are real-life issues that the people are seriously concerned with as they affect their everyday health. If these natural resources (water, air and soil) are polluted, there will be a detrimental effect on all living organisms. The effects will not only have a direct impact on human health but also have an impact on Thailand's economic growth. These topics are important because they are critical to the quality of our lives.

Purpose of the research study

The purposes of this research study are:

1. To develop the high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach.

2. To study the implementation of the high school science curriculum that is related to real-life issues and that uses inquiry cycle approach.

Significance of the research study

The result of this research is a science high school curriculum on natural resources and environmental pollution related to real-life issues using inquiry cycle approach. In addition, it includes learning plan and instruction by using inquiry cycle (5Es). This curriculum was examined and verified by experts for effectiveness as a science curriculum with the aim to develop students in the following points: learning abilities, awareness of natural resources and environmental pollution, and opinion toward a high school curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach.

Scope of the research study

Design and methodology

Developing the high school science curriculum based on real-life issues and using inquiry-cycle approach consists of two stages:

Stage I: Curriculum development. This stage involves determining the relevant science content and to develop the high school science curriculum draft. The high school science curriculum draft was piloted in Sampran Wittaya School in the central region of Thailand in Nakhon Pathom province. After pilot study, the high school science curriculum draft was revised and readied for implementation in science classrooms.

Stage II: Curriculum implementation. This stage proceeds with the implementation of the high school science curriculum in King's College in the central region of Thailand in Nakhon Pathom province.

Target sources of this research study

Target sources of this study in each stage are as follows:

1. Stage of curriculum development

1.1 Determining the relevant science content and developing the high school science curriculum draft. The target sources are one science teacher drawn from Sampran Wittaya School and two science teachers drawn from King's College. Both schools are in the central region of Thailand in Nakhon Pathom province.

1.2 Piloting the high school science curriculum draft and the target sources are as follows:

1.2.1 A science teacher drawn from Sampran Wittaya School.

1.2.2 One classroom of high school science students drawn from Sampran Wittaya School. Students from this school were studying in the level 4 (grade 10) in the second semester of the academic year 2003.

2. Stage of curriculum implementation

2.1 Two science teachers drawn from King's College.

2.2 Two classrooms of high school science students drawn from King's College in Nakhon Pathom province. These students were studying in the level 4 (grade 10) in the second semester of the academic year 2003.

Variables of this research study

The variables of this study are as follows:

1. Independent variable: The method of learning used of the high school science curriculum on natural resources and environmental pollution related to real-life issues using inquiry cycle approach.

2. Dependent variables:

2.1 Student achievement in science content of natural resources and environmental pollution

2.2 Student portfolios

2.3 Student awareness toward science of natural resources and environmental pollution

2.4 Student opinion toward the high school science curriculum on natural resources and environmental pollution

2.5 Teacher opinion toward the high school science curriculum on natural resources and environmental pollution

Definition of terms

1. The high school science curriculum on natural resources and environmental pollution: Science curriculum that is designed by using "themes" such as real-life issues for its development. Sources of the related issues are news, articles or events that occur in everyday life. This science curriculum involves the content and activities related to water and water pollution, air and air pollution, as well as soil and soil pollution.

2. Natural resources: Everything in nature that is useful for human beings in any way. This can be provided in 3 categories; (1) Non-Exhaustible Resources such as air, water, climate, (2) Renewable Natural Resources such as plant, animal wildlife, forest, soil, and (3) Exhaustible Natural Resources such as petroleum, oil, natural gas, shale oil, lignite, and mineral. In this study, it is focused on water, air and soil.

3. Environmental pollution: Degradation of the environment. In this study, which focuses on biophysical aspect, it means the presence of abnormally high concentration of harmful substance in the environment that affects healthy living.

4. High school science teachers: In this study it means the teachers who volunteer and are willing to participate in this research study. These teachers are experienced having taught biology for at least 15 years and they are familiar to and collaborate in curriculum development with the biology staffs of the Institute for the Promotion of Teaching Science and Technology (IPST).

5. Inquiry cycle approach: A teaching-learning process based upon inquiry cycle. The inquiry cycle consists of 5 stages and is often referred to as 5Es cycle such as engage, explore, explain, elaborate, and evaluate. In this study, inquiry cycle is opened inquiry.

6. Student achievement in science content on natural resources and environmental pollution: Abilities in learning, understanding, and applying the high school science curriculum on natural resources and environmental pollution incorporating real-life issues.

7. Student portfolio: A portfolio is a purposeful collection of student work that tells the story of student achievement or growth. Portfolios are not folders of all the work a student does, but they are the outcomes of the work that express student knowledge progression. Within this limited definition there are portfolio systems that: promote student self-assessment and control of learning; support student-led parent conferences; select students into special programs; certify student competence; grant alternative credit; demonstrate to employers certain skills and abilities; build student self-confidence; and evaluate curriculum and instruction. This study is to assess students in understanding, skill and application.

8. Awareness toward science on natural resources and environmental pollution: In this study it means personal feeling toward science incorporating natural resources and environmental pollution. It is the result of learning science through different activities. These feelings include an interest in, acceptance and application of the importance of natural resources and environment.

9. Student opinion toward science on natural resources and environmental pollution: Views of students toward implementation of the high school science curriculum on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach.

10. Teacher opinion toward science on natural resources and environmental pollution: Views of teachers toward implementation of the high school science curriculum on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach.

Conceptual framework of the study

Since education reform in Thailand and the 1999 National Education Act mandates changes specific to the teaching-learning process, a science curriculum needs to be developed. In addition, an instructional process is learner-centered, where teacher acts as facilitator and student acts as active learner. From these ideas this research is designed to reach the goal of education change by using inquiry cycle approach in curriculum development based on real-life issues. The conceptual framework in this research study is:

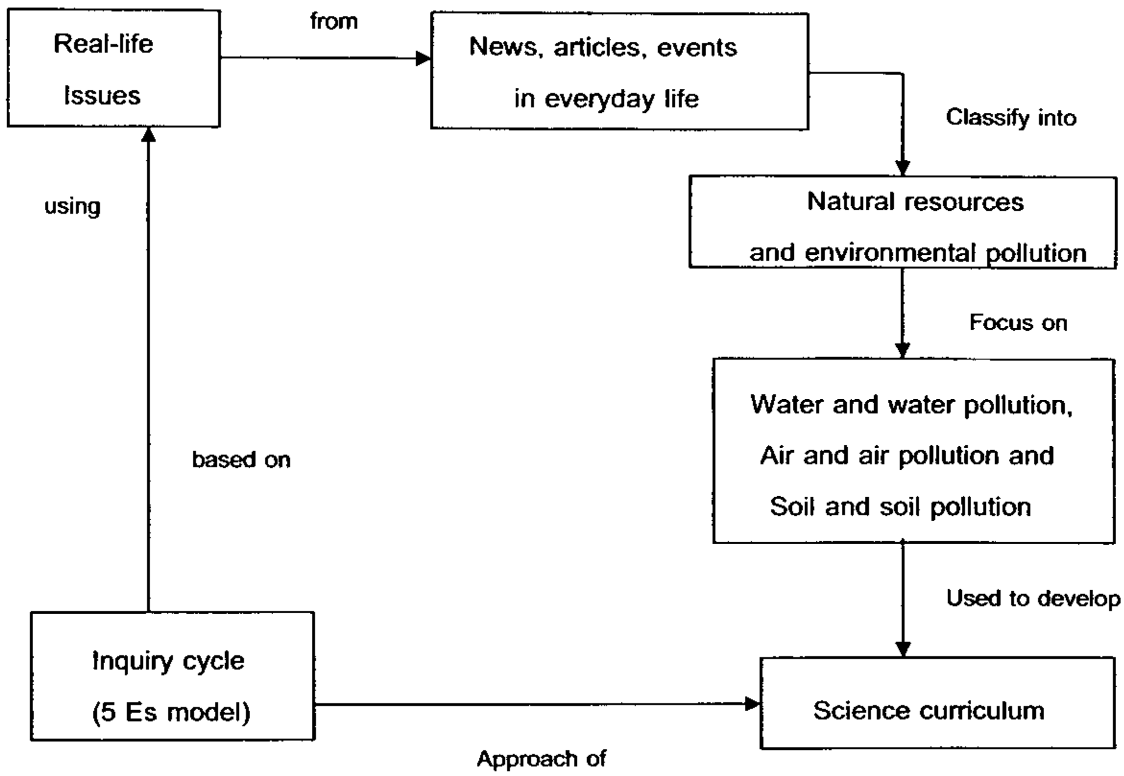

Figure 1 Conceptual framework of this study

Hypotheses

1. Student achievement scores after this science curriculum was implemented are higher than students in the same group before using the science curriculum.

2. Student portfolio scores after the science curriculum was implemented are more favorable.

3. Student awareness scores toward science curriculum on natural resources and environmental pollutions after the science curriculum was implemented are more favorable.

4. Student opinion scores toward science on natural resources and environmental pollutions after the science curriculum was implemented are more favorable.

5. Teacher opinion scores toward science on natural resources and environmental pollutions after the science curriculum was implemented are more favorable.

Chapter Two

Review of Related Literature

In this chapter, several related studies are described. The literature closely connected with this research is in curriculum development (such as curriculum development model, science curriculum content), inquiry-based instruction (such as learning theories related to inquiry cycle approach, and an inquiry cycle model) and assessment of science content outcome.

The Literature related to curriculum development

1. Curriculum development

Curriculum development involves three major components: curriculum planning, curriculum implementation, and curriculum evaluation. Oliva (1997) explains that planning is the thinking or design phase, implementing is a way to translate plans into action, and evaluating is the assessment of student learning outcomes. Curriculum design is "....the way in which curricula are created, especially the actual arrangement of the parts of the curriculum plan" (Ornstein & Hunkins, 1993: 232). The planning component is an integral aspect of curriculum development. The researcher believes that a well-planned curriculum will lead students to successful learning. Posner argues that curriculum planners need to think about critical elements in the designing phase. These elements are:

1. Objectives: What knowledge, skills, or attitudes should students acquire?
2. Rationale or educational philosophy behind the curriculum: Why should they learn this? What is the value of this?
3. Content: What content, i.e., what topics, concepts, skills, etc., should be covered?
4. Characteristics of target audience: Who is this for? (consider interests, abilities, background knowledge)
5. Activities: What should they do?
6. Materials: What resources will they need?
7. Sequencing principles: In what order should this be done?
8. Schedule: How long will each part take?
9. Teacher training and attitudes: What do the teachers need to know, be able to do, and be committed to?

10. Evaluation: How will success be determined? What will count as success?
11. Administrative structure, school facilities, and financial constrains: How will it be implemented in a school?
12. Other parts of curriculum: How will it relate to other subjects? (Posner, 1992:43)

1.1 Curriculum development models

Curriculum development models act as a roadmap for curriculum construction for curriculum developers. In this section, various models are explored to determine which ones are appropriate for this research. In addition, research closely relevant to learning environmental science will also be explored. Many models of curriculum development have been proposed by educators such as Tyler, 1949; Taba, 1962; Hunkin, 1980; and Saylor, Alexander and Lewis, 1981. The Tyler model, one of the most widely used model, consists of four basic principles: "purposes of the school; educational experiences related to these purposes; organization of these experiences; and evaluation of these purposes" (Ornstein & Hunkins, 1993: 267). Similar to the Tyler model is the Taba model. This model is known as a grass-roots approach and consists of seven major phases: 1) diagnosis of needs 2) formulation of objectives 3) selection of content 4) organization of content 5) selection of learning experiences 6) organization of learning activities and 7) evaluation and means of evaluation (Ornstein & Hunkins, 1993: 268-269). Oliva (1997: 150-151) points out that accomplishing curriculum change using the Taba model involves a five-step sequence:

1. Producing pilot units representative of the grade level or subject area. This step proposes the following eight-step sequences: a) diagnosis of needs, b) formulation of objectives, c) selection of content, d) organization of content, e) selection of learning experiences, f) organization of learning activities, g) determination of what to evaluate and of the ways and means of doing it, h) checking for balance and sequence.
2. Testing experimental units.
3. Revising and consolidating.
4. Developing a framework.
5. Installing and disseminating new units.

The systematic approach to curriculum development is presented in the Saylor, Alexander, and Lewis Model. This model consists of four stages: 1) goals, objectives, and domains 2) curriculum design 3) curriculum implementation and 4) curriculum evaluation (Ornstein & Hunkins, 1993: 269-270; Oliva, 1997: 151-153). Another model to assist in decision-making for curriculum development is the Hunkin model. This model represents seven major stages: curriculum conceptualization and legitimization; diagnosis; content selection; experience selection; implementation; evaluation and maintenance (Ornstein & Hunkins, 1993: 270-273). Armstrong (1989: 32) analyzes these curriculum development models and concludes that they generally include these components: identify needs and purposes; select and organize participants; develop a master program management scheme; develop components needed for each setting; pilot test/ assess/ reorganize; disseminate and implement; evaluate and revise.

The above-mentioned models have been explored in details. Based on research objectives, adaptations to these models have been made to create a model pertinent to this research (see Figure 2). This model consists of two main stages: curriculum development and curriculum implementation.

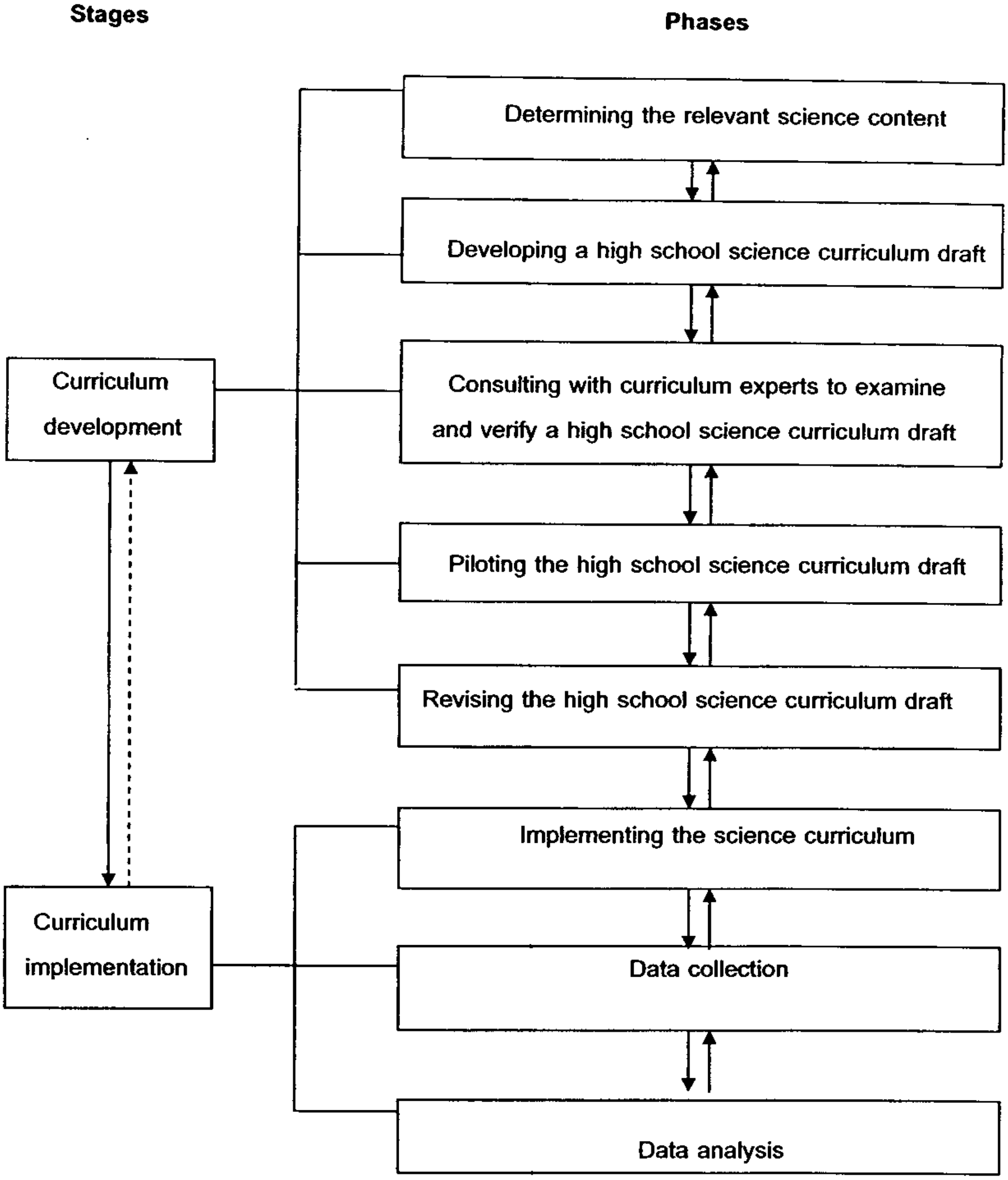

Figure 2 Curriculum development model for this research study

This model is versatile in that it can be used to develop an entire science curriculum or individual instructional units. For the first stage, curriculum development has five phases: 1) determining the relevant science content, 2) developing a high school science curriculum draft, 3) consulting with curriculum experts to develop a high school science curriculum draft, 4) piloting the high school science curriculum draft, and 5) revising the high school science curriculum draft. The last stage is implementation the science curriculum in the classrooms.

1.1.1 Stage of curriculum development

This stage consists of six phases:

1) Determining the relevant science content

The first phase of curriculum development is determining the relevant science content. Selecting a theme or content is an important aspect of designing a curriculum. Armstrong (1989: 8) states that in order to select the content, the curriculum developer must answer the following questions. "What content is to be selected? How is content to be selected? How is content to be organized? How is content to be sequenced? How is content to be prioritized? How is content to be transmitted? How is content acquisition to be evaluated? How are curriculum decisions to be reflected in written form?"

The first phase focuses on science content and the teaching and learning process. Martinello & Cook (2000) point out that in developing a curriculum for any theme as content, three major criteria should be considered at the beginning: the interest of the learners, the availability of resources, and curriculum standards. They also address the criteria that may guide curriculum developers and teachers to think about the theme in the process of teaching and learning. The theme should be:

> 1) appropriate to the developmental level of the children; 2) open to broad areas of inquiry; 3) familiar enough to preclude extensive preliminary study; 4) varied enough to appeal to different interests; 5) supported by various types of accessible resources, including primary sources; 6) explorable from a variety of perspectives; and 7) related to required content and skills goals and standards (Martinello & Cook, 2002: 84).

In this phase, the study focuses on the science content which is based on Thailand's Basic Education Curriculum B.E. 2544 (MOE, 2001), sub-strand # 2 "Life and the Environment" and learning standard as standard science # 2.2. According to Martinello & Cook (2000: 84), "developing a theme study is a fluid, continuous process of broadening and narrowing: generating ideas and categorizing these ideas, developing a large field of alternatives and selecting from those alternatives." In narrowing the content to study, the researcher decided to focus on the topic of natural resources and environmental pollutions as main topics and water and water pollution, air and air pollution, and soil and soil pollution as sub topics based on Thailand's educational standards. These topics are important to healthy living. Students will learn these topics and become aware of how to save natural resources and how to protect and improve the environment. In addition, the topic of environmental pollution is related to real-life current issues. The teachers can use real-life current issues of environmental problems in the classroom with inquiry-based instruction. This content is appropriated for high school science students at grades 10-12.

2) Developing a high school science curriculum draft

The second phase involves developing a high school science curriculum draft in collaboration with participating teachers. This phase aims to produce a science curriculum, which includes curriculum documents (classroom learning activities, laboratory exercises, instructional tools and student achievement tests). Martinello & Cook (2000) suggest that the developers should make sure that the selected topics are learnable to the children. For example, the topic should not be too easy or too difficult and the content should involve desirable types of thinking and skills required by the curriculum. This suggestion is important for curriculum developers to engage students in science learning.

3) Consulting with curriculum experts to examine and verify the high school science curriculum draft

The third phase of curriculum development involves consulting with curriculum experts to examine and verify the high school science curriculum draft. Important aspects of curriculum development that the experts examined were: "how course development proceeds and how instructional units are framed, how identification of content priorities are, and how content sequencing is addressed" (Armstrong, 1989).

4) Piloting the high school science curriculum draft

The fourth phase is piloting the high school science curriculum draft. In this phase the science curriculum draft must be tested "to establish...validity and teach-ability and to set...upper and lower limits of required abilities" of students (Oliva, 1997: 151). Armstrong (1989: 35) indicates that "pilot testing may involve small numbers of teachers who will teach from these materials, note their reaction and those of their students, and report findings back to leaders of the curriculum development project." In this phase teachers and students were evaluated in order to determine the appropriateness of using this science curriculum. For example, the evaluation of students include in pre-test and post-test, student portfolios, survey of students' attitude toward science on natural resources and environmental pollution and survey of students' opinion toward the science high school curriculum on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach. The teachers were evaluated on the implementation of the science curriculum based on real-life environmental issues and the expectation of classroom behavior when using inquiry-based approaches. If the science curriculum needs modification following the piloting phase, the curriculum developers shall revise it accordingly.

5) Preparing teachers to implement the science curriculum

The science curriculum is prepared before implementing in the classroom. Teachers need to know how to teach, how to manage classroom and how to evaluate their students.

6) Revising the high school science curriculum draft

The fifth phase of curriculum development involves revising the high school science curriculum draft. After pilot testing phase, the high school science curriculum draft may be "modified to conform to variations in student needs and abilities, available resources, and different styles of teaching so that the curriculum may suit all types of classrooms" (Oliva, 1997: 151). After necessary revisions are made then the curriculum planning is ready to proceed to classroom implementation.

1.1.2 Stage of curriculum implementation

This stage consists of three phases:

1) Implementing the science curriculum

This phase is implementation of the science curriculum in the classroom. During this phase, data were collected using observation tools such as observation forms and videotape recorder. The teachers collected data resulting from achievement tests.

2) Data collection

Data were collected by both researcher and teacher in order to evaluate the science curriculum for its appropriateness.

3) Data analysis

This is the last phase of curriculum implementation. Data were analyzed by using fundamental statistics.

1.2 Science curriculum content

In the past, Thailand had science curricula for each school level. At primary level, science was an integrated subject and taught in a subject group of "Life Experiences." In lower secondary level, science was a general science that was taught in all schools of Thailand and this general science was composed of physics, chemistry, biology, geology and astronomy. In addition, at upper secondary level, science curriculum was divided into two branches: academic and vocational. The academic branch was divided into science and non-science program. Science program was related to physics, chemistry, biology and environmental science while the non-science program was related to physical science and environmental science. Science for the vocational branch was dependent on scope and content that students would be required to follow as fundamental science for professional courses.

Recently Thailand has changed its educational system. Along with the Basic Education Curriculum B.E. 2544 (A.D. 2001) all schools or institutes are required to develop their own curricula. The structure of the basic education curriculum is divided into four levels; 1) first level-primary education, grades 1-3, 2) second level-primary education, grades 4-6, 3) third level-secondary education, grades 7-9, and 4) fourth level-secondary education, grades 10-12. The fundamental substance consists of 8 groups; Thai Language, Mathematics, Science, Social Studies, Religion and Culture, Health and Physical Education, Art, Career and Technology, and Foreign Languages. The science group is divided into 7 sub-strands; (1) Living Things and Living Processes, (2) Life and the Environment, (3) Matters and Properties of Matters, (4) Forces and Motion, (5) Energy, (6) Processes that Shape the Earth, and (7) Astronomy and Space.

In order to develop a science curriculum in this research, the sub-strand # 2 "Life and the Environment" and standard science # 2.2 was the focus. Science contents were classified into the "themes." Funderstanding, a website, (2002) states "the organization of curriculum around macro "themes" is based on the idea that people best acquire knowledge when learning in the context of a coherent "whole", and when they can connect what they're learning to the real world." In addition, it also states that themes "often involve a large, integrated system (such as a city, an ecosystem, and so on) or a broad concept (such as democracy, weather, and so on)." Instructors often strive to connect the theme to the everyday life of students. Based on standard science # 2.2 the themes of natural resources and environmental pollution were selected for this study. The relevant literature that relates to this area of study is:

1.2.1 Natural resources

Miller (2003: 10) states "a resource is anything obtained from the environment to meet human needs and wants." Similarly Chankaeow (2001: 138) and Para (1997: 9) point out that "natural resources are anything that occurs in the nature and is useful for human life and is also supportive human needs." Miller (2003: 10-12) continues to classify the resources based on a human time scale into three groups:

1) Perpetual resources such as direct solar energy, winds, tides, flowing water. These resources are expected to last at least 6 billion years as the Sun completes its life cycle.
2) Renewable resources such as fresh air, fresh water, fertile soil, plants and animals. These resources can be replenished fairly rapidly through natural processes as long as they are not used up faster than they are replaced.
3) Nonrenewable resources are fossil fuels, metallic minerals (iron, copper, aluminum), and non metallic minerals (clay, sand, phosphates). These resources exist in a fixed quantity in the earth's crust.

Chankaeow (2001: 138-139) and Para (1997: 9-11) divide natural resources based on human use into three categories:

1) Non-exhaustable natural resources such as sunlight, water, air and soil. These resources are essential for living organisms.

2) Exhaustable natural resources such as rocks, minerals, natural gases and petroleum. These resources are nonrenewable natural resources and can be depleted much faster than they are formed.

3) Renewable natural resources such as water, soil and organisms such as wild animals, grasslands, forests. These resources can be recycled or reused several times in the same form.

Due to the value of natural resources, it is most important that people should be aware of how to use natural resources in a sustainable yield, how to conserve natural resources for longer use, and how to protect natural resources from overuse and pollution. The problems of natural resources that are of concern are overusing, degradation, and pollution.

1.2.2 Environment and environmental pollution

1.2.2.1 Enivronment

The term of environment is close in meaning to the term natural resource. Miller (2002: G4) states environment is "all external conditions and factors, living and non living (chemicals and energy), that affect an organism or other specified system during its life-time." Cunningham and Saigo (1999: 614) define environment as "the circumstances or conditions that surround an organism or group of organisms as well as the complex of social or cultural conditions that affect an individual or community." Thailand's Pollution Control department (1994: 1) states environment is "natural things which form the physical and biological conditions surrounding man and man-made things." Para (1997) analyzes these meaning and concludes that natural resource and environment are similar as they are from nature. The difference between natural resource and environment is all natural resources are environment but only the some of environments are natural resources.

1.2.2.2 Pollution

Miller (2003: 12) states pollution is "any addition to air, water, soil, or food that threatens the health, survival, or activities of humans or other living organisms." Thailand's Pollution Control Department (1994: 2) points out that pollution is "the state of the environment that has been affected, changed or contaminated by pollutants, resulting in deterioration of environmental quality, such as water pollution, air pollution, or soil pollution." In addition, Cunningham & Saigo (1999: 620) state that pollution is "to make foul, unclear, dirty; any physical, chemical, or biological change that adversely affects the health, survival, or activities of living organisms or that alters the environment in undesirable ways."

The above meanings of pollution are concerned with natural resources and environment and pollution itself is also caused by human or living organisms. What is the relationship between environment and pollution?

1.2.2.3 Environmental pollution

Chankaeow (2001: 300-301) states environmental pollution is the effect of pollutants or hazardous substances that contaminate the environment over the environmental quality standard. Pollutants are found in solid, liquid, and gas forms. Miller (2003: 12-13) points out unwanted effects of pollutants that include: 1) disruption of life-support systems for humans and other species, 2) damage to wildlife, human health, and property, and 3) nuisances such as noise and unpleasant smells, tastes, and sights. Moreover, Miller (2003) also states the major environmental and resources problems are air pollution, water pollution, waste production, food supply problems, and biodiversity depletion.

Learning environmental science is an area that interests educational researchers (Fraser, 1994). It was decided in this study to develop the content of "Life and the Environment" because this topic is important and concerned with students' daily lives. Bell; et al. (2003) state an environmental education program should emphasis learning content and developing positive attitudes toward environmental science. Referring to learning environmental science, Keiny & Zoller (1991) point out that the main objective of environmental education includes "increasing environmental awareness, educating toward responsibility and concern for environmental problems, stimulating the learner's ability and willingness to make a personal contribution and involving the learning in activities to improve the environment.

In one of many research studies related to environmental science, Bennett (1999) reports his research study on learning science through collaborative discussions on current events that "students view learning as more valuable when the teacher seeks out students' ideas." By seeking resources and information, students used their experiences and interests (in science) to solve real world problems. On the one hand, Olsen (2000: 5) posited, "Environmental problems constitute a broad conglomerate of problems that are amenable to scientific approaches and present ample opportunities for student engagement." In a current series of study in South Africa, three research studies (Mailula; et al., Seopa; et al., and Ntuli, Aldridge and Fraser) focus on classroom learning environment. Mailula; et al. (2003) use the Outcomes-Based Education (OBE) approach to implement in school-level environment; Seopa; et al. (2003) develop an instrument which is used to monitor the success of Outcomes-Based Learning Environments (OBLE) in science classroom; and another Ntuli, Aldridge and Fraser (2003) use learning environmental assessments to improve elementary school teaching during a distance inservice course. In the case study conducted by Dori and Herscovitz (1999: 411), they use real-world problems to improve students' abilities in problem solving. They report "this indicates an increase in students' awareness of the need for and feasibility of seeking practical solutions to a given problem, as well as considerable improvement of their ability to analyze a related case study." In another case study, Bouillion and Gomez (2001: 878) state "real-world problems and school–community partnerships are used as contextual...for bridging students' community-based knowledge and school-based knowledge, as a way to provide all students opportunities for meaningful and intellectually challenging science learning." Similarly, Comeaux and Huber (2001: 236) state "knowledge emerges from the interaction between and among instructors and students as they engage in problem solving, real world (authentic) experiences."

2. Inquiry-based instruction

In this section, literature is focused on the relevant research on inquiry-based instruction, which includes the definition of inquiry, learning theories, traditional science instruction versus inquiry instruction, inquiry in teaching and learning science, and inquiry cycle model.

2.1 The definition of inquiry

Inquiry is a well-known term used in science education. Although teachers are familiar with this term they may not be quite exactly sure what inquiry means. Inquiry has many definitions and interpretations from science educators. Science educators and researchers have provided many similar definitions for inquiry; some of which will be addressed below.

Teachers use inquiry as an instructional method in their classroom. Not only do teachers use inquiry but inquiry is also the process used by students to construct meaning in learning science and in being active learners (Sunal & Sunal, 2003; Anderson, 2002). Similarly, Haren (2002) states "inquiry is a major means for learners to extend their understanding of the natural and man made environment" (cited by Llewellyn, 2002: 4). Inquiry is the process of answering testable, scientific questions through investigation (Szesze, 2001: Online). These definitions emphasize the importance for students to find out the answer-how do we know what we know. According to the definition given by the National Research Council (NRC, 1996: 23)

> inquiry is a multifaceted activity that involves making observations; posing questions, examining books and other sources of information to see what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results, inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.

and the standards set by the NRC (1996: 105) highlight scientific inquiry:

> students in all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in

ways associate with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about the relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.

These definitions focus on student learning through inquiry process. Thomson and Stewart (2003: 162) point out the way using scientific inquiry for teachers. They state that "the historical development of scientific inquiry is one method teachers may use to construct thoughtful lessons that can provide insight as to how the nature of inquiry has addressed past complex problems in science." Welch; et al. (1981: 34) address the concept of inquiry in three major aspects:

1) science process skills, include the usual range of science processes, such as observing and measuring, seeing and seeking solution to problems, interpreting data, generalizing, and building, testing, and revising theoretical models;
2) the nature of scientific inquiry is essentially epistemological;
3) general inquiry process, includes strategies, such as problem-solving, use of evidence, logical and analogical reasoning, clarification of values, decision-making, and safeguards and custom of inquiry.

In order to incorporate efficient inquiry-based instructional approaches into science classrooms, teachers need to have a clear understanding of inquiry. Llewellyn (2002: x) asks the question in the introduction of his book "How can we expect our students to engage in inquiry-based activities if we, as teachers, do not have a sufficient understanding of inquiry ourselves?" The above meanings of inquiry inform the teachers the fact that it is important to know about inquiry. Because inquiry is an instructional strategy that teachers can use effectively to teach science in which both students and teachers become more involved in interactive learning.

2.2 Learning theories related to inquiry

The idea of new science philosophy is that science knowledge is derived from creativity in each individual and based on prior knowledge, environment, and society. Llewellyn (2002: 42) addresses "the new era in educational psychology ushered in the cognitive and constructivist theorists." Constructivism theory believes that all students have their own knowledge as basic concept and learning in new concept will be also based on prior knowledge. Learning science by constructivism is the process in which students will inquire, search, and investigate knowledge by themselves. They will understand and gain knowledge and could construct concepts by their own. Szesze (2001: Online) states "constructivism would be inefficient to have students 'discover' everything they are to learn about science. It is important however to be selective in the timing and pacing of constructivism in the curriculum so that students build accurate conceptions of science knowledge and process not misconceptions." Constructivist science classroom involves twelve descriptors, which are:

1. Encourage and accept student autonomy and initiative.
2. Use raw data and primary sources, along with manipulative, interactive and physical materials.
3. When framing tasks, use cognitive terminology, such as: classify, analyze, predict, create, etc.
4. Allow student thinking to drive lessons, and shift instructional strategies or alter content based on student responses.
5. Inquire about students' understandings of those concepts.
6. Encourage students to engage in dialogue, both with the teacher and with one another.
7. Encourage student inquiry by asking open-ended questions of students and encouraging students to ask questions of others.
8. Seek elaboration of students' initial hypotheses, and then encourage discussion.
9. Engage students in experiences that might engender contradictions to students' initial hypotheses, and then encourage discussion.
10. Allow wait time after posing questions.
11. Provide time for students to construct relationships and create metaphors.
12. Nurture students' natural curiosity through frequent use of the 5Es learning cycle. (Szesze, 2001: Online).

Learning with emphasis on students' center will pass through many processes, for example, inquiry cycle approach. In this study, the literature related to inquiry cycle is based on learning theories which are:

2.2.1 Dewey's theory

Dewey's theory is based on natural world education. He believed that "teaching should be an active process, including solving problems that interested students. Problem posed to pupils too often involved the interests of the teacher rather than the students and thinking arises when a person confronts a given problem" (Phillips & Soltis, 1991: 39). In addition, in short, Dewey wanted schools to engage students in meaningful problems" (Llewellyn, 2002: 42).

2.2.2 Piaget's theory

Piaget's theory is concerned with cognitive development. His research focuses on the cognitive structure. The development of mental reasoning was identified by Piaget in four stages. This characterizes the development of knowledge and use of logical thinking. Piaget believed that "children construct cognitive representations from their experiences expressed by the term *schema*. As children experience new information, they used these schemas to assimilate new ideas in constructing knowledge" (Llewellyn, 2002: 43). In addition, on the lecture # 13, Piaget represented the statement that:

> Schemas get changed as a result of acting on the world, and are actively constructed by the child so as to make sense of their experiences. On the one hand, schemas tend to be conservative, and the child tries to fit the world to them: Piaget terms this assimilation. But often, the results of their actions don't 'fit' the world too well, and they need to modify their schemas to take account of this. Piaget terms this accommodation. (Department of Psychology, Massey University, 2003: Online)

Piaget's learning theory has been applications and widely used in education. The related concepts into inquiry are:

1. learning should be active and discovery based.
2. Children should be given every opportunity to interact with their peers.
3. Instructional strategies should be adapted to fit the cognitive structure of children.
4. Conceptual change should promoted by allowing children to test their presently held theories and become aware of inconsistencies in their thinking when compared with scientific models (Llewellyn, 2002: 44).

2.2.3 Vygotsky's theory

Vygotsky's theory is presented to the zone of proximal development. The zone of proximal development is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky', 1879: 86 cited by Department of Psychology, Massey University, 2003: Online).

The above theories mentioned indicate that the learning process will engage students to solve the problems. Problem solving will be promoted for students to use their potential and ability to find out the results or answers. Several instructional methods can be used to assess students' prior knowledge such as posing the "what and why" questions in the beginning of the class or using learning cycle in the classroom.

2.2.4 Ausubel's theory

Ausubel's idea about cognitive is the framework of hierarchical concepts. He believed that "with meaningful learning, linkages are formed or subsumed between previous, more general concepts and new knowledge. Meaningful learning occurs when new information is linked (or assimilated) to existing or previous concepts" (Novak, 1977 and 1998 cited by Llewellyn, 2002: 44).

The above theories related to inquiry are based upon constructivism. Llewellyn (2002: 44) states "constructivism today has an increasingly significant impact on educational reform and is increasingly being adopted theory on how children learn." In addition, one of key points in constructivism related to inquiry is "inquiry is a viable teaching strategy to test the *degree of fit* between one's previously held theories and *scientific* explanations of things" (Llewellyn, 2002: 45).

2.3 Traditional science instruction versus the inquiry instruction

The education reform efforts in various countries that have been mentioned in the previous chapter have as their goals to promote inquiry-based instruction in the classroom. The teachers in the new education reform should change their traditional teaching style into inquiry-based approaches. Some teachers are familiar with inquiry and some of them are worried about how to teach their students by inquiry-based approaches.

Byers and Fitzgerald (2002) state that it is difficult for teachers to change from teaching in the traditional ways to enact inquiry-centered approaches. Because teaching science with the traditional instruction teachers dispense knowledge from textbooks which gather the science curricula to passive student audiences; students rarely have direct experiences with the nature of science (Wise, 1996). Similarly Sunal and Sunal (2003: 19-20) expand on the notion of traditional science teaching:

> teaching in order to stimulate active learning differs from traditional and behavioristic orientations to science teaching. Traditional science teaching may involve techniques that enhance memorization and recall, including frequent repetition and the use of punishment to enhance learning. Another aspect of traditional science teaching is that it often uses direct instruction targeting a narrow learning objective.

In a case study Huber and Moore (2001: 33) report that "...traditional methods might be extended into inquiry, much of that literature is of limited value [in teaching] to novice teachers, because it [traditional approach] is too specific, too modest, or too ambitious in its approach." Most teachers are familiar with traditional lecturing techniques and direct instruction because they feel comfortable teaching and controlling their classrooms (Erick & Samford, 1999; Torp & Sage, 2002). Teaching by inquiry is different from traditional approaches due to the roles of both teachers and students. The role of teacher in this approach is to act as a facilitator, guider and resource person and students' role is as an active participant. Llewellyn (2002) points out the learning cycle as a 5E model that is composed of engagement, exploration, explanation, elaboration or extension, and evaluation. He also states the way that represents an inquiry-based investigation as the inquiry cycle. In the inquiry cycle, students collaborate in group working and the stages are;

> 1) Inquisition; stating a question to be investigated, 2) Acquisition: "brainstorming" possible solutions, 3) Supposition: selecting a statement to test, 4) Implementation: designing and carrying out a plan, 5) Summation: collecting evidence and drawing conclusions, and 6) Exhibition: sharing and communicating results (Llewellyn, 2002: 15)

This cycle supports teachers to generally plan an investigation for their student. Therefore it is important for teachers to consider using inquiry-based approaches in the science classroom. The characteristics of teachers using inquiry-centered instruction will be:

> 1) encourage and accept student autonomy and initiative; 2) use raw data and primary sources, along with manipulative, interactive, and physical materials; 3) when framing tasks, use cognitive terminology such as classify, analyze, predict, and create; 4) allow student responses to drive lessons, shift instructional strategies, and alter content; 5) familiarize themselves with students' understandings of concepts before sharing their own understandings of those concepts; 6) encorage students to engage in dialogue, both with the teacher and with one another; 7) encorage students inquiry by posing thoughtful, open-ended questions and asking students to question each other; 8) seek elaboration of students' initial response; 9) engage students in experiences that pose contradictions to their initial hypotheses and then encourage discussion; 10) allow time after posing questions; 11) provide time for students to construct relationships and create metaphors; and 12) nurture students' natural curiosity. (Brooks and Brooks, 1993: 102-118 cited by Layman, Ochoa. and Heikkinen, 1996: 34-35)

A change from traditional instruction to inquiry-based approaches will be beneficial both to the teachers and to the students. Inquiry in teaching and learning will be discussed in the next section.

2.4 Teaching and learning science based on inquiry

Due to reform initiatives in science education, many science educators and teachers have focused on inquiry-based approaches with the hope of increasing student achievement. Learning science based on inquiry involves students in using past experiences in science to design and carry out an investigation: gather information, formulate hypotheses, collect and interpret data, and draw logical conclusions (Cain, 2002; Chang & Mao, 1999). In addition, students either ask their own questions or are posed a question by the teacher who will wait for the answers without immediately telling them to the students. This situation [asking the questions] can occur through investigation in science during designing and executing controlled experiments, making measurements and observations, or building and testing models (Hebrank, 2002: 1).

A Taiwan case study by Chang and Mao compared an inquiry-group versus a traditional instruction on group student learning outcomes. Student achievement scores were higher for the inquiry group approaches (using cooperative learning). The results indicate, "inquiry-group instruction should be broadly developed and widely used in science classrooms" (Chang & Mao, 1999: 345). According to Byers and Fitzgerald (2002) "learning based upon inquiry encourages students to investigate questions [problems] on their own initiative and ability in real-life situations." Similarly Bennett (1999) in her study indicates during science talks, teachers encourage students without direction or interference to share ideas, thoughts, questions and discussions freely with each other, students can create their own language of science. The argument supports "allowing students to use scientific language for themselves will allow them to gain a stronger identity as scientific thinkers and to value their role as thinkers and knowers" (Bennett, 1999: 4; Gallas, 1994: 77). According to Etheredge and Rudnitsky (2003: 17), the heart of teaching inquiry is understanding of "How do we know what we know?" They go on to state that teaching about inquiry is complex because teachers combine content with an inquiry-based teaching approach without first creating an appropriate classroom environment. Although some educators point out that inquiry is the complete way for teachers to teach science. However, some of science teachers do not like an inquiry approach because they think that most students are not able to be involved in inquiry methods (Costenson & Lawson, 1986). Inquiry-based teaching requires a deep understanding of science content, as well as [the] ways to mentor, coach, and collaborate with students (Keys & Bryan, 2001; Crawford, 2000). For the effectiveness of inquiry teaching in science education, the teachers had to understand "what inquiry in the classroom means" (Bell; et al., 2003: 55).

While some teachers have noticed some problems with inquiry approaches, many educators and researchers have discussed the benefits of using inquiry-based instruction. The report of Bransford; et al. (2002) called "How People Learn" explained the reason why inquiry is successful as an instructional method.

1. Understanding science involves more than obtaining a knowledge base alone, including comprehending what these ideas mean, application of these ideas and strategies for scientific thinking and problem solving.
2. Students build scientific understanding (as well as misconceptions) at least in part upon observations they have made about the world around them.
3. Students modify scientific understanding when they discover conflicts between their observations of the natural world and their understanding, adapting new explanations that seem plausible to them.

4. Learning is a social activity, and students specifically "benefit from opportunities to articulate their ideas...challenge each others' ideas, and in doing so reconstruct their own ideas."
5. Powerful learning situations involve metacognition, initiative, choice, and some degree of control on the part of the learner.
6. When students comprehend concepts, they are better able to transfer this understanding to new contexts (cited by Byers and Fitzgerald, 2002: 82-83).

Lazarowitz and Tamir (1994) summarized the arguments based upon the research on inquiry in science teaching. Further support for encouraging inquiry:

1. Concrete activities and manipulative help students grasp abstract concepts
2. Inquiry participation allows students to experience the "spirit" of science and understand how it works
3. Inquiry promotes the development of higher order thinking skills
4. Inquiry promotes the development of basic skills, including communication and familiarity with science procedures
5. Inquiry provides the opportunity to grasp the components of the scientific method, such as hypothesizing, assumptions, predictions, and conclusions
6. Inquiry promotes habits of mind associated with science, such as openness, skepticism, curiosity, and honesty
7. Students enjoy hands-on exposure to scientific ideas and may have increased motivation to science

The arguments supporting inquiry-based instruction indicate that using inquiry in the classroom encourages students to investigate and discover science. In inquiry classroom students are active participants as they explore their own questions, and develop their thinking processes. Teachers act as facilitators, initiators, and coaches in order to maintain and manage appropriate classroom that engage students in inquiry-based learning. Learning with this approach encourages students to gain the process skills of science and problem solving.

2.5 Inquiry cycle model.

Learning is a cycle in which new knowledge will be based on the old knowledge. Learning Cycle is a method of structuring a science lesson that is based upon constructivist learning theory, research-based best practices in science pedagogy and cognitive psychology (Szesze, 2001: Online). Inquiry cycle involves 5 stages of learning and is called "the 5Es cycle" which comprises of engage, explore, explain, elaborate and evaluate.

2.5.1 Level of Inquiry

There are three levels of inquiry (Colburn, A. 2002 cited Szesze. 2001: Online), that include:

1) Structured Inquiry : The teacher provides students with a hands-on problem to investigate, as well as the procedures, and materials, but does not inform them of expected outcomes. Students are to discover relationships between variables or otherwise generalize from data collected. These types of investigations are similar to those known as cookbook activities. Structured inquiry is used to teach a specific concept, fact, or skill and provides the groundwork for open inquiry. Example: "Students are given a step-by-step procedure, including diagrams for making various types of electrical circuits, including series and parallel. Questions prompt students to remove individual bulbs from each circuit and record their observations."

2) Guided Inquiry: The teacher provides the materials and problem for students to investigate. Students devise their own procedure to solve the problem. The teacher facilitates the investigation and encourages students to generate questions that may lead to further investigations. Example: "Students are given batteries, bulbs, wires, and other materials. Procedures instruct them to make a bulb light as many ways as they can use the supplies provided. Later, they are instructed to make two bulbs light, again, using different combinations of materials. Finally, students are asked to note what happens when they remove individual bulbs from their circuits."

3) Opened Inquiry: This is similar to guided inquiry, with the addition that students formulate their own problem to investigate. Open inquiry allows students to develop their understanding of a concept and use scientific reasoning. An important goal for all students would be to conduct open inquiry independently. Example: "Students are given batteries, bulbs, wires, and other materials. They are instructed to investigate how bulbs light in electrical circuits".

2.5.2 Teaching using the 5Es cycle model

"5Es" model based on constructivism was developed by the Biological Sciences Curriculum Study (BSCS). 5 Es cycle model includes 5 steps that begin with the letter "E": engage, explore, explain, elaborate and evaluate. Each E step is explained as follows: (BSCS, 1997: IG-14-16; Layman, Ochoa & Heikkinen, 1996: 36-37; Szesze, 2001: Online).

The first stage is "**engage.**" This is the introduction to the lesson that is to capture the learners' attention. Activities should be based on past learning experiences and connected to present learning experience. The teacher's role will be asking a question, defining a problem, showing a discrepant event, and acting out a problematic situation. The learners should be curious in the major concept, process and skill.

The second stage is "**explore.**" This is the exploration that learners participate in activities. They explore the concepts and ideas through their experiences and define the phenomena by their own words. The learners have time and opportunity to talk with another learner. Then they articulate their own understanding and to understand one another's view point.

The third stage is "**explain.**" This is the exploration for the concept that the learners have been exploring. The learners should be able to define the concept that they understand through their experience and prior knowledge.

The fourth stage is "**elaborate.**" This is the students' opportunity to apply the concept in new situations and to practice desired skills and behaviors through discussion. This stage, the learners should gain a deeper understanding of the concepts.

The fifth stage is "**evaluate.**" This is an important stage that the learners receive feedback from their explanations and understandings. The learners will continue to develop their understanding in concepts. The learner will evaluate students' understanding of key concepts and development of essential skills.

2.5.3 5Es Strategies for teaching science

The strategies for teaching science by using 5E's cycle are shown in table 1 (Szesze, 2001: Online).

TABLE 1 5Es STRATEGIES FOR TEACHING SCIENCE

Stage	Strategies
1. Engage	- Observe surroundings for points of curiosity
	- Ask questions about the real world
	- Consider possible responses to questions
	- Note unexpected phenomena
	- Identify situations where student perceptions vary

TABLE 1 (continued)

Stage	Strategies
2. Explore	- Engage in focused play
	- Brainstorm possible alternatives
	- Experiment with materials
	- Observe specific phenomena
	- Design a model
	- Collect and organize data
	- Employ problem-solving strategies
	- Select appropriate resources
	- Discuss solutions with others
	- Design and conduct experiments
	- Engage in debate
	- Identify risks and consequences
	- Define parameters of an investigation
3. Explain	- Communicate information and ideas
	- Construct and explain a model
	- Construct a new explanation
	- Review and critique solutions
	- Utilize peer evaluation
	- Assemble multiple answers/solutions
	- Determine appropriate closure
	- Integrate a solution with existing knowledge and experiences
4. Elaborate or Extend	- Analyze data
	- Make decisions
	- Apply knowledge and skills to other disciplines
	- Transfer knowledge and skills
	- Share information and ideas orally and in writing
	- Ask new questions
	- Develop products and promote ideas
	- Use models and ideas to elicit discussions and acceptance by others
	- Conduct more investigations
	- Conduct activities in other disciplines

TABLE 1 (continued)

Stage	Strategies
5. Evaluate	- Journals, Logs, etc.
	- Portfolios
	- Constructs mental and physical models
	- Student data sheets
	- Performance assessments
	- Produce a Product
	- Rubrics and Scoring Tools

3. The assessment based on learning outcomes

3.1 Learning domains

The learning domains, as stated by Vinson, (n.d.) "sometime referred to as categories of learning outcomes." The learning objectives must address the student's learning needs as well as their abilities. Bloom's taxonomy of educational objectives has identified three domains of educational activities. The three domains are cognitive (about knowing), affective (about attitudes, feelings), and psychomotor (about doing).

3.1.1 Cognitive Domain

The "cognitive domain" includes those performances (outcomes) that require *knowledge* of specific information (principles, concepts, and generalizations necessary for problem solving). Conditions (circumstances under which such performances would be accomplished) could be any situation in which the learner is given information to process. Criteria within the cognitive domain will usually call for accuracy of the information to a particular standard. Levels within the cognitive domain from basic to complex are as follows:

1) Knowledge: recognition and recall of facts and specifics.

2) Comprehension: interpretation, translation, summarization, or paraphrasing of given information. Knowledge is required in order to demonstrate comprehension.

3) Application: usage of information in a situation different from the original learning context. Application requires comprehension of information in order to apply in new situations.

4) Analysis: separation of a whole into its parts until relationship among elements is clear. Analysis requires an ability to apply information.

5) Synthesis: combination of elements to form new entity from original one. Synthesis requires analysis.

6) Evaluation: involves decision-making, judging, or selecting based on criteria and rationale; Evaluation requires synthesis.

3.1.2 Affective Domain

The "affective domain" involves the demonstration of feelings, attitudes, or sensitivities toward other people, ideas, or things. The conditions involve clarifying when and where these performances must be demonstrated (i.e., "at all times within the laboratory," "in the actual work situation," "upon completion of the unit on personnel relations," etc). Since feelings are not directly measurable, the criteria by which achievement of an objective/outcome are measured relate to behavior that demonstrates that a feeling or attitude is present.

1) Receiving: awareness, or passive attention to certain phenomena (i.e, listening).

2) Responding: complying with given expectations by attending or reacting to stimuli or phenomena and stimuli (i.e., interests).

3) Valuing: displaying of behavior consistent with the desired belief or attitude in situations where the learner is not forced to comply or obey.

4) Organizing: committing to a set of values as displayed by behavior.

5) Characterizing: total behavior consistent with values internalized.

3.1.3 Psychomotor Domain

materials or environment. The criterion for the achievement of a psychomotor outcome will relate to the actual performance or the finished product and to the necessary level of performance that must be achieved. Appropriate criteria for outcomes in the psychomotor domain might involve accuracy within a certain tolerance limit, speed, degree of excellence, or reference to other material outlining the criteria for judgment.

1) Imitation: observation of skill and attempting to repeat it.

2) Manipulation: performance of a skill according to instruction rather than observation.

3) Precision: reproduction of a skill with accuracy, proportion, and exactness; usually performed independent of original source.

4) Articulation: combining more than one skill in sequence with harmony and consistency.

5) Naturalness: completion of one or more skills with ease and making the skill automatic with limited physical or mental exertion.

3.2 Conceptual framework for assessing student learning

The North Central Accreditation Commission on Institutes of Higher education suggests that "All assessment of student learning be based on the conceptual framework established in three domains: cognitive (knowledge acquisition), behavioral (skill acquisitions), and affective (attitudinal development)" (Lopez, 1995 cited by The National Communication Association, NCA). Students learning based upon the three domains includes:

3.2.1 Cognitive learning: Knowledge acquisition

The cognitive domain of learning is concerned with knowledge and understanding. At the lowest level, this domain focuses on specific facts. At the middle level, the cognitive domain focuses on principles and generalizations. At the highest level of cognitive learning, the focus is on synthesis and evaluation based on learning that has already taken place at the lower levels. This domain of learning encompasses the content of a field.

3.2.2 Behavioral learning: Skill acquisition

The behavioral domain of learning is concerned with psychomotor skills. Skills are viewed as the ability of an individual to perform certain behaviors. Skills can be learned and possessed by the learner, and then they can be demonstrated through performance as observable behaviors. This domain encompasses the ability to perform as a function of cognitive learning. Inferences about cognitive and affective learning can be made through observing behaviors.

3.3.3 Affective learning: Attitude development

The affective domain of learning is concerned with the attitudes and feelings of the learner in regard to knowledge and behaviors acquired in the other two domains. In most learning environments, affective learning is incidental to both cognitive and behavioral learning. This domain encompasses attitudes toward what has been learned cognitively and motivation to perform learned behaviors.

Examples of the three domains of cognitive, behavioral and affective learning are:

1) Knowledge acquisition: Some examples of direct measures of cognitive learning would be: pre- and post-testing in a general education program using a measure of critical thinking such as the Watson-Glasser Critical Thinking Test; in a department of music, faculty-juried exams on studio instruction; comprehensive written exams in bachelors, masters, and doctoral programs, and the writing of and the defense of the thesis or dissertation. In any major, a paper-and-pencil test of the cognitive content essential to the discipline could be pre-test and post-administered at the beginning and end of the student's tenure in the program, as an entrance test of freshmen and an exit test of graduating seniors.

2) Behavioral learning: Skill acquisition. Examples typically associated with this domain include oral communication skills such as interpersonal, group interaction, and presentational skills; leadership; managerial skills; written communication abilities demonstrated in essay writing, etc.; or problem solving skills. Examples of measures of incremental behavioral learning include faculty-juried recitals in music or dance and pre- and post- standardized measures of general skill acquisition for specific content areas such as mathematical reasoning (e.g. Academic Profile).

3) Affective learning: Attitude development. Most exemplary of this domain are self-report instruments and surveys. These types of tools are the most common type of measures used to evaluate the attitudinal development of students. They do not directive indicate cognitive learning, but the information yielded is useful in determining change and growth in what students themselves perceived or are perceived by others. Examples of these measures include: student satisfaction and attitude surveys, alumni surveys, and employer surveys. The student goals exploration survey and the cooperative institutional research program question, which measure attitudes and opinions of students entering graduate programs are typical examples.

Chapter Three

Methodology

This research is to develop a high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach. The following steps are used in this study in order to develop a science curriculum.

1. Target source of the study
2. Materials of this study
3. Procedures
4. Roles of individuals in this research
5. Statistical analyze procedures

1. Target source of the study

Target sources of this study were three science teachers and three classrooms of high school science students. A science teacher and one classroom of high school science students were drawn from Sampran Wittaya School, and other two science teachers and two classrooms of high school science students were drawn from King's College. The target sources of this study are shown in table 2

TABLE 2. TARGET SOURCE OF THIS STUDY

Developing a science curriculum	Number of schools	Number of teachers	Number of classrooms
- Determining and developing a high school science curriculum draft	2	3	-
- Piloting the high school science curriculum draft	1	1	1

TABLE 2 (continued)

Developing a science curriculum	Number of schools	Number of teachers	Number of classrooms
- Implementing the high school science curriculum	1	2	2

2. Materials of this research

Materials of this research are classified into two sections.

Section 1: The high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach.

Section 2: Materials for collecting data.

2.1 An achievement test on natural resources and environmental pollution

2.2 An assessment of student portfolios

2.3 An assessment of student awareness toward science on natural resources and environmental pollution

2.4 An assessment of student opinion towards the high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach

2.5 An assessment of teacher opinion toward the high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach

3. Procedures

The high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach involved two stages of development (see Table 3). The stages are summarized as a concept scheme of study shown in figure 3.

TABLE 3 THE STAGES OF CURRICULUM DEVELOPMENT

Stage	Activities
1. Curriculum Development	- Determining the relevant science content - Developing a high school science curriculum draft - Consulting with curriculum experts to examine and verify the high school science curriculum draft - Piloting the high school science curriculum draft - Preparing the teachers to implement the high school science curriculum - Collecting the piloting study data and evaluation - Revising the high school science curriculum draft
2. Curriculum Implementation	- Implementing the high school science curriculum - Data collection - Data Analysis

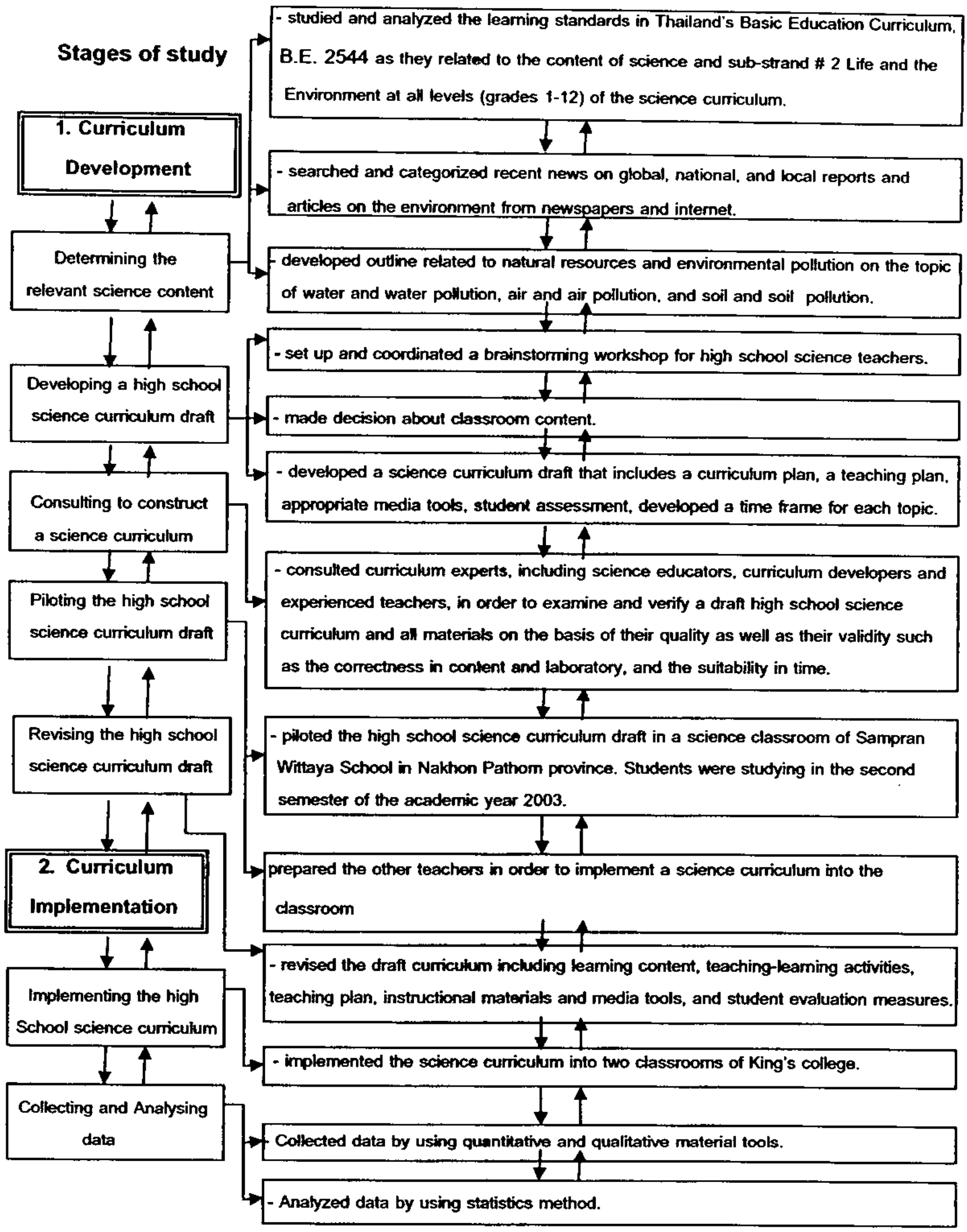

Figure 3 Concept scheme of study

3.1 Stage of Curriculum Development

The curriculum development stage consists of six phases:

3.1.1 Determining the relevant science content

The first phase of curriculum development is determining the relevant science content. In this first phase the learning standards in Thailand's Basic Education Curriculum, B.E. 2544 (Ministry of Education, 2001) were studied and analyzed. The science strand (content) and sub-strand # 2 "Life and the Environment" at all levels (grades 1-12) of the science curriculum (see Appendix B) was explored. This research study focused on standards science # 2.2 at grades 10-12. Standard science # 2.2 is described as follows:

a. Investigate and analyze environmental problems and natural resource (water, air, and soil) usage at the local, national, and global levels.

b. Analyze causes of environmental problems.

c. Collaborate and participate with the local community in order to develop plans for environmental protection, conservation, and problem solving.

This standard was used as a guideline for choosing the appropriate content in the science curriculum. Recent news on global, national, and local reports and articles on the environment from newspapers and internet were searched. Some examples of news related to natural resources and environmental pollution were: "Water is severely polluted in Mae-Klong River, Rajchaburi province to Samut-sakorn province"; "Water pollution and garbage dump in Kho-Lan"; Michican bans herbicide linked to pollution"; and "Traffic law reform fuels debate over air quality." Based on these newspaper headlines, a set of issues that are relevant to natural resources and environmental pollution for the classroom was generated for this curriculum research study. Finally an outline related to natural resources and environmental pollution based on real-life issues for students in grades 9 - 12 was developed in this study (see Table 4).

TABLE 4 OUTLINE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION

Topic	Learning outcomes	
	Concepts	Skills
1. Water and water pollution	The concepts that students should know are: 1.1 What is water? - water properties such as water density, solvency, heat transfer, heat absorption, etc. 1.2 Where does water come from? - sources of water such as ground water, surface water, and precipitation. - water cycle 1.3 What will be judged as polluted water? - water qualities (such as physical, chemical and biological quality) - water standards (from WHO and Thailand's national water standards 1.4 What is water pollution? - waste water - water pollutants 1.5 How is water polluted? - human activities	Students will be able to: - describe water qualities. - investigate water qualities. - discuss and explain the uses of water at the local and national level. - discuss and explain the effects of water usages and changes of the environment by nature and human beings. - create and develop the ideas of water conservation; and how to use water and the environment - design experiments to test water quality. - discuss and present ways to use and save our water and to prevent water pollution. - illustrate ideas and personally participate in the care and protection of water. - develop scientific process skills with an emphasis on gathering, analysis and synthesis of information about water problems as well as

TABLE 4 (continued)

Topic	Learning outcomes	
	Concepts	Skills
		communication and decision-making skills.
	1.6 What are the effects of polluted water? - the effects on living organisms.	- apply scientific knowledge and processes to solve the water problems in order to protect and improve the environment at the individual, local and national level.
2. Air and Air pollution	2.1 What is in a breath? - Air components. 2.2 What will be judged as polluted air? - Air quality and air quality standards: ambient air standards of Thailand, industrial emission standards. 2.3 What is air pollution? - Air pollutants; sources and solutions; global warming. 2.4 How is air polluted? - human activities such as emissions from transportation, and emissions from industries, etc.	- describe air qualities. - investigate air qualities. - discuss and explain the problem of air and air pollution at the local and national level. - discuss and explain the effects of air polluted and changes of the environment by nature and human beings. - create and develop ideas of air preservation by using and applying their knowledge of science and technology. design experiments to test air pollution. - discuss and present ways to save our air and to prevent air pollution.

TABLE 4 (continued)

Topic	Learning outcomes	
	Concepts	Skills
	2.5 What are the effects of air pollution? - the effects on living organisms, health effects such as allergies, respiratory disease, and dermatitis. - the effects on non living thing such as iron corrosion, paint deterioration on building, etc.	- illustrate ideas and participate in the care and protection of air and air pollution. - develop scientific processes with emphasis on gathering, analysis and synthesis of information about environmental problems as well as communication and decision-making skills. - apply scientific knowledge and processes to solve the air problems in order to protect and improve the environment at the individual, local and national level.
3. Soil and Soil pollution	3.1 What is soil? - soil properties such as soil density, soil absorption, soil fertility, etc. 3.2 How does soil derive? - sources of soil such as decomposition, sedimentation. 3.3 What will be judged as polluted soil?	- describe soil qualities. - investigate soil qualities. - discuss and explain the problems of soil pollution at the local and national levels. - discuss and explain the effects of soil usages and changes of the environment by nature and human beings. - create and develop the ideas of soil conservation for sustainable

TABLE 4 (continued)

Topic	Learning outcomes	
	Concepts	Skills
3. Soil and Soil pollution (continued)	- soil qualities (such as physical, chemical and biological quality - soil contamination 3.4 What is soil pollution? - soil pollutants 3.5 How is soil polluted? - human activities 3.6 What is the effects on soil pollution? - the effects of living organisms.	yield by using and applying the knowledge of science and technology. - design experiments to test soil pollution. - discuss and present ways to use and save our soil and to prevent soil pollution. - illustrate ideas and take personal participation in the care and protection of soil. - develop scientific processes with emphasis on gathering, analysis and synthesis of information about soil problems as well as communication and decision making skill. - apply scientific knowledge and processes to solve soil problems in order to protect and improve the environment at the individual, local and national levels.

3.1.2 Developing a high school science curriculum draft

The second phase of curriculum development is to develop a high school science curriculum draft. This phase consists of two steps as follows:

3.1.2.1 Developing a high school science curriculum draft on natural resources and environmental pollution, and instructional plan. Much of the content was drawn from the learning standard "science strand" of the Basic Education Curriculum B.E. 2544 (2001), sub-strand #2: "Life and the Environment" for Level 4, grades 10, 11, and 12. Real-life issues that were previously identified in Phase One were used to select the science content on natural resources and environmental pollution used in this study. The determined content focused on water and water pollution, air and air pollution, and soil and soil pollution and was used to develop curriculum goals, learning content, organizing content, teaching-learning activities, instructional materials, and assessment tools. A science curriculum draft that includes a curriculum plan, a teaching plan, appropriate media tools, and student evaluation measures was developed in this study.

3.1.2.2 Setting and coordinating a brainstorming workshop for high school science teachers. Participants in this workshop included three high school science teachers, and the researcher. One of the science teachers was drawn from Sampran Wittaya School and the other two science teachers from King's College in Nakhon Pathom province. The principals of these high schools were contacted and asked to designate teachers for this research project. The workshop lasted over two days, and involved two major components: providing teachers from Nakhon Pathom province schools with an overview of inquiry cycle-based instruction, considering and discussion on a science curriculum draft, activities, instructional plan and setting of instruction periods.

The first component of the workshop was to provide the teachers with instruction on how to use inquiry-cycle based instructional approaches related to real-life environmental issues. The workshop included mini-lectures but the major goals of the workshop are group discussion and active participation (see Appendix B, "Workshop on science curriculum for high school teachers"). There were handouts related to learning science standards, framework of concept map on natural resources and environmental pollution, outline on natural resources and environmental pollution, an instructional plan, and documents and activities on water and water pollution, air and air pollution, and soil and soil pollution. The second component of the workshop involved setting a time frame for each topic. Collaboration with the teachers in this activity and in the consideration of assessment tools was sought.

3.1.3 Consulting to examine and verify the high school science curriculum draft

The third phase is to consult with curriculum experts, including science educators, curriculum developers and experienced teachers, in order to complete a high school science curriculum draft. These persons examined and verified the high school science curriculum draft and all materials on the basis of their qualities as well as their validities and the suitability of time allocation. This curriculum draft is revised as suggested by the curriculum experts. After these activities, the curriculum draft was tried out in a science classroom.

3.1.4 Piloting the high school science curriculum draft

A science classroom from Sampran Wittaya School with approximately 21 high school science students was involved in the pilot study. This was the same high school that one of the teachers who attended the workshop teaches at. The high school science curriculum draft consisted of 25 periods or 37.5 hours of instruction early in the academic year 2003. This curriculum was taught by the teacher and was closely observed by the researcher. Five research tools for this pilot study are an achievement test, an assessment of student portfolio, an assessment of student awareness toward science on natural resources and environmental pollution, an assessment of student opinion toward science curriculum, and an assessment of teacher opinion toward science curriculum. These tools were used in order to assess the efficiency of the high school science curriculum draft. These tools are described below:

3.1.4.1 An achievement test

A tool to assess students' achievement was designed and developed by following these steps:

Step I: Designed an achievement test

1) Determining the science content and learning outcome. An achievement test was developed focusing on the content of natural resources and environmental pollution. The test consisted of two parts;

Part one was multiple choice test questions and four answers type. The test was 60 questions and was evaluated in three domains; (1) concept domain consisted of 6 questions (2) cognitive domain consisted of 34 questions and (3) application domain consisted of 20 questions.

Part two was open-ended test questions. The test was 20 questions and was evaluated in two domains; (1) cognitive domain consisted of 15 questions and (2) application domain consisted of 5 questions.

2) Examining and verifying the validity of tests. The tests were examined for quality by seven experts. These persons evaluated the validity of content and structure and the Item-Objective Congruence (IOC) between each question and learning outcome. Questions with an IOC above 0.50 were selected and the test was improved by the experts' suggestions.

3) Trying out the quality of the tests. The tests were evaluated for quality in one classroom of 46 high school science students of Tepleela School in Bangkok Metropolis. This school was not the target source. The students' scores in each item were used to test item difficulty (p) and item discrimination (r) in the upper and lower 50% of the sample group.

4) Selecting the tests. Each question for the test was selected by considering of the p value between 0.20 and 0.80 and the r value above 0.20. The result of the selection was 40 questions for the final version of the test.

5) Estimating the reliability of the test. The selected 40 questions were estimated for reliability using the Kuder–Richardson formula 20 (K-R 20). The reliability of the test was 0.51.

6) Using the final version of the test with the target group. The test was used to assess students' achievement in the pilot study and the curriculum implementation phase.

3.1.4.2 An assessment of student portfolio

An assessment portfolio tool was designed and developed to assess students' understanding, skills and application in learning science on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach. The steps were as follows:

1) Determining the relevant document of portfolios. The portfolios were focused on the holistic score and analytical score of assessment.

2) Designing the portfolio assessment. The assessment was authentic and focused on the analytical score. The score was rating scale type of 4 categories: 3 = complete

and well detailed, 2 = complete but with less detail, 1 = incomplete and with less detail, 0 = incomplete and no detail.

The portfolio was focused on three domains: cognitive domain, skill domain, and application domain.

3) Examining and verifying the validity of portfolio assessment. The portfolio assessment was examined for quality by seven experts. These persons evaluated the validity of structure and appropriateness of the portfolio assessment. The IOC value was selected above 0.50. The experts' suggestions were used to improve the portfolio assessment.

4) Trying out the quality of the portfolio assessment. The portfolio assessment was used to evaluate the quality in three high school science teachers of Tepleela School in Bangkok Metropolis, which were not the target source. The results of these trials were used to improve the portfolio assessment before the real use with the target group in the next phase.

3.1.4.3 An assessment of student awareness toward science on natural resources and environmental pollution

An assessment of student awareness toward science on natural resources and environmental pollution was designed as follows:

1) Determining the relevant questionnaire on student awareness toward science by applied from a Likert Scale type.

2) Designing the assessment of student awareness toward science. The assessment of student awareness contained 40 statements of a Likert-scale type consisting of five categories: 5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, and 1 = strongly disagree. The item statement was two-tailed with a positive side and a negative side.

3) Examining and verifying the validity of awareness assessment. The assessment of student awareness was examined for quality by seven experts. These persons evaluated the validity of structure and appropriateness of the awareness assessment. The IOC value was selected at above 0.50. The experts' suggestions were used to improve the assessment of student awareness for the final version.

4) Trying out the quality of the assessment of student awareness. The assessment was used to evaluate the quality in one classroom of 46 high school science students of Tepleela School in Bangkok Metropolis, which were not the target source.

5) Estimating the assessment of student awareness. The students' awareness scores were used to estimate the reliability from the Alpha Coefficient of Cronbach (α-Coefficient) and the reliability of awareness assessment was 0.68.

6) Improving the assessment of student awareness. The results of this evaluation were used to improve the assessment of student awareness before the real use with the target group in the next phase.

3.1.4.4 An assessment of student opinion toward science curriculum

A questionnaire to assess students' opinion toward science on natural resources and environmental pollution based on inquiry cycle approach was designed as follows:

1) Determining the relevant questionnaire on student opinion toward science on a Likert-scale type.

2) Designing the assessment of student opinion toward science. The assessment of student opinion contained 35 items on a Likert-type scale consisting of five categories: 5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, and 1 = strongly disagree.

3) Examining and verifying the validity of student opinion assessment. The assessment of student opinion toward science was examined for quality by seven experts. These persons evaluated the validity of structure and appropriateness of the student opinion assessment. The IOC value was selected at above 0.50. The experts' suggestions were used to improve the assessment of student opinion assessment.

4) Trying out the quality of the assessment of student opinion toward science. The assessment was used to evaluate the quality in one classroom of 46 high school science students of Tepleela School in Bangkok Metropolis, which were not the target source.

5) Improving the assessment of student opinion toward science. The results of this evaluation were used to improve the assessment of student opinion toward science before the real use with the target group in the next phase.

3.1.4.5 An assessment of teacher opinion toward science.

A questionnaire to assess teachers' opinion toward science on natural resources and environmental pollution based on inquiry cycle approach was designed as follows:

1) Determining the relevant questionnaire on teacher opinion toward science on a Likert-type scale.

2) Designing the assessment of teacher opinion toward science. The assessment of teacher opinion contained 35 items on a Likert-type scale consisting of five categories: 5 = strongly agree, 4 = agree, 3 = neither agree nor disagree, 2 = disagree, and 1 = strongly disagree and 4 open-ended questions.

3) Examining and verifying the validity of teacher opinion assessment. The assessment of teacher opinion toward science was examined for quality by seven experts. These persons evaluated the validity of structure and appropriateness of the teacher opinion assessment. The IOC value was selected at above 0.50. The experts' suggestions were used to improve the assessment of teacher opinion.

4) Trying out the quality of the teacher opinion assessment. The teacher opinion assessment was used to evaluate the quality in three high school science teachers of Tepleela School in Bangkok Metropolis, which were not the target source. The results of this trial were used to improve the teacher opinion assessment before the real use with the target group in the next phase.

In addition, in this pilot study both teachers from King's College also observed an instructional method in the classroom in order to prepare themselves before utilizing the high school science curriculum.

3.1.5 Collecting the pilot study data for evaluation

Data collection during the pilot study was used for both quantitative and qualitative research instruments. Quantitative methods were used in this research to collect student achievement data such as pre-test and post-test on science content and portfolio assessment. The student questionnaires were used to survey students' awareness and opinions toward science curriculum on natural resources and environmental pollution based on inquiry cycle approach. In addition, the teacher questionnaire was used to survey teachers' opinions toward science curriculum on natural resources and environmental pollution based on inquiry cycle approach. These questionnaires were collected at the end of the pilot study.

Qualitative methods were used for classroom observations. The classroom instruction such as teaching-learning activities and the reaction of students was observed. Video tape recorder was used to provide a sense of the classroom atmosphere.

3.1.6 Revising the high-school science curriculum

The final phase of curriculum development involves revision of the high school science curriculum draft. Information and suggestions from the above observations, tests, and questionnaires were used to make revisions to the curriculum. The high school science curriculum draft including learning content, teaching-learning activities, instructional plan, instructional materials and media tools and student assessments were revised.

After the revisions were completed during the second stage, the actual implementation of the science curriculum is described below. The procedures related to the implementation of the curriculum were basically the same as those in the pilot study phase except for some variations that are described.

3.2 Stage of curriculum implementation

This curriculum implementation involved three major phases: implementing the science curriculum, collecting data for evaluation, and analyzing the data.

3.2.1 Implementing the science curriculum

The science curriculum was implemented in two classrooms of approximately 85 high school science students drawn from King's College. This school was the home school of one of the teachers who attended the workshop and who was involved in implementation and evaluation the initial curriculum draft. The revised curriculum consisted of 25 periods or 37.5 hours of instruction over the late second semester of the academic year 2003.

3.2.2 Collecting data for evaluation

Data collection to evaluate the science curriculum utilized both quantitative and qualitative tools. The same quantitative tools used in the pilot study were used to gather data on student achievement (e.g. pre-test and post-test of science content that focus on natural resources and environmental pollution concerns in Thailand, assessing student knowledge, understanding and application). Questions were multiple choice and open-ended types.

Portfolio assessment was also used to assess student understanding, skills and application. In addition, the questionnaire relating student awareness towards natural resources and environmental pollution, the value of natural resources and the environment, and conservation of natural resources will be evaluated. Questionnaire was related to students' opinion and teachers' opinion of science curriculum on natural resources and environmental pollution related to real-life issues such as usefulness and preference were included in the data collection.

Video tape recorder was used to observe teaching-learning science in both classrooms.

3.2.3 Data Analysis

The data were analyzed using the information that were collected through pre-test and post-test, portfolio assessment form, an assessment of student awareness toward science, an assessment of student and teacher opinion toward science curriculum and observation tool. The data from the above instruments were analyzed using the following methods. The descriptive statistics such as mean, t-test, and standard deviation were used to analyze the student pre-test and post-test results. In addition, statistics were also used to analyze content validity and reliability of pre-test and post-test and an assessment of student awareness toward science. Moreover, descriptive statistics were used to analyze the quantitative characteristics of findings from questionnaires. Content analysis was also used to analyze the questionnaires and observations.

4. Roles of individuals

This study involved three groups of people.

4.1 The researcher

The researcher developed a high school curriculum draft on natural resources and environmental pollution related to real-life issues and approach by inquiry cycle. This curriculum includes activities, laboratories, instructional plan, instructional media, and assessments. The researcher collaborated with the teachers in a brainstorming workshop in order to develop the high school science curriculum draft. During the pilot study and curriculum implementation, the researcher was an observer of instructional process in the classrooms. Video tape recorder was also used to assist in the observation.

4.2 The high school science teachers

Three high school science teachers drawn from Sampran Wittaya School and King's College in Nakhon Pathom province collaborated with researcher in the brainstroming workshop and assisted the researcher in all stages of curriculum development. They also taught this curriculum in the pilot study and curriculum implementation stages.

4.3 The high school science students

Three classrooms of high school science students drawn from Sampran Wittaya School and King's College in Nakhon Pathom province were learners in this study and went through the science curriculum in the areas of content, activities, instructional media, and instructional process administered to them in the research study.

5. Data analysis

5.1 Material developing and data analyzing

The developed materials of this research study were analyzed as follows:

5.1.1 Analyzing the validity of an achievement test, an assessment of portfolio, an assessment of student awareness, an assessment of student opinion, and an assessment of teacher opinion. The analysis was focused on the Item-Objective Congruence (IOC).

5.1.2 Analyzing the test item difficulty (p) and item discrimination (r) of an achievement test.

5.1.3 Analyzing the reliability of an achievement test used of Kuder – Richardson formula 20 (K-R 20).

5.1.4 Analyzing the reliability of an assessment of student awareness used of the Alpha Coefficient of Cronbach (α-Coefficient).

5.2 Hypotheses testing

The five hypotheses of this research study were analyzed using statistics as follows:

5.2.1 Analyzing a student achievement score. An achievement test was used to assess student before starting the class and at the end of the class. Pre-test and post-test students' scores were analyzed using *t*-test dependent for Paired Sample Statistics.

5.2.2 Analyzing a student portfolio score. After the science curriculum was implemented in the classroom, an assessment of student portfolio was used. Students' portfolio score were analyzed using *t*-test for One-Sample Statistics. The t-test scores were compared with the criteria score setting under the normal curve.

5.2.3 Analyzing an awareness student score. An assessment of student awareness was used to assess students after the science was implemented in the classroom. The student awareness scores were analyzed using *t*-test for One-Sample Statistics. The mean and standard deviation of each student was evaluated and weighted to the score as follows:

The positive question, the score was weighted to

- Strongly agree	the score = 5
- Agree	the score = 4
- Neither agree nor disagree	the score = 3
- Disagree	the score = 2
- Strongly disagree	the score = 1

The negative question, the score was weighted to

- Strongly agree	the score = 1
- Agree	the score = 2
- Neither agree nor disagree	the score = 3
- Disagree	the score = 4
- Strongly disagree	the score = 5

The mean score of student awareness was evaluated by comparing with the criteria score setting under the normal curve. The criteria score had three levels as follows:

The positive question, mean score was interpreted as:

- A mean score 3.67 – 5.00 was interpreted as a high level of awareness
- A mean score 2.34 – 3.66 was interpreted as medium level of awareness
- A mean score 1.00 – 2.33 was interpreted as a low level of awareness

The negative question, mean score was interpreted as:

- A mean score 3.67 – 5.00 was interpreted as a high level of awareness
- A mean score 2.34 – 3.66 was interpreted as medium level of awareness
- A mean score 1.00 – 2.33 was interpreted as a low level of awareness

5.2.4 Analyzing a student opinion score. An assessment of student opinion was used to assess student after the science was implemented in the classroom. The students' opinion scores were analyzed using *t*-test for One-Sample Statistics. The mean and standard deviation of each student was evaluated and weighted to the score as follows:

- Strongly agree	the score = 5
- Agree	the score = 4
- Neither agree nor disagree	the score = 3
- Disagree	the score = 2
- Strongly disagree	the score = 1

The mean score of student opinion was evaluated comparing with the criteria score setting under the normal curve. The five category scores as follows:

- The mean score 4.51 – 5.00	interpreted as the highest level of opinion
- The mean score 3.51 – 4.50	interpreted as a high level of opinion
- The mean score 2.51 – 3.50	interpreted as a medium level of opinion
- The mean score 1.51 – 2.50	interpreted as a low level of opinion
- The mean score 1.51 – 2.50	interpreted as the lowest level of opinion

5.2.5 Analyzing a teacher opinion score. An assessment of teacher opinion form was used to assess teacher after the science was implemented in the classroom. The teachers' opinion scores were analyzed using *t*-test for One-Sample Statistics. The mean and standard deviation of each teacher was evaluated and weighted to the score as follows:

- Strongly agree	the score = 5
- Agree	the score = 4
- Neither agree nor disagree	the score = 3
- Disagree	the score = 2
- Strongly disagree	the score = 1

The mean score of teacher opinion was evaluated by comparing with the criteria score setting under the normal curve. The five category scores as follows:

- The mean score 4.51 – 5.00	interpreted as the highest level of opinion
- The mean score 3.51 – 4.50	interpreted as a high level of opinion
- The mean score 2.51 – 3.50	interpreted as a medium level of opinion
- The mean score 1.51 – 2.50	interpreted as a low level of opinion
- The mean score 1.51 – 2.50	interpreted as the lowest level of opinion

In this research study, the data were analyzed using a computer with SPSS program (Statistical Package for the Social Sciences)

6. Statistics

The statistics used in this research study were as follows:

5.1 Basic statistics

The basic statistics such as mean, and variance were used to analyze the scores of pre-test and post-test, student portfolio, student awareness, student opinion, and teacher opinion.

5.2 Statistics of testing materials

5.2.1 Estimating of reliability of content, an assessment of student portfolio, an assessment of student awareness toward science on natural resources and environmental pollution, an assessment of students and teachers opinion toward science curriculum on natural resources and environmental pollution. These materials were analyzed using an Item-Objective Congruence (Taweerat, P. 1997: 117).

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

Where IOC is the index of congruence

$\sum R$	is	the total number of expert's opinion
N	is	the total number of content experts

5.2.2 The test item difficulty (p) and item discrimination (r) of achievement tests by item analysis (Taweerat, P. 1997: 129-130)

$$p = \frac{R}{N}$$

Where p is the each of test item difficulty

R is the total number of right answer items

N is total number of students

$$r = \frac{(R_U - R_L)}{\frac{N}{2}}$$

where r is the each item discrimination

R_U is the total number of students in the upper group

R_L is the total number of students in the lower group

N is the total number of students in the upper group and the lower group

5.2.3 Reliability of achievement tests by using Kuder-Richardson 20 (K-R 20) (Taweerat, P. 1997: 123)

$$r_{tt} = \frac{K}{K-1}\left\{1 - \frac{\sum pq}{S_t^2}\right\}$$

where r_{tt} is reliability of the test

k is the total number of items in the tests p is ratio of right answer in each item $= \dfrac{\text{total of right item}}{\text{total of students}}$

q is ratio of wrong in each item $= 1 - p$

S^2_t is variable of whole tests

5.2.4 Reliability of student awareness toward science on natural resources and environmental pollution by using α - Coefficient of Cronbach (Charoenpitaya, N. 1999: 226)

$$\alpha = \frac{k}{k-1}\left\{1 - \frac{\Sigma s^2_i}{S^2_t}\right\}$$

where α is α - Coefficient reliability

k is the total number items in the tests

S^2_i is variable score of each item

S^2_t is variable score of whole test

Chapter Four

Results of This Research

This research aimed to develop a high school science curriculum on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach. The stages used in this study were composed of curriculum development, piloting a high school science curriculum draft, and curriculum implementation with the target groups. The results are as follows:

Stage 1: Curriculum development

The curriculum development stage was developed in three phases as follows:

1. Determining the relevant science content on natural resources and environmental pollution.

The curriculum development of this research started with studying and analyzing the learning standards of Thailand's Basic Education Curriculum, B.E. 2544 (Ministry of Education, 2001). The findings showed that the natural resources and environmental pollution content was related to the science strand. In particular, sub-strand # 2 "Life and the Environment" of the science curriculum was related at grades 1-12 and the standard science # 2.2 was focused at grades 10-12 (see Appendix B). The indicated relationships were used as guidelines for selecting appropriate content as related to real-life issues.

A set of issues based on recent news on global, national, and local reports and articles relevant to natural resources and environmental pollution in everyday life was generated for this curriculum research study. The content on natural resources and environmental pollution targeted three main topics: water and water pollution, air and air pollution, and soil and soil pollution. These topics were used to develop curriculum goals, learning content, teaching- learning activities, instructional materials, and assessment tools.

2.1 Developing a high school science curriculum draft on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach. Two steps were used for this process as follows:

2.1 Step one developed a science curriculum draft on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach. The draft of the science curriculum included content and laboratory activities on water and water pollution, air and air pollution, and soil and soil pollution. The content and laboratories were used as guideline to develop an instructional plan. The teaching methods focus was based on real-life issues with emphasis on inquiry cycle approach consisting of five stages: engagement, exploration, explanation, elaboration, and evaluation. Using the inquiry cycle approach of this research enabled a one course one cycle instructional plan. Each stage of an inquiry cycle could allow development of an appropriate sub cycle inquiry as needed.

2.2 Step two involved setting and coordinating a brainstorming workshop for high school science teachers. The brainstorming workshop was aimed at teachers who joined this research study to enable them to understand the curriculum development methodology, share ideas, and collaborate on the development of this science curriculum. Participants in this workshop included three high school science teachers, and the researcher. One of the science teachers was drawn from Sampran Wittaya School and the other two science teachers from King's College in Nakhon Pathom province. The activities over two days of workshop were provided in mini-lectures of inquiry cycle approach in the science curriculum draft. The other components of the workshop determined the science content and laboratories, instructional plan, and assessment tools. The instructional plan set an appropriate period in each stage of an inquiry cycle approach (see Appendix B, "Workshop on science curriculum for high school teachers").

3. Evaluating of science curriculum qualities.

The science curriculum draft was verified by seven curriculum experts, including science educators, curriculum developers and experienced teachers. These persons evaluated and verified the quality, appropriateness, and validity of the science curriculum draft. The results of evaluating the quality of the science curriculum draft were as follows:

TABLE 5 THE RESULT OF EVALUATING THE APPROPRIATE OF THE SCIENCE CURRICULUM DRAFT ACCORDING TO EXPERTS' OPINION

No.	The evaluation list	No. of items	N = 7		The results
			Mean	S.D.	
1.	The content	7	4.47	0.65	Highly appropriate
2.	The method of instructional procedures	9	4.54	0.71	Highest appropriate
3.	The instructional materials	5	4.34	0.80	Highly appropriate
4.	The measurement and evaluation	5	4.51	0.71	Highest appropriate
5.	The benefit of using the science curriculum	4	4.07	0.94	Highly appropriate
	Total	30	4.39	0.76	Highly appropriate

The result of each list showed that the high school science curriculum draft on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach was highly appropriate in all lists.

The other result of validity of the science curriculum draft as evaluated by curriculum experts is described in Table 6.

TABLE 6 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC) OF THE SCIENCE CURRICULUM DRAFT

No.	The item consideration	N = 7	Interpretation
1.	The purpose of the science curriculum with the principle of the curriculum.	1.00	Appropriate
2.	The purpose of the science curriculum with the content of the curriculum.	1.00	Appropriate
3.	The purpose of the science curriculum with the instructional plan.	1.00	Appropriate
4.	The purpose of the science curriculum with the strategy of the curriculum.	1.00	Appropriate

TABLE 6 (continued)

No.	The item consideration	N = 7	Interpretation
5.	The content of the curriculum with the laboratories of the curriculum.	1.00	Appropriate
6.	The content of the curriculum with the method of using inquiry cycle approach.	1.00	Appropriate
7.	The content of the curriculum with using the real-life issues/ real events.	1.00	Appropriate
8.	The content of the curriculum with instructional media.	1.00	Appropriate
9.	The content of the curriculum with the measurement and evaluation.	1.00	Appropriate
10.	The content of the curriculum with the benefit of using the science curriculum.	1.00	Appropriate

The results of the validity of the science curriculum draft showed the appropriateness of all items in the curriculum structure. Therefore, this curriculum was ready to move to the next stage.

Stage 2: Pilot study the science curriculum draft

The pilot study stage aimed to determine the appropriateness of using a high school science curriculum draft in the classroom at content and instructional method levels. The result of this pilot study was used to improve the science curriculum before applying in an actual classroom setting.

The pilot study process was as follows:

1. Piloting the science curriculum draft in the classroom

The sample group in this study was one classroom of 21 high school science students at level 4 (grade 10) of Sampran Wittaya School. The science curriculum was introduced and used in the second semester in the academic year 2003 in November through December. The instruction period was 25 periods (1 period = 50 min) with a full scale of instruction in the classroom. The target of this pilot study was to: 1) study the result of using science curriculum in the classroom and 2) prepare the other participating teachers in order to use the real science curriculum in the implementation stage.

The teacher of Sampran Wittaya School taught this curriculum as a master teacher and the other two teachers of King's College and the researcher were involved in classroom observation. During the classroom observations, the observation form and videotaping were used to record the results of the pilot study.

The pilot study of the science curriculum draft was evaluated using five research tools including: 1) a student achievement test on natural resources and environmental pollution, 2) an assessment of student portfolio, 3) an assessment of student awareness toward science on natural resources and environmental pollution, 4) an assessment of student opinion toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach, and 5) an assessment of teacher opinion toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach. The results of this pilot study evaluation were analyzed and showed as follows:

1) The comparison of student achievement test on natural resources and environmental pollution

The data were collected using an achievement test at the beginning and the end of the class. The student scores before and after using the curriculum were analyzed using *t*-test dependent for Paired Sample Statistics. The result is shown in Table 7.

TABLE 7 THE COMPARISON OF STUDENT ACHIEVEMENT TEST ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION ACCORDING TO THE PILOT STUDY GROUP

The test	Mean	S.D.	t
Before using the science curriculum draft	30.10	3.55	18.56*
After using the science curriculum draft	46.8t1	2.96	
		N = 21	

* P < .05

The students' achievement score after using the science curriculum draft was significantly higher than students' score in the same group before using a science curriculum at the .05 level of significance.

2) The assessment of student portfolio score after using the curriculum draft

The student portfolio was evaluated in three domain topics, 1) cognitive domain composed of 14 items, 2) skills domain composted of 12 items, and 3) application domain composed of 6 items. The total scores and the mean scores of each domain were analyzed using *t*-test for One-sample Statistics which compared to the criterion setting at high level. The results are summarized in Table 8.

TABLE 8 THE STUDENT PORTFOLIO SCORES AFTER USING THE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

The domain	Total maximum scores	Criterion	Mean	S.D.	t
Cognitive	42	29	34.71	3.94	40.39*
Skills	36	25	29.43	2.94	45.83*
Application	18	13	14.29	1.62	40.49*
Total	96	65	78.43	26.41	4.27*
		$N = 21$			

* P < .05

The student portfolio scores of all domains after using the science curriculum draft were significantly higher at the .05 level of significance.

3) The assessment of student awareness toward science on natural resources and environmental pollution after using the curriculum draft.

The student awareness was evaluated using 40 statement items on a Likert-scale type. The statements were concerned about the use of natural resources and the ways to prevent the pollution on water, air, and soil. Students responded with their feelings about these concerns and the mean scores were analyzed using *t*-test for One-sample Statistics, which compared to the criterion setting at high level. The results are summarized in Table 9.

TABLE 9 THE STUDENT AWARENESS SCORES AFTER USING THE SCIENCE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

The statement of items analysis	Criterion	Mean	S.D.	t
Natural resources and environmental pollution	3.67	4.07	0.64	40.11*
		N = 21		

* $P < .05$

The student awareness scores after using the science curriculum draft were significantly higher level at the .05 level of significance.

4) The assessment of student opinion toward science curriculum on natural resources and environmental pollution related to real-life issues after using the curriculum draft

The student opinions were evaluated by using question items on a Likert-scale type. The mean scores were analyzed using *t*-test for One-sample Statistics, which compared to the criterion setting at high level. The results are summarized in Table 10.

TABLE 10 THE STUDENT OPINION SCORES TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

The question items analysis	Criterion	Mean	S.D.	t
Students' opinion toward science curriculum	3.51	4.35	0.20	119.76*
		N = 21		

* $P < .05$

The student opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach after using the curriculum draft were significantly higher at the .05 level of significance.

5) The assessment of teacher opinion toward science curriculum on natural resources and environmental pollution related to real-life issues after using the curriculum draft.

The teacher opinion was evaluated using 35 question items on a Likert-scale type. These question items consisted of 5 domains; 1) content domain composed of 7 items, 2) instructional method domain composed of 11 items, 3) instructional media domain composed of 4 items, 4) assessment domain composed of 6 items, and 5) application domain composed of 7 items. The mean scores of each domain were analyzed using *t*-test for One-sample Statistics, which compared to the criterion setting at high level. The results are summarized in Table 11.

TABLE 11 THE TEACHER OPINION SCORES TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES AND BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

Domain item	Criterion	Mean	S.D.	t
1. Content	3.51	4.00	0.35	15.33*
2. Instructional method	3.51	3.90	0.28	19.00*
3. Instructional media	3.51	4.00	0.35	15.33*
4. Assessment	3.51	3.83	0.23	22.94*
5. Application	3.51	3.71	0.14	36.10*
Total	3.51	3.88	0.11	82.32*
			N = 21	

* $P < .05$

The teacher opinion scores toward science curriculum on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach after using the curriculum draft were significantly higher at the .05 level of significance.

Moreover, the teacher responded his opinion on open-ended questions which related to these five categories. 1) The content was completed and covered the goal of learning, 2) The instructional method and the activities were focused and encouraged students to learn by themselves based on inquiry cycle from real-life issues. These activities were also challenged student ability, 3) The instructional media were appropriate and enough for student study, and 4) The assessments, they were an authentic assessment and could assess student learning progress as well.

2. Preparing teachers who joined this research project to implement this curriculum into the classroom.

2.1. Prepared teachers to implement the real science curriculum

During the pilot study the curriculum draft, the other two teachers were prepared by observing in the classroom. They observed an instructional method using five stages of inquiry cycle approach which followed the instructional plan. They also recorded the data using the observation form. At the end of class, both teachers, researcher, and the master teacher collaborated to discuss and share ideas about the instructional method and plan. The information of these discussions was also used to improve the curriculum in order to prepare for implementation in an actual classroom setting.

2.2 Observed the classroom by the researcher

The researcher observed the instructional activities in the pilot study classroom. Videotaping and the observation form were used to record during the classroom observation. The results of the observation as follow:

Teacher's role: By integrating the learning process, the teachers were able to use inquiry cycle approach method followed with learning plan for their instructions. Teachers allowed their students to investigate real-life issues based on their interests. The students had opportunities to pose questions, discuss, and share their ideas in the class. The teachers acted as facilitators to help their students and they also observed students working in each group. Also, the teachers allowed students report their progress during each stage of the inquiry cycle.

Students' role: The finding is that students collaborated with each other to do activities in the group. Students provided their responsibilities for all members. In each group, students planed and brainstormed and then they discussed and shared their ideas in the class. Students also presented their works clearly and they used some media in their presentations.

Instructional atmosphere: The finding is that students felt they were familiar with their classmates and the teachers. Students took responsibility and were able to express their abilities much more than in the past. The instructional atmosphere was enjoyable and not stressful.

3. Revising the high school science curriculum draft from the pilot study

During the pilot study stage, the researcher and teachers in this research study observed and recorded data in the observation form. The discussion and sharing opinions were used in order to revise the high school science curriculum draft in a collaborative manner. In addition, when the pilot study ended, the researcher and teachers met to consider the revised curriculum before applying in an actual classroom setting.

The results of the meeting discussion showed that the revised curriculum was suitable in the use of real-life issues for the teaching and, learning process. The teachers found it to be very effective to teach with the instructional plan and use of the inquiry cycle approach at each stage. However, the teachers thought that the length of each stage of inquiry cycle should be revised as appropriate. For example, the engagement stage should be extended to five periods and also the exploration stage should be longer, because in the exploration stage, students must have time to search for information on their topics. Students must also spend more time preparing, summarizing, and presenting the results of their experiments. Therefore, the exploration stage should be at 10 periods. The explanation stage should not take more than 4 periods. In this stage, students present their works after they well-prepared and each group is involved in the discussion. The teachers also agreed that more times should be added to the elaboration stage.

The results of the pilot study were conducted to revise the science curriculum on natural resources and environmental pollution for the periods of the instructional plan. The revised instructional plan is described in Table 12.

TABLE 12 THE SUMMARY OF REVISED PERIODS IN THE INSTRUCTIONAL PLAN

The instructional process by using inquiry cycle approach	Total of periods (1 period = 50 min)	
	Before revised	After revised
1. Engagement stage	6	5
2. Exploration stage	8	10
3. Explanation stage	6	4
4. Elaboration stage	3	4
5. Evaluation stage	2	2
Total	25	25

The pilot study of a high school science curriculum draft in the classroom revealed the appropriateness in 1) the content which used real life issues and inquiry cycle approach for teaching and learning process, 2) the total periods of 25 periods was suitable but it must be revised and adjusted the period of time for some stages of inquiry cycle. This revision of instructional plan was consulted and determined by the experts again before the next implementation stage.

Stage 3: The curriculum implementation

The revised curriculum was used to gather data and information for testing hypotheses. The sample group of the curriculum implementation on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach included two classrooms of high school science students (grade 10) who were studying in the second semester of the academic year 2003 and drawn from King's College. The instructional period was 25 and the teaching-learning process was conducted by the instructional plan as follows:

High school science students (grade 10)	Total students	Periods / week	Total periods
Classroom I	42	3	25
Classroom II	43	3	25

These two science classrooms were taught by the other two teachers who joined in this research study and also drawn from King's College. These teachers were well-prepared for using the curriculum and instructional process in the pilot phase. The results of the curriculum evaluation were tested the five research hypotheses by the following:

1. The first hypothesis stated that "student achievement scores after a science curriculum was implemented are higher than student in the same group before using a science curriculum".

To test this hypothesis, student achievement tests which composed of 40 multiple choices test questions (40 scores) and 10 open-ended test questions (30 scores) were used to collect data of both classes at the beginning and the end of the classes. Student scores were used to test hypothesis with *t*-test Independent for Paired Sample Statistics. The results are shown in Table 13 through 14 for separate classes as follows:

TABLE 13 THE COMPARISON OF STUDENT ACHIEVEMENT ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION BEFORE AND AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

The test	Mean	S.D.	t
Before using the science curriculum	28.62	4.68	5.52*
After using the science curriculum	33.87	5.51	
		N = 42	

* P < .05

T-test statistics results indicated that students' achievement in studying natural resources and environmental pollution in classroom I after using the science curriculum were significantly higher than achievement of students in the same group before using the science curriculum at the .05 level of significance.

TABLE 14 THE COMPARISON OF STUDENT ACHIEVEMENT ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION BEFORE AND AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM II

The test	Mean	S.D.	t
Before using the science curriculum	22.17	6.69	12.65*
After using the science curriculum	34.76	5.46	
		N = 43	

* P < .05

And the *t*-test statistics results indicated that students' achievement scores on natural resources and environmental pollution of classroom II after using the science curriculum were significantly higher than scores of students in the same group before using a science curriculum at the .05 level of significance.

The whole student achievement scores of both classrooms are presented in Table 15.

TABLE 15 THE COMPARISON OF STUDENT ACHIEVEMENT ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION BEFORE AND AFTER USING THE SCIENCE CURRICULUM ACCORDING TO BOTH CLASSROOMS

The test	Mean	S.D.	t
Before using the science curriculum	25.36	6.60	11.30*
After using the science curriculum	34.32	5.47	
		N = 85	

* P < .05

The results of the first tested hypothesis (as table 13 -14) were represented by students who learned with the science curriculum on natural resources and environmental pollution as related to real-life issues based on an inquiry cycle approach, the achievement scores after using the science curriculum were significantly higher than scores of students in the same the same group before using the science curriculum at the .05 level of significance. The results supported this hypothesis.

2. The second hypothesis stated that "student portfolio scores after the science curriculum is implemented are more favorable."

To test this hypothesis, student portfolio assessment which consisted of three main topics; 1) cognitive domain composed of 14 items, 2) skills domain composed of 12 items, and 3) application domain composed of 6 items. The total scores of all three domains and the mean scores of each domain were used to analyze with *t*-test Independent for Paired Sample Statistics, which compared to the criterion setting at high level of the students' portfolio scores. The results of separating classes are shown in Table 16 and 17 as follows:

TABLE 16 THE ASSESSMENT OF STUDENT PORTFOILO SCORES AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

The domain	Total maximum scores	Criterion	Mean	S.D.	t
The cognitive	42	29	35.05	3.08	73.84*
The skills	36	25	26.67	2.99	57.90*
The application	18	13	13.12	2.20	37.84*
Total	96	65	74.84	10.94	3.96*
		N = 42			

*P < .05

The results indicated that the portfolios scores of students after using the science curriculum of classroom I were significantly higher at the .05 level of significance.

TABLE 17 THE ASSESSMENT OF STUDENT PORTFOILO SCORES AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM II

The domain	Total maximum scores	Criterion	Mean	S.D.	t
The cognitive	42	29	34.71	2.89	77.83*
The skills	36	25	26.57	2.38	72.35*
The application	18	13	13.71	1.33	66.81*
Total	96	65	74.99	10.59	4.09*
		N = 43			

*P < .05

The results indicated that the student portfolio scores after using the science curriculum of classroom II were significantly higher at the .05 level of significance.

The whole student portfolio scores of both classrooms are presented in Table 18.

TABLE 18 THE ASSESSMENT OF STUDENT PORTFOILO SCORES AFTER USING THE SCIENCE CURRICULUM ACCORDING TO BOTH CLASSROOMS

The domain	Total maximum scores	Criterion	Mean	S.D.	t
The cognitive	42	29	34.88	2.99	10.86*
The skills	36	25	26.62	2.67	26.62*
The application	18	13	13.42	1.77	13.42*
Total	96	65	74.92	10.82	4.00*
		N = 85			

*P < .05

The results of the second hypothesis tested (as table 16-17) were represented by students who learned with the science curriculum on natural resources and environmental pollution as related to real-life issues and based on inquiry cycle approach, the portfolio scores after using the science curriculum were significantly higher at the .05 level of significance. The results supported this hypothesis.

3. The third hypothesis stated that "student awareness scores toward science on natural resources and environmental pollution after a science curriculum was implemented are more favorable".

To test this hypothesis, student awareness questions toward science on natural resources and environmental pollution were used. The statement question was a Likert-scale type and consisted of 40 items. The mean scores of student awareness were used to test with *t*-test Independent for Paired Sample Statistics, which compared to the criterion setting at high level. The results of separating class are shown in Table 19 and 20 as follows:

TABLE 19 THE ASSESSMENT OF STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

The analysis	Criterion	Mean	S.D.	t
Natural resources and environmental pollution	3.67	3.93	0.78	31.95*
		N = 42		

*P < .05

The results indicated that the awareness scores of students toward science on natural resources and environmental pollution after using the science curriculum of classroom I were significantly higher at the .05 level of significance.

TABLE 20 THE ASSESSMENT OF STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM II

The evaluation	Criterion	Mean	S.D.	t
Natural resources and environmental pollution	3.67	3.93	0.75	33.28*
		N = 43		

*P < .05

The results indicated that the awareness scores of students toward science on natural resources and environmental pollution after using the science curriculum of classroom II were significantly higher at the .05 level of significance.

The whole student awareness scores toward science on natural resources and environmental pollution after using the science curriculum of both classrooms are presented in Table 21.

TABLE 21 THE ASSESSMENT OF STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE SCIENCE CURRICULUM ACCORDING TO BOTH CLASSROOMS

The analysis	Criterion	Mean	S.D.	t
Natural resources and environmental pollution	3.67	3.93	0.77	785.0*
		N = 85		

*P < .05

The result of the third hypothesis tested was represented by students who learned with the science curriculum on natural resources and environmental pollution related to real-life issues based on an inquiry cycle approach. The awareness scores after using the science curriculum were significantly higher at the .05 level of significance.

4. The fourth hypothesis stated that "student opinion scores toward science curriculum on natural resources and environmental pollution after the science curriculum was implemented are more favorable."

To test this hypothesis, student opinion questionnaire toward science curriculum on natural resources and environmental pollution related to real life issues based on inquiry cycle approach was used. The questionnaire was a Likert-scale type and consisted of 30 items. The mean scores of student opinion were used to test with *t*-test Independent for Paired Sample Statistics, which compared to the criterion setting at high level. The results of separating class are shown in Table 22 and 23 as follows:

TABLE 22 THE SCORE OF STUDENT OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

The analysis	Criterion	Mean	S.D.	t
Students' opinion toward science curriculum	3.51	4.23	0.20	116.65*
		N = 42		

*P < .05

The results indicated that the scores of student opinion toward science curriculum on natural resources and environmental pollution after using the science curriculum of classroom I were significantly higher at the .05 level of significance.

TABLE 23 THE SCORE OF STUDENT OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM II

The analysis	Criterion	Mean	S.D.	t
Students' opinion toward science curriculum	3.51	4.13	0.15	150.91*
		N = 43		

*P < .05

The results indicated that the scores of student opinion toward science on natural resources and environmental pollution after using the science curriculum of classroom II were significantly higher at the .05 level of significance.

The whole student opinion sores toward science curriculum on natural resources and environmental pollution after using the science curriculum of both classrooms are presented in Table 24.

TABLE 24 THE SCORE OF STUDENT OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM ACCORDING TO BOTH CLASSROOMS

The analysis	Criterion	Mean	S.D.	t
Students' opinion toward science curriculum	3.51	4.18	0.07	83.60*
		N = 85		

*P < .05

The result of the fourth hypothesis tested was represented by students who learned with the science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach, the opinion scores after using the science curriculum were significantly higher at the .05 level of significance.

5. The fifth hypothesis stated that "teacher opinion scores toward science curriculum on natural resources and environmental pollution after a science curriculum was implemented are more favorable".

To test this hypothesis, teacher opinion questionnaire toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach was used. The questionnaire was a Likert-scale type and consisted of 35 items. These items provided in 5 domain topics; 1) content domain composed of 7 items, 2) instructional method domain composed of 11 items, 3) instructional medias domain composed of 4 items, 4) assessment domain composed of 6 items, and 5) benefit domain composed of 7 items. The mean scores of teacher opinion in each domain were used to test with *t*-test Independent for Paired Sample Statistics, which compared to the criterion setting at high level. The results of separating teacher are shown in Table 25 and 26 as follows:

TABLE 25 THE SCORE OF THE FIRST TEACHER'S OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM

Domain	Criterion	Mean	S.D.	t
1. Content	3.51	4.57	0.53	7.62*
2. Instructional method	3.51	4.18	0.60	11.48*
3. Instructional medias	3.51	4.50	0.58	8.10*
4. Assessment	3.51	4.67	0.52	7.10*
5. Benefit	3.51	5.00	0.00	5.71*
Total	3.51	4.58	0.30	34.61*

*P < .05

The results indicated that the scores of the first teacher's opinion toward science curriculum on natural resources and environmental pollution after using the science curriculum were significantly higher at the .05 level of significance.

TABLE 26 THE SCORE OF THE SECOND TEACHER'S OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM

Domain	Criterion	Mean	S.D.	t
1. Content	3.51	4.29	0.49	10.00*
2. Instructional method	3.51	4.00	0.45	15.33*
3. Instructional medias	3.51	3.25	0.50	26.00*
4. Assessment	3.51	3.83	0.41	22.94*
5. Benefit	3.51	4.00	0.00	15.33*
Total	3.51	3.87	0.39	22.44*

*P < .05

The results indicated that the scores of the second teacher's opinion toward science curriculum on natural resources and environmental pollution after using the science curriculum were significantly higher at the .05 level of significance.

The whole teacher opinion sores toward science curriculum on natural resources and environmental pollution after using the science curriculum of both teachers are presented in Table 27.

TABLE 27 THE SCORE OF THE BOTH TEACHERS' OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM

Domain	Criterion	Mean	S.D.	t
1. Content	3.51	4.43	0.20	31.64*
2. Instructional method	3.51	4.10	0.13	45.44*
3. Instructional medias	3.51	3.88	0.88	6.20*
4. Assessment	3.51	4.25	0.59	10.12*
5. Benefit	3.51	4.50	0.71	9.00*
Total	3.51	4.23	0.25	37.65*

*P < .05

The result of the fifth hypothesis tested was represented by teachers who taught with the science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach, the opinion scores after using the science curriculum were significantly higher at the .05 level of significance.

In addition, The teachers expressed their opinions about this science curriculum on opened-end questions which could summarized as follows; 1) the content domain was suitable for high school student, 2) the instructional method domain, they said that using inquiry cycle approach for instruction was the good method, 3) the instructional media domain was appropriated, and 4) the assessment domain was consistent with authentic situations.

The development of the high school science curriculum on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach in this research study indicated that:

1. Student achievement scores after a science curriculum was implemented were higher than scores of student in the same group before using the science curriculum at the .05 level of significance.

2. Student portfolio scores were more favorable after the science curriculum was implemented.

3. Student awareness scores toward science on natural resources and environmental pollution were more favorable after the science curriculum was implemented.

4. Student opinion scores toward science curriculum on natural resources and environmental pollution were more favorable after the science curriculum was implemented.

5. Teacher opinion scores toward science curriculum on natural resources and environmental pollution were more favorable after the science curriculum was implemented.

6. Teacher opinions related to science curriculum from opened-end questions were appropriate in content, and use of an inquiry cycle approach was suitable for actual classroom situations and implementation.

Chapter Five

Conclusions, Discussion and Recommendations

This research study is the development of a high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach. The study's findings and methodology for curriculum implementation are as follows:

Purpose of research

The purposes of this research were:

1. To develop a high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach.
2. To study the implementation of a high school science curriculum that is related to real-life issues and that uses an inquiry cycle approach.

Hypotheses

In this research study, the hypotheses to be tested were:

1. Student achievement scores after a science curriculum was implemented are higher than the scores of students in the same group before using a science curriculum.
2. Student portfolio scores after the science curriculum was implemented are more favorable.
3. Student awareness scores toward science on natural resources and environmental pollution after the science curriculum was implemented are more favorable.
4. Student opinion scores toward science curriculum on natural resources and environmental pollution after the science curriculum was implemented are more favorable.
5. Teacher opinion scores toward science curriculum on natural resources and environmental pollution after the science curriculum was implemented are more favorable.

Procedures

The high school science curriculum on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach involved two stages of development.

Stage 1: Curriculum development

Curriculum is developed in six phases as follows:

1.1 Determining the relevant science content on natural resources and environmental pollution. This phase studied and analyzed the learning standards of Thailand's Basic Education Curriculum, B.E. 2544 (Ministry of Education, 2001). The finding showed that the content on natural resources and environmental pollution was related to the science strand (content) and sub-strand # 2 "Life and the Environment" and the standard science # 2.2 at grades 10-12. This learning standard was used as frame and guideline to develop a draft of the high school curriculum. This high school science curriculum draft was developed and based on real-life issues and inquiry cycle approach for the teaching-learning process.

1.2 Developing the high school science curriculum draft on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach. This phase used the guidelines and content of the previous phase to develop a science curriculum draft in two steps:

1.2.1 Developing a science curriculum draft: The content on natural resources and environmental pollution identified three main topics; water and water pollution, air and air pollution, and soil and soil pollution in order to develop documents, laboratory activities, instructional plan, and assessment tools.

1.2.2 Setting and coordinating a brainstorming workshop for high school science teachers. The participants in this workshop were from three dissertation committees including chairman and two other committees, three teachers who joined in this research study and the researcher. The workshop was two days in length. Activities included information and details about science curriculum development, mini-lectures about inquiry cycle approach, and collaboration among teachers to develop a science curriculum draft, instructional plan, and assessment tools.

1.3 Evaluating the quality of science curriculum by seven curriculum experts. These experts included science educators, curriculum developers and experienced teachers. The science curriculum draft was verified for appropriateness and validity using appropriate evaluation forms. The data were collected to analyze mean score, S.D., and index of IOC.

1.4 Piloting the science curriculum draft in the classroom: This phase consisted of two steps as follows:

1.4.1 The high school science curriculum draft was tried out in the pilot study. This science curriculum draft, which was verified for its quality was used as a pilot in one classroom of 21 high school science students. These students were drawn from Sampran Wittaya School at level 4 (grade 10) and were studying in the second semester of the year 2003 (during November – December 2003). The instruction period was 25 periods (1 period = 50 min) and was taught by the master teacher at the school.

1.4.2 Preparing the other teachers who were involved in this research study: The other two teachers from King's College were well prepared to implement the science curriculum in the classroom in the next phase. The researcher and these teachers observed the teaching-learning process in the classroom. The observation form was used to record and collect data. The data were used to discuss and share ideas about the instructional method and plan among teachers after the end of the class. These data discussion were used to improve the science curriculum before the research use.

1.5 Collecting data and evaluating the results of pilot study: The five assessment tools were used to this pilot study were as follows; 1) student achievement test before and after using a science curriculum draft, 2) student portfolio assessment after using a science curriculum draft, 3) student awareness toward science on natural resources and environmental pollution after using a science curriculum draft, 4) student opinion toward science curriculum on natural resources and environmental pollution related to real-life issues after using a science curriculum draft, and 5) teacher opinion toward science curriculum on natural resources and environmental pollution related to real-life issues after using a science curriculum draft.

These assessment tools were used to evaluate: student achievement scores before and after using a science curriculum draft and the statistics was tested using *t*-test dependent for Paired Sample Statistics; moreover the *t*-test for One-Sample Statistics was used to evaluate students' portfolio scores, students' awareness scores, students' opinion scores, and teachers' opinion scores compared to the criteria setting at high level.

1.6 The revising of a high school science curriculum draft: this phase was conducted together with the pilot study phase by the researcher and teachers in this research project. After the pilot study phase the researcher and teachers had a meeting to determine the revised curriculum in order to prepare for the real implementation.

Stage 2: Curriculum implementation

This stage was finding an effective high school science curriculum on natural resources and environmental pollution as related to real life issues based on inquiry cycle approach. The following are the three phases of this curriculum implementation stage.

2.1 Implementing the high school science curriculum

The revised high school science curriculum was implemented in the target sample of two classrooms of high school science students (grade 10) who were studying in the second semester of the academic year 2003 at King's College. The total number of students was 85 and the instructional period was 25 total periods (during January through February 2004). The other two teachers who were well prepared from the piloting phase from King's College taught these students. The researcher observed both of the classrooms.

2.2 Collecting the data

The assessment tools were the same as used in the pilot study phase. These assessment tools were:

2.2.1 Student achievement test on natural resources and environmental pollution was used to test students before and after using the science curriculum.

2.2.2 Student portfolio assessment was used to assess students after using the science curriculum.

2.2.3 Student awareness assessment toward science on natural resources and environmental pollution was used to assess students after using the science curriculum.

2.2.4 Student opinion assessment toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach was used to assess students after using the science curriculum.

2.2.5 Teacher opinion assessment toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach was used to assess teachers after using the science curriculum.

2.3 Analyzing the data

The data were collected and analyzed from the five assessment tools. The data was evaluated as follows:

The student achievement scores were tested using *t*- test Independent for Paired Sample Statistics before and after using the science curriculum and *t*-test for One-sample Statistics was tested by comparison to the criteria setting at high level of students' portfolio scores, students' awareness scores, students' opinion scores and teachers' opinion scores.

Conclusions of the research study

The development of high school science curriculum on natural resources and environmental pollution as related to real-life issues and based on inquiry cycle approach consisted of two stages as follows:

Stage 1: Curriculum development

1.1 The finding of determining the relevant science content on natural resources and environmental pollution indicated that the content on natural resources and environmental pollution was related to the science strand and sub-strand # 2 "Life and the Environment" and the standard science # 2.2 at grades 10-12 of the learning standards of Thailand's Basic Education Curriculum, B.E. 2544 (Ministry of Education, 2001).

1.2 The finding of developing the high school science curriculum on natural resources and environmental pollution as related to real-life issues based on inquiry cycle approach was:

1.2.1 The high school science curriculum draft developed included content and laboratories on water and water pollution, soil and soil pollution, and air and air pollution. The instructional plan was based on inquiry cycle approach which consisted of five stages; engagement, exploration, explanation, elaboration, and evaluation and involved in 25 periods.

Moreover the assessment tools consisted of student achievement test, student portfolio assessment, student awareness assessment, student opinion assessment, and teacher opinion assessment.

1.2.2 The workshop for teachers in the research study was relevant and enabled the teachers who participated in this workshop to realize the importance of curriculum development and they also understood and became familiar with the inquiry cycle approach for the teaching-learning process.

1.3 The finding of the evaluation of the quality of science curriculum by experts indicated that the mean scores of the appropriateness and validity of the science curriculum draft were highly appropriate of all items except the method items of instructional procedures. The items of the measurement and evaluation were most appropriate. The index of IOC was 0.71 – 1.00 which was higher than the criteria score of all items.

1.4 The finding about the pilot high school science curriculum with high school students drawn from Sampran Wittaya School indicated that this science curriculum draft was effective and appropriate for use in the classroom. The following are the results from the pilot study as determined by:

1.4.1 The learners, which were considered with:

1.4.1.1 Student achievement scores on natural resources and environmental pollution after the science curriculum was implemented were significantly higher than scores of students in the same group before using a science curriculum at the .05 level of significance.

1.4.1.2 Student portfolio scores after using the science curriculum were significantly higher at the .05 level of significance.

1.4.1.3 Student awareness scores toward science on natural resources and environmental pollution after using the science curriculum were significantly higher at the .05 level of significance.

1.4.1.4 Student opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach after using the science curriculum were significantly higher at the .05 level of significance.

1.4.2 Instructors, which were considered with:

Teacher opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach after using the science curriculum were significantly higher at the .05 level of significance.

Moreover, the teachers expressed their opinions toward the science curriculum with open-ended questions. The data showed that the content of this science curriculum covered the learning outcomes and that the learning activities were focused on students investigating and searching for knowledge from real-life issues which was suitable for them and challenged their abilities, and the evaluation was an authentic assessment which could assess student progress in learning situations.

1.5 The teachers from King's College who implemented the science curriculum for this research study were found to have comprehended very well the inquiry cycle approach in preparing for his study. Their observing of the instructional process in the pilot study classroom and having discussions and sharing ideas with the teacher who taught in the pilot study phase caused this.

1.6 The finding of revising the high school curriculum draft from the pilot study indicated that the periods of some stages of an inquiry cycle in the instructional plan should be revised to the appropriate levels in the implementation stage. The teachers and researcher collaborated in consulting and using the data from the observation form to discuss and determine this change. The result from the discussion was to revise the period of engagement from 6 to 5 periods, the exploration stage from 8 to 10 periods, the explanation stage from 6 to 4 periods, the elaboration stage from 3 to 4 periods, and the evaluation stage was not changed from 2 periods.

Stage 2: Curriculum implementation

The science curriculum was implemented in both of the high school science classrooms of Kings' College and the results indicated that this science curriculum was effective by testing the following research hypotheses:

2.1 The result of the first hypothesis testing found that student achievement scores of both classrooms on natural resources and environmental pollution after the science curriculum was implemented were significantly higher at the .05 level of significance than for students in the same group before using the science curriculum.

2.2 The result of the second hypothesis testing found that student portfolio scores of both classrooms after the science curriculum was implemented were significantly higher at the .05 level of significance.

2.3 The result of the third hypothesis testing found that student awareness scores toward science on natural resources and environmental pollution of both classrooms after the science curriculum was implemented were significantly higher level at the .05 level of significance.

2.4 The result of the fourth hypothesis testing found that student opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on an inquiry cycle approach after the science curriculum was implemented were significantly higher at the .05 level of significance.

2.5 The result of the fifth hypothesis testing found that teacher opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on an inquiry cycle approach after the science curriculum was implemented were significantly higher at the .05 level of significance.

Discussion of the research study

Stage 1: Curriculum Development

1.1 Determining the relevant science content on natural resources and environmental pollution.

This research study developed the science curriculum and focused on the content of natural resources and environmental pollution. According to curriculum development, the curriculum developer must determine the consistence between content which developed and the science strand (content) in Thailand's Basic Education Curriculum, B.E. 2544. This determining was studied by analyzing the learning standard. UNESCO (1991: 27) point out the guideline for developing curriculum that "identify the science knowledge and skills (appropriate to the particular grade levels in the school system) that are necessary to satisfy those needs and which may be taught using the available community resources." On the one hand, Martinello and Cook (2000) state that in developing a curriculum on any theme [content] three major criteria should be considered at the beginning; 1) the interest of the learners, 2) the availability of resources, and 3) curriculum standard. Armstrong (1989: 8) states that the curriculum developer must realize the following questions in order to select the content: "What content is to be selected? How is content to be selected? How is content to be organized?" The researcher realized these are important for the initial curriculum development and used the learning standard of science as a guideline to set up the frame of content in developing this science curriculum. The science curriculum in this research study was developed, used real-life issues and was based on inquiry cycle approach.

1.2 Developing a high school science curriculum draft on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach. The science curriculum draft was developed by following these two phases:

1.2.1 Developing a high school science curriculum draft which classified the content on three main topics; water and water pollution, soil and soil pollution, and air and air pollution. These three main topics were used to develop the science content and laboratories. The instructional plan in this research was also developed and was based on real-life issues and an inquiry cycle approach. The inquiry cycle consisted of five stages; engagement, exploration, explanation, elaboration, and evaluation and involved 25 periods of instruction. The use of real-life issues and an inquiry cycle approach in this research focused on a student-centered approach, used real-life situations, and enabled students to develop their own ideas. This focus is supported the National Education Act of B.E. 2542 (1999) and its section 22 which states the teaching-learning process should be based on that all learners are "capable of learning and self-development, and enabling them to develop themselves at their own pace and to be the best of their potentiality." Wongyai (1997: 19) states learning should be student centered with students involved in the learning process and practicing their skills by group work in a variety of situations. In addition, UNESCO (1991: 1) states "science learning based on real-life experiences of young learners has great potential in making contribution to acquiring basic competencies to cope with demands of daily life."

1.2.2 Setting a brainstorming workshop for high school science teachers. The participating teachers collaborated very well with the researcher to develop and implement the science curriculum in the classroom. They could see the importance of curriculum development and the usefulness of an inquiry cycle approach for instruction. In this workshop brainstorming was provided during the explaining of the main principles of real-life issues for curriculum development, mini-lectures on the inquiry cycle in the teaching-learning process, discussions and sharing of ideas about the content and activities of the science curriculum draft including the instructional plan. Loucks-Horsley; et al. (1998: 88) state workshops or seminars can help teachers learn in teaching context because the model of the workshop consisted of the following steps: explanation of principle; demonstration of a skill; practice of the skill while doing activities; assess the performance; and coaching during the workshop.

1.3 Evaluating the quality of science curriculum by experts indicated that the developed science curriculum was highly appropriate in all components. The instructional method and measurement and evaluation were most appropriate. The following are the results of this finding:

First, development of high school science curriculum on natural resources and environmental pollution was developed and based on the science strand (content) and sub-strand # 2 "Life and the Environment" and the learning standard science # 2.2 at grades 10-12 of the learning standards of Thailand's Basic Education Curriculum, B.E. 2544. This science content related to the use of natural resources and the environmental problems in the local area, country and globally.

Second, the content of natural resources and environmental pollution could be investigated or researched from the news that occurred in everyday-life in students' local areas or communities. The teachers also conducted activities that followed the instructional plan and used local resources as the instructional media in the teaching-learning process.

Third, the content of natural resources and environmental pollution related to real-life issues could be well used during the inquiry cycle of instruction. This inquiry cycle approach enabled students to play important roles more so than during the old lecture style. Students could select the issue of study based on their interests and investigate it.

Fourth, this curriculum development could assess and evaluate in various ways. The assessment was based on authentic situations and could determine the progress of student learning.

From the results mentioned above, the science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach was highly appropriate for implementation in the classroom.

1.4. Piloting the high school science curriculum draft is discussed in the following results:

The high school science curriculum draft was piloted with the one classroom of high school science students at Sampran Wittaya School in the second semester of the academic year 2003. The finding indicated that the teacher was able to teach by using the instructional plan. The success of this teaching-learning approach was considered by students and found that: 1) student achievement scores on natural resources and environmental pollution after the science curriculum was implemented were significantly higher at the .05 level of significance than for the same group of students before using the science curriculum, 2) student portfolio scores after the science curriculum was implemented were significantly higher at the .05 level of significance, 3) student awareness scores toward science on natural resources and environmental pollution after the science curriculum was implemented were significantly higher at the .05 level of significance, and 4) student opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues and based on an inquiry cycle approach after the science curriculum was implemented were significantly higher at the .05 level of significance. In addition, this research found that teacher opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach after the science curriculum was implemented were significantly higher at the .05 level of significance. These finding are discussed as follows:

The inquiry cycle approach in this research study was focused on students learning with real-life situations. Students could investigate activities and enjoy the learning without stress. The findings supported the research of Byers & Fitzgerald (2002: 82) who state that students enthusiastically receive the inquiry learning process and promote students to investigate real problem on their own. Bennett (1999: 16) states that "science current events sparked students' interest in the world around them. Allowing students to choose science articles, which are of interest to them, can provide the spark needed to make learning relevant and meaningful." Similarly Watson; et al. (2004: 26) state that inquiry learning is not an activity that students can do alone but it can provide students' opportunities to work in group activities such as discussion, decision-making and explaining their studies. In addition Byers & Fitzgerald (2002: 86) state that the inquiry cycle allowed students to understand science content from their investigation and it can develop student skill of problem solving and develop student awareness of science.

1.5 Preparing teachers in this research study to implement the science curriculum indicated that the teachers gained more confidence in teaching and could effectively follow the instructional plan. This finding is supported by the following results:

First, the teachers were well prepared in the teaching-learning process. They observed all stages of an inquiry cycle approach followed with the instructional plan, so they could see the whole view of the instructional process.

Second, during the classroom observation these teachers recorded data from their observation by using the observation form and used these data to discuss ideas and observations with the master teacher. The results from the discussions were used to modify the teaching method in order to make it appropriate for each school in context of the school and its students The research findings which supported this research stage are: Loucks-Horsley; et al. (1998: 44) state that developing professional developers must be concerned with skills and knowledge such as presenting, demonstrating, and supporting teacher learning and change from other persons in order to create a true learning experience. They also point out that (p. 45) "strategies that focus on practicing teaching help teachers learn through the process of using a new approach, practice, or process with their students..." this way will increase the teachers' comprehension in teaching-learning and skills.

Third, according to classroom observation, the teachers had the opportunity to give their suggestions to improve the science curriculum before the real implementation in the classroom. Loucks-Horsley; et al. (1998: 64-65) state that when teachers are familiar with the curriculum as learners, they can develop teaching strategies in various ways for use with their students.

From these results mentioned above, the pilot study of a science curriculum draft proceeded.

1.6 Revising the high school science curriculum draft from the pilot study indicated that during the science curriculum draft was implemented in the classroom, if something that it might be not appropriated in the use of curriculum was found, the researcher could revise it prior to the actual implementation. Loucks-Horsley; et al. (1998: 80-81) point out the importance for teachers when implementing the curriculum of knowing how to improve the appropriate curriculum by collaborating with or discussing with peers and experts in the same areas of study. This will make it an effective and appropriate curriculum for use in the classroom.

Stage 2: Curriculum implementation

The science curriculum was implemented in the classroom and the results of the implementation were analyzed according to the following five hypotheses:

2.1 The results of the first hypothesis indicated that student achievement scores of both classrooms on natural resources and environmental pollution after the science curriculum was implemented were significantly higher than for students in the same group before using a science curriculum at the .05 level of significance. These findings were supported by the following:

This science curriculum focused on real-life issues which enabled students to choose the issues on natural resources and environmental pollution according to their interests. The approach in this curriculum by using an inquiry cycle increased student skills such as 1) scientific skill because students had to plan how to study their chosen topics, designed and conducted experiments, analyzed data, concluded and interpreted the data on their own, 2) communication skills because students must present their findings or project more often and the results from their experiments were also presented in class. In addition, students had chances to share ideas and knowledge with peers in a classroom setting. Students also worked in groups so they provided tasks to members and collaborated and helped each other. Chang & Mao (2001: 344) conducted research on inquiry instruction in earth science in Taiwan and their results revealed that students who learned with inquiry process performed significantly better than students who learned with normal instruction. This finding indicated that learning with an inquiry cycle encouraged students to work collaboratively in small groups and helped students to construct their own meaningful learning. Similarly the research of Ertepinar & Gaban (1996), Scruggs & Mastropieri (1993) and Huveyda (1994) revealed that inquiry-oriented instruction produced positive outcomes in student science achievement. Moreover, Chiappetta & Russell (1982) state instruction of problem solving results in higher student achievement using problem solving.

2.2 The results of the second hypothesis tested found that student portfolio scores of both classrooms after the science curriculum was implemented were significantly higher at the .05 level of significance. These findings were supported by the following:

First, this science curriculum was approached by an inquiry cycle and the focus was student centered so students were able to choose their topics of interests to study. Students planned to solve the problem, designed experiments, investigated experiments, analyzed data, and made conclusions based on their own studies. Learning by doing with these activities enabled students to understand the content, skills and the application very well. OERI. (2001: 9) states that portfolio was collected on student tasks which they did and teachers were involved in the responses of student tasks, and student tasks were used as the achievement measure of students.

Second, the portfolio assessment was an authentic assessment which can be used to assess the progress of students in learning. Doran; et al. (2001: 48) state that "portfolios often contain many samples of student works and student must be responsible for their own portfolios". Portfolio is an alternative assessment of each one and each group. This is an authentic assessment of students by their quality of tasks. In addition, Wiggins (1998: 71) states that " authentic tasks and better feedback will improve learning" and he also point out (p.191) "a portfolio designed to chart progress over time with a strong emphasis on selt-assessment", and then (p.21) "authentic assessment is true assessment of performance because we thereby learn whether students can intelligently use what they have learned in situations that increasingly approximate adult situations, and whether they can innovate in new situations". Moreover, OERI (2001: 19) address portfolio promotes students in the skills of language communicating, writing, and working skill, students were self-responsibilities and they also well collaborate and interaction with peers, teachers and their parents. The research study about development of science process skills in authentic context of Roth (1993: 127) revealed that "students develop higher order process skills through nontraditional laboratory experiences that provided the students with freedom to perform experiments of personal relevance in authentic contexts". Students learned to identify variables, interpret and analyze data, plan and design experiment. Students were free to design their own experiments and this research study of Roth (p.141) found that students successfully chose their own equipments, identified, collected, and analyzed data. This research finding supports the real-world situations in which effective learning is based on everyday life situations.

2.3 The result of the third hypothesis tested found that student awareness scores toward science on natural resources and environmental pollution of both classrooms after the science curriculum was implemented were significantly higher at the .05 level of significance. These findings were supported by the following:

When the science curriculum was implemented in the classroom and teachers taught students by following with the instructional plan. Students studied on natural resources and environmental pollution which related to the real-issues that occurred in everyday life in their local areas. Students found the problems of the environment in their real situations and these findings made them realized and enthused them to prevent and solve the problems. Students had self-consciousness toward natural resources and environment in the positive way to their studies. The following of issue topics that students interested and chose to solve were classified in three main areas of study: water, soil, and air. In classroom I, students wanted to study and solve the problems of water in three groups such as; 1) wastewater treatment, 2) studying on the way how to treat the wastewater around the school, and 3) decreasing water pollution by filtration process. For the air topic, three groups of students were interested to investigate such as; 1) determining the air pollution in school, 2) measurement the amount of dust in different areas of school, and 3) studying of air pollution. However, two groups of students were interested to study on soil topic such as; 1) studying on soil erosion, and 2) determining soil pollution. The same as students in classroom I study, students in classroom II studied on these topics as follows: general topic, one group wanted to investigate environmental pollution around the school. On the topic of water had two groups studied such as 1) comparing on the amount of sediment between Sanphet Canal and Thacheen River, and 2) studying on wastewater treatment of communities around the school. The topic of air had two groups of students studied such as 1) studying air pollution around the school, and 2) studying on which areas of the school had the most of dust. The last three groups of students wanted to investigate on soil topic such as, 1) studying on the effect of garbage toward soil, 2) preventing the surface of soil erosion, and 3) surveying the amount of garbage around the school which effected on environment.

From these topics mentioned above, the findings were that students could collaborate with members in group to plan, design, and investigate the experiment from their choosing. Doing the experiment helped students to understand very well the problem or issue of the study. Ramsey; et al. (1977) state that "environmental awareness instruction is relative ineffective for developing in students the ability to initiate positive citizenship". The same as, Atson; et al. (2004: 42-43) state that using scientific inquiry play an important role in develop student understand in science between evidence and theory, and ability scientific skills. In addition, Chang & Barufaldi (1999) point out inquiry teaching enhanced students' positive attitudes toward science more than traditional teaching. Another report by Gabel; et al. (1997) reveal that "inquiry-oriented instruction significantly improved students' attitudes toward science".

However, student awareness scores of the both classrooms were considerate in each item indicated that the scores of some items were below the criteria setting (See Table 37 and 38 of Appendix C). For example, item (5) "I think that water which used from many activities in home, domestic, and hospital should be leaved to wastewater of public tank", item (6) "After eating, if there is any piece of food on the plate, I will use water to rinse it and leave it wasted throughout public tank", item (7) "In my home, we have the policy to save water such as after using water from one activity, we can use it for the other activity in often", item (8) "I like to leaving water running while cleaning my face, washing hands, and brushing teeth and turning the water off after all these activities done", (9) "I like shower in which leaving water running on all time because I do not turning it on and off in often", item (14) "I think that my community have the most problem of water pollution", item (15) "I am unsatisfied very much if the teacher called me to clean the room or pick up garbage that I did not make", item (24) "I think that my community have the most problem of air pollution", item (34) "I think that my community have the most problem of soil pollution", and item (38) "I know about conservative projects of natural resources and environmental pollution management more than five ones". All these items mentioned above indicated that student awareness scores were below the criteria setting. They might be caused by students responded their feelings based on their prior knowledge and experiences of personal differences. Therefore these made student scores were different levels. Bell; et al. (2003: 64) state that students use their prior knowledge and evidence to answer questions generated by the teacher. In addition, Llewellyn

(2002: 49) states "the child's knowledge is a result of his or her prior experiences, and children learn to make observations about the natural world by using their sense".

2.4 The result of the fourth hypothesis tested found that student opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues based on an inquiry cycle approach after the science curriculum was implemented were significantly higher at the .05 level of significance. These findings were supported by the following:

First, the instruction based on inquiry cycle approach and related to real-life issues enabled students to study the real problem of their interests. Students enjoyed and were challenged to find out the knowledge by themselves and they could plan, design and do experiment which was different from the traditional instruction method used in teaching. Shepard (2000: 7) states that "school learning should be authentic and connected to the world outside of school not only to make learning more interesting and motivating to students but also to develop the ability to use knowledge in real-world setting". In addition, Aho; et al. (1989: 641) state that "analysis of environmental problems in their school environment could be made and possible solution models proposed". Students finally could analyze the environmental questions of their own areas in the field work. The study on students learning science through collaborative discussion on current event in science by Bennett (1999: 2) revealed that students' opinion in learning science were more valuable when teachers found out students' ideas and wonderings students' experience and interest in study of current event were motivated them to conduct follow-up internet searches to solve the problems in their lives.

Second, Learning by inquiry cycle approach changed the student's role away the lecture style. Because students have self-confidence and they dare to act and share ideas with others. Students also work in group and collaborate with each other. Learning by inquiry method, students were more responsibilities and gained direct experience from studying by their own.

Third, inquiry based instruction were allowed students to develop thought processes and creative thinking skill. Not only did students develop thinking skill, but they also developed scientific skill and communication skill from this learning. Bennett (1999:3) states that "by encouraging students to share thoughts, ideas, and questions freely with each other, without teacher direction or interference, the languages of the child and of science melded together to create a scientific discourse". Similarly Pestel (1993: 86), he points out if student do not engage to discuss their assignments, students will not acquire inquiry skill.

2.5 The result of the fifth hypothesis testing found that teacher opinion scores toward science curriculum on natural resources and environmental pollution related to real-life issues and based on an inquiry cycle approach after using the science curriculum were significantly higher at the .05 level of significance. These findings were supported by the following:

First, the development of this science curriculum is involved teachers who joined this research study in the initially phase of determining a science curriculum draft. Teachers collaborated with the researcher in the workshop of brainstorming, and share ideas about the science curriculum draft of the content, instructional activities, assessment, and including the instructional plan. Therefore teachers were familiar and comprehended very well in this developed curriculum.

Second, during the pilot study of a science curriculum draft, both teachers of the implementation phase were prepared for using of this science curriculum. The preparation phase of teachers enabled them to view the whole situations of classroom instruction. Teachers could adapt teaching techniques in order to the appropriateness of using in their classroom. Helgeson; et al. (1977: 192) state that training teachers about inquiry approach, is an evidence to indicate that teachers are significantly changed their teaching style.

Third, Inquiry instruction focused on student role to construct knowledge by themselves which difference from teachers lecture in the class. Students were challenged to inquire knowledge from various sources and used these information based to plan, design and solve the problem study. Thus, most of instructional media come from documents, textbooks, or data searched from internet and library. However, in this research study found that the second teacher's opinion scores of instructional media were below the criteria setting (See Table 26 of Chapter 4). The findings caused by learning sources for this instruction were not cover issues that students chose to study. Then students must be asked their teachers for advising. Roth (1993: 141) states that "when students felt they had run out of their own resources, did students seek guidance from the teachers". In addition, Bennett (1999: 5-6) states that 'students learning centers teachers spend less time as deliverers of knowledge and more time as coaches". The same idea as Germann (1989: 236), he points out "teacher provides as little guidance as possible and expectations are minimal so that students are free to explore and leam on their own". Moreover, Windschitl (2002: 112) states that teachers must prepare themselves on knowledge, skills, and thinking in order to be students' mentors through investigate process in the real-world.

Another finding of teacher opinion in this research study when considered in each topic is instructional method. The teacher opinion scores of teaching-learning method in some items were below than the criteria setting such as, item (14) "You allowed students to have chances to report their progress", this item, the researcher reviewed the teacher who taught in classroom I and responded the low score in a special case and she said that in sometime she can not allowed students to report their progress in the class because of the limiting of period instruction. Students in classroom I learned science in the first period at 07:00 am so that they were not active and ready to study in sometime. The item (18) "the period of instruction by using an inquiry cycle approach followed with the content in this science curriculum was appropriate", the second teacher expressed his opinion in lower score of the criteria setting as inappropriate. The special review revealed that school had more special extra activities often and results in abnormal of periods study in the class. Sometime teacher arranged the instruction out of classroom period in order to coming up in time with the instructional plan. Moreover, in the item of assessment of item (28) "the method and assessment tool can evaluate personal difference of students", the second teacher also expressed his opinion below the criteria setting. He said that students do activities in group and sometime he could not take after of all students, so that assess by using students' achievement test can evaluate the personal difference in appropriateness.

Recommendations

In this research study, the following recommendations might be useful for instruction as follows:

1. Recommendations for policy making

1.1 The development of science curriculum for using in school revealed that schools or institutes can develop their own curriculum and this development can succeed through focus and collaboration such as 1) school's administrator must realize the importance of curriculum development and must support the teacher for this developing, and 2) teachers must pay attention and collaborate with others to develop science curriculum and implement in their classrooms.

1.2 The development of the high school science curriculum related to real-life issues and based on inquiry cycle approach in this research study found that inquiry instruction on natural resources and environmental pollution and based on real-life situations enhanced student learning. Students gained more skills of learning by themselves, therefore they comprehended and could plan to solve problems and could apply their learning to their daily lives. In order to have life long learning and sustainable, schools or institutes should support this curriculum development in to the classroom continuously.

1.3 The results of this curriculum development should be supported and distributed to other schools and person who interested to use in the classroom or another using.

2. Recommendations for using the results of this research study

2.1 The instruction of inquiry cycle approach as one course-one cycle in this research study is different from the usual instruction in the classroom. The inquiry instruction in this study focused on students to acquire knowledge by their own more than teachers give knowledge by lecture. At the first time of this instruction, students may not be familiar with the new approach of this teaching style, so that teachers should tell and explain students on the way of using inquiry instruction before the class begins in order to have an effective instruction of inquiry.

2.2 Teachers should prepare themselves by studying the inquiry cycle of all five stages of engagement, exploration, explanation, elaboration, and evaluation. They should understand their roles clearly in order to be as mentors or facilitators and to use the instructional plan effectively.

2.3 Teachers should explain students to understand the assessment method including the criteria using of evaluation for this inquiry instruction in order to follow up the progress of their studies. Students should understand the authentic assessment which was

2.4 The use of the instructional plan which related to real-life issues based on inquiry cycle approach in this research study, teachers should find the way and plan how to access all students in the class. This research study found that there were some students who avoided involvement doing activities in the classroom, so that the activities might not result in their achievements. Teachers must find the way to determine student learning continuously. The example for determining students in learning is the report of student on 1) students' progress on learning in each stage of inquiry cycle, and 2) the collaboration with peers in which they involved in doing activities. The student's journal will be used to determine their progress on learning and if the findings indicated the problem of students, teachers could help them to solve problem immediately.

2.5 For the teaching-learning activity, this research revealed that by allowing students choose the topics study with their interests, teachers should pay more attention about this activity, because some students may choose the topic study by followed their friends or their favorite persons and that is not their real interests. In this case, it found that when they were in group working, they might not pay attention in learning much more than they should be and it was difficult to control the classroom.

2.6 The use of the instructional plan in this research study indicated that the schedule of student learning was concerned with the effective instruction. Teachers should avoid arranging teaching science class in the first and in the last period of the day. Since after the first period, students must change the subject study and move to another class, therefore, the science activities are interrupted. In addition, in the last period of the classroom, students have special activities which were given by the teacher, therefore, the science activities are also interrupted and are not available. In the appropriateness of instruction, teachers should arrange the periods of science study at least two periods continuously or to the lunch break in order to allow students continue doing their science activities and prepare themselves to move to the next subject.

2.7 Characteristic of school is important in using inquiry instruction. The findings of this research were indicated that the school of implementation phase was a boarding school of boys. The following views will be useful for implementing this curriculum:

First, students in boarding school have advantage with time spending in the school. Teachers might have high expectation on them in that students can use extra time of class for doing experiment, and teachers can comfortable arrange time for students in doing activities. However, the researcher had reviewed the teachers in this study and found that students did not pay more attention in doing activities over the normal class. Most of students will attend the special of tutor class outside school and they will spend time in the tutorial schools around their local areas.

Second, students in boarding school might be getting up late and they also attend the class in the first period late too. Sometime teachers have to wait for students before starting the instructional plan. For example, all students should be in the class before sharing the ideas or discussion about their progress reports.

Third, in the boy school, students do not work meticulously. They would like to play more than learning especially when they are doing in group. Teachers must pay attention to look after students in each group.

2.8 Teachers should involve with students in each group in order to evaluate their peers by using an authentic assessment without bias. The assessment of students will be indicated very well in collaboration in group working. In addition, teachers should allow students to evaluate other groups. Moreover teachers can incorporate moral and ethic topics in the instruction to support the National Education Act of B.E. 2542 (1999).

3. Recommendations for further study

The results of using this science curriculum development which related to real-life issues based on an inquiry cycle approach indicated that students were having more abilities in thinking and they also gained the skills of planning, designing the experiment, analyzing and interpreting data, presenting their works and communicating with others. For further study, the research should be focused on student ability on thinking such as problem solving thinking, creative thinking, and higher order thinking, in order to promote and develop more effective and sustainable students thinking.

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APPENDIX

Appendix A

1. The list of experts who verified the research materials

2. The list of teachers who involved this research study

The list of experts who verified the research materials

1. Dr. Sanong Thongpan

   Srinakharinwirot University
2. Dr. Charida Pukahuta

   Ubon Ratchathani University
3. Mrs. Supaporn Sirisopana

   Srinakharinwirot University
4. Mrs. Nanthiya Boonklerb

   Senior specialist from IPST
5. Assist. Prof. Salee Tangkajiwangkool

   Retied professor from Pranakhon Si Ayuttaya Rajabhat University
6. Miss Duangkamol Helmmarattana

   Depsirin School
7. Mrs. Sriwilai Charoenwong

   Horwang School

The list of teachers who involved this research study

1. Mr. Sanom Wanphen	Sampran Wittaya School
2. Mrs. Chortip Trakoolsawangpop	King's Colledge
3. Mr. Prathueng Phaowprapat	King's Colledge

APPENDIX B

1. The Science Strand (sub-strand # 2: Life and the Environment)
2. Workshop on science curriculum for high school teachers

Sub-strand 2 : Life and the Environment

Standard Sc 2.1 : The student should be able to **understand** the local environment, relationship between living things and environment, interrelationship between living things in different ecosystems, **master** the investigative processes and **possess** a scientific mind, **communicate** the acquired knowledge for positive use.

Level Standards grade 1 – grade 3	Level Standards grade 4 – grade 6	Level Standards grade 7 – grade 9	Level Standards grade 10 – grade 12
1. **investigate** the local environment, **analyze** data, **discuss** and **explain** the relationship between cohabiting living things and **present** the study.	1. **observe, investigate, discuss**, and **explain** the relationship between groups of living things in different habitats, **write** diagrams showing food chains and **explain** relationship between the environment and life and living things.	1. **explore** and **analyze** status of various local ecosystems, **explain** relationships between components within the ecosystem, energy transfer, cycles of substance and change of population size.	1. **analyze, discuss** and **explain** succession of living things, importance of biodiversity, diversity and balance in the ecosystem.

Standard 2.2 : The student should be able to **understand** importance of natural resources, utilization of natural resources at local, national and international levels, **master** the investigative processes and **possess** a scientific mind, **communicate** the acquired knowledge for positive use and sustainable management of natural resources and local environment.

Level Standards grade 1 – grade 3	Level Standards grade 4 – grade 6	Level Standards grade 7 – grade 9	Level Standards grade 10 – grade 12
1. **search** for information, **discuss** and **explain** the exploitation on natural resources and the problems of local natural resources and environment. 2. **discuss** and **suggest** different methods of economical utilization of natural resources and **participate** in the implementation.	1. **observe, investigate, discuss** and **explain** local natural resources, impacts of natural resource exploitation, changes in the environment caused by nature and man, **show** ideas and **participate** in the care and preservation of natural resources and environment.	1. **investigate** and **analyze** degree of local environmental problems and natural resources, **propose** ideas for maintaining balance in the ecosystems, sustainable usage of natural resources based on knowledge of science and technology, also **participate** in protecting the environment and solving its problems.	1. **investigate** and **analyze** degree of environmental problems and natural resources at the local, national and global levels, **identify** causes, **plan** and **participat e** in the protection, solving problems, monitoring, conserving and developing natural resources and environment.

Workshop on science curriculum for high school teachers

Day	Time	Topic	Participant
1	8.00 am-10.00 am	- Introduction Workshop overview: The development of teaching and learng in new educational reform by using inquiry cycle approach (5Es) Instructor: Dr.Preechan Dechsri (Associate director of The Institute for The Promotion of Teaching Science and Technology, IPST)	- Mr. Sanom Wanpen[1] - Mrs. Chortip Trakoolsawangpop[2] - Mr. Prathueng Phaowprapat[3] - Miss. Wanida Tanaprayothsak[4] - Dr.Somson Wongyounoi[5] - Dr.Precham Dechsri[6] - Dr.Somsri Tangmongkollert[7]
	10.00 am-10.15 am	- Coffee break	
	10.15 am-12.00 pm	The development of teaching and learng in new educational reform by using inquiry cycle approach (5Es) (Continued)	
	12.00 pm-1.00 pm	- Lunch break	
	1.00 pm-2.30 pm	- Brainstroming of team researchers in the development of science curriculum on these following topics: **The content on natural resources and environmental pollution at high school level*	
	2.30 pm-2.45 pm	- Coffee break	
	2.45 pm-4.30 pm	- Brainstroming of team researchers in the development of science curriculum (continued): **Activities / laboratories*	
2	8.00 am-10.00 am	- Workshop: brainstorming and determining Instructional methods by using inquiry cycle approach (5Es) on natural resources and environmental pollution related to real-life issues. **Instructional plan*	

Workshop (Continued)

Day	Time	Topic	Participant
2	10.00 am-10.15 pm	- Coffee break	
	10.15 am-12.00 pm	- Workshop: brainstorming and determining Instructional methods by using inquiry cycle approach (5Es) on natural resources and environmental pollution related to real-life issues. **Instructional plan* (continued)	
	12.00 pm-1.00 pm	- Lunch break	
	1.00 pm-2.30 pm	**Instructional time setting*	
	2.30 pm-2.45 pm	- Coffee break	
.	2.45 pm-4.30 pm	**Evaluation methos*	

[1] teacher from Sampran Wittaya school in Nakhon Pathom Province

[2,3] teachers from King's college in Nakhon Pathom Province

[4] Researcher

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APPENDIX C

The results of data analysis

TABLE 28 THE RESULT OF VERIFYING APPROPRIATE DEVELOPMENT OF HIGH SCHOOL SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH ACCORDING TO EXPERTS' OPINION

No.	Domain consideration item	N = 7		The appropriate level
		Mean	S.D.	
	Content domain			
1.	Content was consistent to the learning purposes.	4.57	0.53	Highest appropriate
2.	Content in each topic was in order and related.	4.29	0.52	Highly appropriate
3.	Content was appropriately difficult for students.	4.29	0.82	Highly appropriate
4.	Content was enough for student to use as learning sources for searching and reference.	4.29	0.76	Highly appropriate
5.	Content was related to real-life issues or real-events.	4.71	0.76	Highest appropriate
6.	Content in each topic was appropriate for using inquiry cycle approach.	4.43	0.79	Highly appropriate
7.	Content of science curriculum was appropriate for student to use in daily life.	4.71	0.49	Highest appropriate
	Mean of content domain	4.47	0.65	Highly appropriate
	Instruction domain			
8.	Using inquiry cycle approach, teachers could arrange activities appropriate to content as related to real-life issues.	4.57	0.79	Highest appropriate
9.	Using inquiry cycle approach supported student centered activities.	4.86	0.38	Highest appropriate
10.	Using inquiry cycle approach, students could express their potential ideas.	4.57	0.79	Highest appropriate
11.	Using inquiry cycle approach was well promoted to students for their thinking skill practice.	4.57	0.79	Highest appropriate
12.	Using inquiry cycle approach promoted students to use their ability to solve problems based on scientific process.	4.57	0.79	Highest appropriate
13.	Using inquiry cycle approach allowed students to play an important role in teaching-learning process.	4.29	0.76	Highly appropriate

TABLE 28 (continued)

No.	Domain consideration item	N = 7		The appropriate level
		Mean	S.D.	
14.	Using inquiry cycle approach promoted students in group working process and skills.	4.43	0.79	Highly appropriate
15.	Using inquiry cycle approach encouraged teachers to be active and enthusiastic in their teaching.	4.57	0.53	Highest appropriate
16.	Using inquiry cycle approach helped students with different personalities.	4.43	0.79	Highly appropriate
	Mean of instruction domain	4.54	0.71	Highest appropriate
	Instructional media domain			
17.	Students had opportunities using learning sources which related to real-life/ real-events from the environment around them.	4.71	0.49	Highest appropriate
18.	Students learned better by using instruction media acquired from real-life/ real-events.	4.43	0.98	Highly appropriate
19.	Students had opportunities to gain additional knowledge from various sources including Internet.	4.00	1.00	Highly appropriate
20.	Students had opportunities to use their creative thinking to construct instructional media on their topic study.	4.29	0.76	Highly appropriate
21.	Studying on real-life/ real-events saved budget resources for teachers to construct instructional media.	4.29	0.76	Highly appropriate
	Mean of instructional media domain	4.34	0.80	Highly appropriate
	Assessment domain			
22.	Students intended to work in groups because their tasks were involved in evaluation.	4.29	0.95	Highly appropriate
23.	Using inquiry cycle approach, students developed thinking, analyzing and reporting skills.	4.57	0.53	Highest appropriate
24.	Using inquiry cycle approach, teachers could assess students in an authentic assessment.	4.71	0.49	Highest appropriate
25.	Using inquiry cycle approach, teachers could assess students in various ways.	4.43	0.79	Highly appropriate

TABLE 28 (continued)

No.	Domain consideration item	N = 7		The appropriate level
		Mean	S.D.	
26.	Using inquiry cycle approach focused students on construct their tasks/ project.	4.57	0.79	Highest appropriate
	Mean of assessment domain	4.51	0.71	Highest appropriate
	Application domain			
27.	Using inquiry cycle approach helped teachers in their teaching responsibility.	4.14	1.07	Highly appropriate
28.	Using inquiry cycle approach, teachers saved time to prepare their teaching.	3.29	1.38	Medium appropriate
29.	Using inquiry cycle approach promoted student creative thinking.	4.29	0.76	Highly appropriate
30.	Using inquiry cycle approach promoted greater student responsibility.	4.57	0.53	Highest appropriate
	Mean of application domain	4.07	0.94	Highly appropriate

TABLE 29 STUDENT ACHIEVEMENT SCORES BEFORE AND AFTER USING THE SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH ACCORDING TO THE PILOT STUDY GROUP

Student	Pre-test			Post-test		
No.	Part I	Part II	Total	Part I	Part II	Total
1.	18	12	30	23	20	43
2.	20	15	35	24	22	46
3.	16	18	34	23	25	48
4.	17	14	31	24	24	48
5.	18	16	34	26	20	46
6.	20	16	36	24	22	46
7.	21	13	34	29	22	51
8.	14	16	30	21	23	44
9.	14	16	30	20	22	42
10.	15	14	29	21	23	44
11.	15	12	27	26	25	51
12.	11	15	26	28	22	50
13.	16	16	16	23	25	48
14.	18	10	10	28	20	48
15.	16	13	13	24	23	47
16.	14	10	24	23	21	44
17.	15	17	32	21	28	49
18.	16	15	31	22	25	47
19.	16	7	23	22	23	45
20.	18	13	31	26	27	53
21.	12	14	26	20	23	43
N = 21	*Mean = 30.10*			*Mean = 46.80*		

TABLE 30 THE RESULT OF ANALYSIS ON STUDENT PORTFOLIO SCORES ACCORDING TO THE PILOT STUDY GROUP

No.	Item consideration	N = 21
		Mean
	Cognitive domain	
1.1	Understood the content of studying very well and clearly.	2.53
1.2	Searched more data for the topic of studying.	2.76
1.3	Planed for working in step and clearly.	2.39
1.4	Discussed and collaborated with peers in the group often.	2.76
1.5	Understood all steps of activities very well.	2.51
1.6	Designed the methodology to experiment/ investigate based on principle.	2.51
1.7	Showed the method of activities/ experiment clearly.	2.37
1.8	Designed table for collecting data clearly and appropriate.	2.37
1.9	Did activities/ experiments by following the plan.	2.51
1.10	Analyzed and summarized the study/ activities/ experiment correctly and appropriately.	2.39
1.11	Reported the results of studying /doing activities/doing experiment by using picture/ graph/ chart.	2.44
1.12	Described the details of picture/ graph/ chart in the report.	2.27
1.13	Reported the results correctly and had references.	2.39
1.14	Used creative thinking in work.	2.51
	Mean of cognitive domain	34.71
	Skill domain	
	<u>Activity/ laboratory skill</u>	
2.1	Brainstormed with peers and worked within the groups often.	2.76
2.2	Provided and assigned tasks to group clearly.	2.51
2.3	Did activities/ experiments by following the plan.	2.51
2.4	Used the appropriate science equipment to do activities/ experiments appropriately and correctly.	2.54
2.5	Did the activities/ laboratories correctly.	2.51
2.6	Recorded the results of activities/ experiments correctly.	2.37
2.7	Recorded the errors from doing activities/ experiments.	2.04
	<u>Reporting skill</u>	
2.8	Arranged the activities/ experiments in order and correctly.	2.39
2.9	Reported the results of doing activities/ experiments clearly and understandably.	2.51
2.10	Used equipment/ media to report the task as appropriate.	2.39

TABLE 30 (continued)

No.	Item consideration	N = 21 Mean
	Reporting skill (continued)	
2.11	Used the language and style to report as appropriate with the classroom atmosphere.	2.51
2.12	Reported the task completely and in time.	2.39
	Mean of skill domain	29.43
	Application domain	
3.1	Applied the activity/ experiment related to real-life issues/ real events.	2.54
3.2	Applied the materials using in local/ community resources to do the activities/ experiments.	2.54
3.3	Gave suggestions/ ideas to do activities/ experiments.	2.09
3.4	Activities/ experiments could be used to solve the problems/ situations.	2.51
3.5	Applied the knowledge to do community/ social activities.	2.39
3.6	Distributed the knowledge of study to school/ community/ and social sources.	2.22
	Mean of application domain	**14.29**

TABLE 31 THE RESULT OF ANALYSIS ON STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE SCIENCE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

No.	Item consideration	N = 21 Mean	Interpretation
1.	I agree with water, air, and soil is more valuable of natural resources for living organisms especially human beings.	5.00	High level
2.	I agree with natural resources are four basic factors of life which mostly important for human beings surviving.	5.00	High level
3.	I think that water, air, and soil are public treasure that everybody should involve in taking care and maintenance.	4.90	High level
4.	I think that water, air, and soil are generally in everywhere in the world.	4.62	High level
5.	I think that water used from many activities in home, domestic, and hospital should be leaved to wastewater public tank.	3.33	Medium level
6.	After eating, if there is any piece of food on the plate, I will use water to rinse it and leave it wasted throughout public tank.	2.95	Medium level
7.	In my home, we have the policy to save water such as after using water from one activity, we can use it for the other activity in often.	3.86	High level
8.	I like to leave water running while cleaning my face, washing hands, and brushing teeth and turning the water off after all these activities done.	1.76	High level
9.	I like shower in which leaving water running on all time because I do not want to turning it on and off in often.	3.29	Medium level
10.	If I see my neighbor throw garbage or litters to public water resources in my village/ community, I will tell the competent authorities immediately.	3.57	High level
11.	I am pleased and willing to involve in various projects concerned with water conservation often.	4.19	High level
12.	I know about the water pollution problems and I try to involve in solving these problems too.	4.14	High level
13.	I think that I can not solve water pollution by my self.	2.24	High level
14.	I think that in my community have the most water pollution problem.	3.19	Medium level
15.	I am unsatisfied very much if teacher call me to clean the room or pick up litters that I do not throw them.	3.00	Medium level

TABLE 31 (continued)

No.	Item consideration	N = 21 Mean	Interpretation
16.	I agree with if there is air pollution occur in some place, it will distribute to another place, because air is the natural resource which could be circulated.	4.24	High level
17.	I never burn litters because they cause smoke, smell, and smog distribute to the air and make air pollution.	3.86	High level
18.	My family supported the project of using fossil fuel without lead.	4.62	High level
19.	I would like police to be more concentrate and strict with teenagers who modified exhaust manifold of motor cars and drove on the road, because they make loud noise and they cause of smog distribute to the air and make air pollution.	4.66	High level
20.	I agree with the government policy that all public cars such as buses need to check their characteristics every year.	4.62	High level
21.	I am pleased and willing to support my family involve in "the car free day project".	4.48	High level
22.	If I see factories in my community released the waste of smoke, gas or bad smell to the air, I will inform the competent authorities immediately.	3.76	High level
23.	I involved in taking care of environment by planting in my home, school or public areas in order to have the good quality of air.	4.43	High level
24.	I think that my community has the most air pollution problem.	3.24	Medium level
25.	If I were the farmer, I would use the most organic fertilizer rather than chemistry fertilizer to increase products.	4.14	High level
26.	I do not agree with digging the soil surface to sell, because it cause to damage the soil fertility.	4.19	High level
27.	I agree with planting long rooted grasses (Vetiver grass) in the slope areas because it will protect soil erosion.	4.71	High level
28.	I support to get rid of organic garbage by buried into the soil because it is better than burned which cause air pollution.	3.90	High level
29.	I do not agree with some place get rid of chemical substances into the soil.	4.19	High level
30.	I think that farmers used pesticides to control insect results in the most of soil pollution.	3.95	High level

TABLE 31 (continued)

No.	Item consideration	N = 21 Mean	Interpretation
31.	Even though the road construction is benefit to develop community, but in the same time I think that the soil used for agriculture will be decreased.	4.33	High level
32.	I agree with the mixed agriculture because it helps to conserve the soil and environment.	4.67	High level
33.	I am pleased to give the knowledge of soil improving to agriculturists.	4.19	High level
34.	I think that in my community has the most soil pollution problem.	3.10	Medium level
35.	I agree with the problems of water, air and soil are the chain problem, when it occurred, it will be affected to each other.	4.52	High level
36.	I am willing to support and buy products related to conserve the environment.	4.24	High level
37.	I am pleased and willing to expand the knowledge of "The natural resources conservation and environmental protection" to other persons.	4.38	High level
38.	I know about the projects related to natural resources conservation and environmental protection more than five ones.	3.48	Medium level
39.	I think that the project of "Ruam Palang Ham Song" is involved in conservation and solution of natural resources problem very well.	4.62	High level
40.	I intended to apply the knowledge of the natural resources conservation and the environmental protection for using in the daily lives.	4.57	High level
	The whole views	4.00	High level

TABLE 32 THE RESULT OF ANALYSIS ON STUDENTS' OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM DRAFT ACCORDING TO THE PILOT STUDY GROUP

No.	Item consideration	N = 21		Interpretation
		Mean	S.D.	
1.	Study science as related to real-life issues (liked this research), students were interested and would like to learn more.	4.52	0.60	Highest level
2.	Students were satisfied to learn their own interesting topics more than topics given by teacher.	4.24	0.94	Highly level
3.	Students preferred this instruction as student centered more than as teacher centered.	4.14	0.79	Highly level
4.	Studying science by finding and solving the problem enabled students to understand more.	4.38	0.67	Highly level
5.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) promoted students in creative thinking	4.10	0.54	Highly level
6.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) promoted students to develop thinking skills.	4.24	0.54	Highly level
7.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to express their action better.	4.52	0.51	Highest level
8.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to be more responsible.	4.38	0.59	Highly level
9.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to have more self-confidence.	4.33	0.66	Highly level
10.	Teachers allowed students to take chance for studying in real-life issues/ real-events.	4.43	0.60	Highly level
11.	Teachers allowed students to choose real-life issues/ real-events to study according to their interest.	4.52	0.51	Highest level

TABLE 32 (continued)

No.	Item consideration	N = 21		Interpretation
		Mean	S.D.	
12.	Teachers allowed students to consistently involve themselves in groups doing activities based on issues.	4.24	0.54	Highly level
13.	Teachers allowed students to raise questions.	4.62	0.59	Highest level
14.	Teachers allowed students to discuss and share ideas.	4.62	0.59	Highest level
15.	Teachers allowed students to report their progress often.	4.29	0.64	Highly level
16.	Teachers allowed students in each group to present the task/ project.	4.76	0.54	Highest level
17.	Teachers advised and helped students in each group.	4.71	0.56	Highest level
18.	Teachers involved in observe students' working in each group.	4.62	0.50	Highest level
19.	Teachers allowed students to take chance for searching knowledge and information from various sources.	4.38	0.67	Highly level
20.	Students preferred to study and do activities in group.	4.33	0.66	Highly level
21.	Students could do activities very well and collaborated with peers in their groups.	4.38	0.67	Highly level
22.	Students actively shared ideas and discussed with peers in groups and in class.	4.00	0.71	Highly level
23.	Students searched additional knowledge more often over what was studied in class.	4.14	0.57	Highly level
24.	Students understood very well the problem of study.	4.24	0.54	Highly level
25.	Students could create and design activity, experiment or project in order to solve the problem very well.	4.05	0.67	Highly level
26.	Students could understand content better from discussions in the classroom.	4.29	0.72	Highly level
27.	Students gained more scientific process skill.	4.10	0.70	Highly level
28.	Students gained knowledge and understood content from independent study and from classmate presentations.	4.19	0.68	Highly level
29.	Students gained direct learning experience on their own.	4.52	0.51	Highest level
30.	Students could apply knowledge very well for using in daily lives.	4.33	0.48	Highly level
	The whole views	4.35	0.61	Highly level

TABLE 33 STUDENT ACHIEVEMENT SCORES BEFORE AND AFTER USING THE SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH ACCORDING TO CLASSROOM I

Student	Pre-test score			Post-test score		
No.	Part I	Part II	Total	Part I	Part II	Total
1.	20.0	10.0	30.0	21.0	17.5	38.5
2.	18.0	15.5	33.5	18.0	21.0	39.0
3.	16.0	12.5	28.5	11.0	17.0	28.0
4.	15.0	16.0	31.0	13.0	20.0	23.0
5.	17.0	13.5	30.5	21.0	19.0	40.0
6.	16.0	11.5	27.5	23.0	19.0	42.0
7.	15.0	17.0	32.0	24.0	18.5	42.5
8.	15.0	10.0	25.0	20.0	16.5	36.5
9.	17.0	16.5	33.5	16.0	17.0	33.0
10.	16.0	12.5	28.5	17.0	13.5	30.5
11.	8.0	16.0	24.0	11.0	17.5	28.5
12.	9.0	12.0	21.0	16.0	17.0	33.0
13.	9.0	14.0	23.0	15.0	19.0	34.0
14.	20.0	19.5	39.5	17.0	16.5	33.5
15.	24.0	7.0	31.0	21.0	15.5	36.5
16.	10.0	13.0	23.0	12.0	19.0	31.0
17.	22.0	9.5	31.5	13.0	13.0	26.0
18.	9.0	13.0	22.0	20.0	15.5	35.5
19.	13.0	8.5	21.5	12.0	13.5	25.5
20.	15.0	21.0	36.0	17.0	19.5	36.5
21.	12.0	9.0	21.0	19.0	17.5	36.5
22.	17.0	15.0	32.0	17.0	22.0	39.0
23.	14.0	8.0	22.0	11.0	12.0	23.0
24.	19.0	14.0	33.0	21.0	20.0	41.0
25.	19.0	13.5	32.5	17.0	18.0	35.0

TABLE 33 (continued)

Student	Pre-test			Post-test		
No.	Part I	Part II	Total	Part I	Part II	Total
26.	17.0	14.0	31.0	12.0	15.0	27.0
27.	11.0	11.0	22.0	11.0	15.5	26.5
28.	16.0	11.5	27.5	21.0	17.0	38.0
29.	20.0	6.0	26.0	19.0	12.5	31.5
30.	19.0	15.0	34.0	20.0	16.0	36.0
31.	16.0	18.0	34.0	14.0	18.5	32.5
32.	16.0	11.5	27.5	16.0	18.0	34.0
33.	16.0	6.5	32.5	24.0	15.5	39.5
34.	16.0	6.0	22.0	24.0	14.0	38.0
35.	17.0	11.5	28.5	21.0	24.0	45.0
36.	20.0	11.0	31.0	21.0	19.0	40.0
37.	14.0	13.5	27.5	16.0	15.0	31.0
38.	17.0	15.5	32.5	19.0	17.0	36.0
39.	13.0	14.5	27.5	17.0	16.5	33.5
40.	11.0	13.5	23.5	13.0	13.5	26.5
41.	18.0	14.5	32.5	11.0	16.0	27.0
42.	17.0	12.5	29.5	17.0	16.0	33
N = 42		*Mean = 28.40*			*Mean = 34.11*	

TABLE 34 STUDENT ACHIEVEMENT SCORES BEFORE AND AFTER USING THE SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH ACCORDING TO CLASSROOM II

Student	Pre-test score			Post-test score		
No.	Part I	Part II	Total	Part I	Part II	Total
1.	15.0	0	15.0	20.0	13.0	33.0
2.	17.0	0	17.0	24.0	16.5	40.5
3.	16.0	14.0	30.0	20.0	17.0	37.0
4.	10.0	1.0	11.0	12.0	9.5	21.5
5.	8.0	4.0	12.0	16.0	15.5	31.5
6.	14.0	0	14.0	10.0	13.0	23.0
7.	22.0	5.5	27.5	22.0	11.0	33.0
8.	14.0	11.0	14.0	22.0	18.5	40.5
9.	8.0	10.5	18.5	24.0	10.5	34.5
10.	11.0	11.0	22.0	26.0	16.0	42.0
11.	16.0	12.0	28.0	20.0	12.5	32.5
12.	23.0	9.0	32.0	26.0	17.5	43.5
13.	14.0	6.0	20.0	22.0	15.5	37.5
14.	15.0	9.5	24.5	17.0	14.5	31.5
15.	10.0	12.0	22.0	25.0	15.0	40.0
16.	11.0	4.5	45.5	24.0	16.5	40.5
17.	19.0	9.0	28.0	23.0	20.0	43.0
18.	11.0	8.0	19.0	23.0	16.5	39.5
19.	8.0	3.0	11.0	15.0	13.5	28.5
20.	19.0	13.5	32.5	20.0	15.0	35.0
21.	15.0	4.0	19.0	16.0	18.0	34.0
22.	8.0	7.0	15.0	10.0	15.0	25.0
23.	11.0	13.0	24.0	21.0	15.0	36.0
24.	16.0	6.0	22.0	23.0	14.0	37.0
25.	19.0	8.0	27.0	17.0	18.0	35.0

TABLE 34 (continued)

Student	Pre-test			Post-test		
No.	Part I	Part II	Total	Part I	Part II	Total
26.	12.0	14.5	26.5	18.0	20.0	38.0
27.	18.0	0	18.0	20.0	14.0	34.0
28.	17.0	0	17.0	14.0	20.0	34.0
29.	14.0	12.5	26.5	13.0	15.5	28.5
30.	12.0	0	12.0	26.0	15.0	41.0
31.	26.0	0	26.0	22.0	17.0	39.0
32.	18.0	13.5	31.5	21.0	20.5	41.5
33.	19.0	4.0	23.0	16.0	20.0	36.0
34.	23.0	4.0	27.0	21.0	15.0	36.0
35.	23.0	15.0	38.0	22.0	15.0	37.0
36.	11.0	1.0	12.0	14.0	13.0	27.0
37.	17.0	4.0	21.0	14.0	12.0	26.0
38.	6.0	12.5	18.5	19.0	13.0	32.0
39.	16.0	12.5	28.5	23.0	17.0	40.0
40.	15.0	12.5	27.5	15.0	16.5	31.5
41.	18.0	8.5	26.5	23.0	16.0	39.0
42.	15.0	0	15.0	20.0	13.0	33.0
43.	14.0	13.5	27.5	11.0.0	19.0	30.0
N = 43	*Mean = 22.17*			*Mean = 34.85*		

TABLE 35 THE RESULT OF STUDENT PORTFOLIO SCORES ANALYSIS ACCORDING TO CLASSROOM I

No.	Item Consideration	N = 42
		Mean
	Cognitive domain	
1.1	Understood the content of studying very well and clearly.	2.59
1.2	Searched more data for the topic of studying.	2.76
1.3	Planed for working in step and clearly.	2.42
1.4	Discussed and collaborated with peers in the group often.	2.76
1.5	Understood all steps of activities very well.	2.42
1.6	Designed the methodology to experiment/ investigate based on principles.	2.42
1.7	Showed the method of activities/ experiments clearly.	2.42
1.8	Designed table for collecting data clearly and appropriate.	2.42
1.9	Did activities/ experiments by following the plan.	2.66
1.10	Analyzed and summarized the study/ activities/ experiments correctly and appropriately.	2.54
1.11	Reported the results of studying/ doing activities/ doing experiment by using picture/ graph/ chart.	2.42
1.12	Described the details of picture/ graph/ chart in the report.	2.33
1.13	Reported the results correctly and had references.	2.30
1.14	Used creative thinking in work.	2.59
	Mean of cognitive domain	35.05
	Skill domain	
	<u>Activity/ laboratory skill</u>	
2.1	Brainstormed with peers and worked within the groups often.	2.49
2.2	Provided and assigned tasks to group clearly.	2.19
2.3	Did activities/ experiments by following the plan.	2.19
2.4	Used the appropriate science equipment to do activities/ experiments appropriately and correctly.	2.19
2.5	Did the activities/ laboratories correctly.	2.19
2.6	Recorded the results of activities/ experiments correctly.	2.42
2.7	Recorded the errors from doing activities/ experiments.	1.82
	<u>Reporting skill</u>	
2.8	Arranged the activities/ experiments in order and correctly.	2.42
2.9	Reported the results of doing activities/ experiments clearly and understandably.	2.19
2.10	Used equipment/ media to report tasks as appropriate.	2.19

TABLE 35 (continued)

No.	Item Consideration	N = 42 Mean
	Reporting skill (continued)	
2.11	Used the language and style to report as appropriate with the classroom atmosphere.	2.19
2.12	Reported the task completely and in time.	2.19
	Mean of skill domain	26.67
	Application domain	
3.1	Applied the activities/ experiments related to real-life issues/ real events.	2.54
3.2	Applied the materials using in local/ community resources to do the activities/ experiments.	2.42
3.3	Gave suggestions/ ideas for activities/ experiments.	1.66
3.4	Activities/ experiments could be used to solve the problem/ situations.	2.42
3.5	Applied the knowledge to do community/social activities.	2.42
3.6	Distributed knowledge of study to school/ community/ and social sources.	1.66
	Mean of application domain	13.12

TABLE 36 THE RESULT OF STUDENT PORTFOLIO SCORES ANALYSIS ACCORDING TO CLASSROOM II

No.	Item Consideration	N = 43 Mean
	Cognitive domain	
1.1	Understood the content of studying very well and clearly.	2.53
1.2	Searched more data for the topic of studying.	2.76
1.3	Planed for working in step and clearly.	2.39
1.4	Discussed and collaborated with peers in the group often.	2.76
1.5	Understood all steps of activities very well.	2.51
1.6	Designed the methodology to experiment/ investigate based on principle.	2.51
1.7	Showed the method of activities/ experiments clearly.	2.37
1.8	Designed table for collecting data clearly and appropriately.	2.37
1.9	Did activities/ experiments by following the plan.	2.51
1.10	Analyzed and summarized the study/ activities/ experiment correctly and appropriately.	2.39
1.11	Reported the result of studying / doing activities/ doing experiments by using picture/ graph/ chart.	2.44
1.12	Described the details of picture/ graph/ chart in the report.	2.27
1.13	Reported the results correctly and had references.	2.39
1.14	Used creative thinking in work.	2.51
	Mean of cognitive domain	34.71
	Skill domain	
	Activity/ laboratory skill	
2.1	Brainstormed with peers and worked within the groups often.	2.53
2.2	Provided and assigned tasks to groups clearly.	2.09
2.3	Did activities/ experiments by following the plan.	2.09
2.4	Used the appropriate science equipment to do activities/ experiments appropriately and correctly.	2.53
2.5	Did the activities/ laboratories correctly.	2.20
2.6	Recorded the results of activities/ experiments correctly.	2.20
2.7	Recorded the errors from doing activities/ experiments.	2.04
	Reporting skill	
2.8	Arranged the activities/ experiments in order and correctly.	2.20
2.9	Reported the results of doing activities/ experiments clearly and understandably.	2.20
2.10	Used equipment/ media to report the task as appropriate.	2.20

TABLE 36 (continued)

No.	Item Consideration	N = 43 Mean
	Reporting skill (continued)	
2.11	Used the language and style to report as appropriate with the classroom atmosphere.	2.20
2.12	Reported the task completely and in time.	2.09
	Mean of skill domain	26.57
	Application domain	
3.1	Applied the activity/ experiment related to real-life issues/ real events.	2.53
3.2	Applied the materials using in local/ community resources to do the activities/ experiments.	2.44
3.3	Gave suggestions/ ideas to do activities/ experiments.	2.09
3.4	Activities/ experiments could be used to solve the problems/ situations.	2.41
3.5	Applied the knowledge to do community/ social activities.	2.20
3.6	Distributed the knowledge of study to school/ community/ and social sources.	2.04
	Mean of application domain	13.71

TABLE 37 THE RESULT OF ANALYSIS ON STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

No.	Item consideration	N = 42 Mean	Interpretation
1.	I agree with water, air, and soil is more valuable of natural resources for living organisms especially human beings.	4.95	Highly level
2.	I agree with natural resources are four basic factors of life which mostly important for human beings surviving.	4.83	Highly level
3.	I think that water, air, and soil are public treasure that everybody should involve in taking care and maintenance.	4.90	Highly level
4.	I think that water, air, and soil are generally in everywhere in the world.	4.43	Highly level
5.	I think that water used from many activities in home, domestic, and hospital should be leaved to wastewater public tank.	3.24	Medium level
6.	After eating, if there is any piece of food on the plate, I will use water to rinse it and leave it wasted throughout public tank.	2.86	Medium level
7.	In my home, we have the policy to save water such as after using water from one activity, we can use it for the other activity in often.	3.57	Medium level
8.	I like to leave water running while cleaning my face, washing hands, and brushing teeth and turning the water off after all these activities done.	2.62	Medium level
9.	I like shower in which leaving water running on all time because I do not want to turning it on and off in often.	3.17	Medium level
10.	If I see my neighbor throw garbage or litters to public water resources in my village/ community, I will tell the competent authorities immediately.	3.67	Highly level
11.	I am pleased and willing to involve in various projects concerned with water conservation often.	4.07	Highly level
12.	I know about the water pollution problems and I try to involve in solving these problems too.	3.98	Highly level
13.	I think that I can not solve water pollution by my self.	4.62	Highly level
14.	I think in my community have the most water pollution problem.	3.27	Medium level
15.	I am unsatisfied very much if teacher call me to clean the room or pick up litters that I do not throw them.	2.81	Medium level

TABLE 37 (continued)

No.	Item of considerations	N = 42 Mean	Interpretation
16.	I agree with if there is air pollution occur in some place, it will distribute to another place, because air is the natural resource which could be circulated.	4.21	Highly level
17.	I never burn litters because they cause smoke, smell, and smog distribute to the air and make air pollution.	3.83	Highly level
18.	My family supports the project of using fossil fuel without lead.	4.33	Highly level
19.	I would like police to be more concentrate and strict with teenagers who modified exhaust manifold of motor cars and drove on the road, because they make loud noise and they cause of smog distribute to the air and make air pollution.	4.64	Highly level
20.	I agree with the government policy that all public cars such as buses need to check their characteristics every year.	4.81	Highly level
21.	I am pleased and willing to support my family involve in "the car free day project".	4.33	Highly level
22.	If I see factories in my community released the waste of smoke, gas or bad smell to the air, I will inform the competent authorities immediately.	3.83	Highly level
23.	I involved in taking care of environment by planting in my home, school or public areas in order to have the good quality of air.	4.12	Highly level
24.	I think that my community has the most air pollution problem.	3.07	Medium level
25.	If I were the farmer, I would use the most organic fertilizer rather than chemistry fertilizer to increase products.	4.38	Highly level
26.	I do not agree with digging the soil surface to sell, because it cause to damage the soil fertility.	4.74	Highly level
27.	I agree with planting long rooted grasses (Vetiver grass) in the slope areas because it will protect soil erosion.	4.74	Highly level
28.	I support to get rid of organic garbage by buried into the soil because it is better than burned which cause air pollution.	4.26	Highly level
29.	I do not agree with some place get rid of chemical substances into the soil.	4.29	Highly level
30.	I think that farmers used pesticides to control insect results in the most of soil pollution.	3.93	Highly level

TABLE 37 (continued)

No.	Item of considerations	N = 42 Mean	Interpretation
31.	Even though the road construction is benefit to develop community, but in the same time I think that the soil used for agriculture will be decreased.	3.98	Highly level
32.	I agree with the mixed agriculture because it helps to conserve the soil and environment.	4.62	Highly level
33.	I am pleased to give the knowledge of soil improving to agriculturists.	4.07	Highly level
34.	I think that in my community has the most soil pollution problem.	3.0	Medium level
35.	I agree with the problems of water, air and soil are the chain problem, when it occurred, it will be affected to each other.	4.45	Highly level
36.	I am willing to support and buy products which related to conserve the environment.	4.23	Highly level
37.	I am pleased and willing to expand the knowledge of "The natural resources conservation and environmental protection" to other persons.	4.26	Highly level
38.	I know about the projects related to natural resources conservation and environmental protection more than five ones.	3.48	Medium level
39.	I think that the project of "Ruam Palang Ham Song" is involved in conservation and solution of natural resources' problem very well.	4.29	Highly level
40.	I intended to apply the knowledge of the natural resources conservation and environmental protection for using in the daily lives.	4.31	Highly level
	The whole views	3.93	Highly level

TABLE 38 THE RESULT OF ANALYSIS ON STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION AFTER USING THE CURRICULUM ACCORDING TO CLASSROOM II

No.	Item of considerations	N = 43 Mean	Interpretation
1.	I agree with water, air, and soil is more valuable of natural resources for living organisms especially human beings.	4.84	Highly level
2.	I agree with natural resources are four basic factors of life which mostly important for human beings surviving.	4.79	Highly level
3.	I think that water, air, and soil are public treasure which everybody should involve in taking care and maintenance.	4.72	Highly level
4.	I think that water, air, and soil are generally in everywhere in the world.	4.12	Highly level
5.	I think that water used from many activities in home, domestic, and hospital should be leaved to wastewater public tank.	3.07	Medium level
6.	After eating, if there is any piece of food on the plate, I will use water to rinse it and leave it wasted throughout public tank.	3.05	Medium level
7.	In my home, we have the policy to save water such as after using water from one activity, we can use it for the other activity in often.	3.72	Highly level
8.	I like to leave water running while cleaning my face, washing hands, and brushing teeth and turning the water off after all these activities done.	2.12	Highly level
9.	I like shower in which leaving water running on all time because I do not want to turning it on and off in often.	3.26	Medium level
10.	If I see my neighbor throw garbage or litters to public water resources in my village/ community, I will tell the competent authorities immediately.	4.0	Highly level
11.	I am pleased and willing to involve in various projects concerned with water conservation often.	4.33	Highly level
12.	I know about the water pollution problems and I try to involve in solving these problems too.	3.91	Highly level
13.	I think that I can not solve water pollution by my self.	4.56	Highly level
14.	I think in my community have the most water pollution problem.	2.60	Medium level
15.	I am unsatisfied very much if teacher call me to clean the room or pick up litters that I do not throw them.	2.62	Medium level

TABLE 38 (continued)

No.	Item of considerations	N = 43 Mean	Interpretation
16.	I agree with if there is air pollution occur in some place, it will distribute to another place, because air is the natural resource which could be circulated.	4.02	High level
17.	I never burn litters because they cause smoke, smell, and smog distribute to the air and make air pollution.	3.79	High level
18.	My family supports the project of using fossil fuel without lead.	4.47	High level
19.	I would like police to be more concentrate and strict with teenagers who modified exhaust manifold of motor cars and drove on the road, because they make loud noise and they cause of smog distribute to the air and make air pollution.	4.60	High level
20.	I agree with the government policy that all public cars such as buses need to check their characteristics every year.	4.79	High level
21.	I am pleased and willing to support my family involve in "the car free day project".	4.44	High level
22.	If I see factories in my community released the waste of smoke, gas or bad smell to the air, I will inform the competent authorities immediately.	4.14	High level
23.	I involved in taking care of environment by planting in my home, school or public areas in order to have the good quality of air.	4.33	High level
24.	I think that my community has the most air pollution problem.	2.98	Median level
25.	If I were the farmer, I would use the most organic fertilizer rather than chemistry fertilizer to increase products.	4.16	High level
26.	I do not agree with digging the soil surface to sell, because it cause to damage the soil fertility.	4.56	High level
27.	I agree with planting long rooted grasses (Vetiver grass) in the slope areas because it will protect soil erosion.	4.60	High level
28.	I support to get rid of organic garbage by buried into the soil because it is better than burned which cause air pollution.	4.02	High level
29.	I do not agree with some place get rid of chemical substances into the soil.	4.26	High level
30.	I think that farmers used pesticides to control insect results in the most of soil pollution.	3.79	High level

TABLE 38 (continued)

No.	Item of considerations	N = 42 Mean	Interpretation
31.	Even though the road construction is benefit to develop community, but in the same time I think that the soil used for agriculture will be decreased.	3.90	Highly level
32.	I agree with the mixed agriculture because it helps to conserve the soil and environment.	4.49	Highly level
33.	I am pleased to give the knowledge of soil improving to agriculturists.	4.23	Highly level
34.	I think that in my community has the most soil pollution problem.	2.67	Medium level
35.	I agree with the problems of water, air and soil are the chain problem, when it occurred, it will be affected to each other.	4.23	Highly level
36.	I am willing to support and buy products related to conserve the environment.	4.32	Highly level
37.	I am pleased and willing to expand the knowledge of "The natural resources conservation and environmental protection" to other persons.	4.30	Highly level
38.	I know about the projects related to natural resources conservation and environmental protection more than five ones.	3.28	Medium level
39.	I think that the project of "Ruam Palang Harn Song" is involved in conservation and solution of natural resources' problem very well.	4.35	Highly level
40.	I intended to apply the knowledge of the natural resources conservation and environmental protection for using in the daily lives.	4.44	Highly level
	The whole views	3.93	Highly level

TABLE 39 THE RESULT OF ANALYSIS ON STUDENT OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM I

No.	Item consideration	N = 42		Interpretation
		Mean	S.D.	
1.	Study science related to real-life issues (liked this research), students were interested and would like to learn more.	4.24	0.58	Highly level
2.	Students were satisfied to learn own interesting topics more than topic given by teacher.	4.19	0.63	Highly level
3.	Students preferred this student centered instruction more than teacher centered instruction.	3.69	0.81	Highly level
4.	Studying science by finding and solving problems enabled better student understanding.	4.24	0.58	Highly level
5.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged student creative thinking.	4.26	0.70	Highly level
6.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to develop thinking skills.	4.26	0.54	Highly level
7.	Science curriculum as related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to express their actions better.	4.19	0.55	Highly level
8.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to be more responsible.	4.14	0.61	Highly level
9.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to have more self-confidence.	4.12	0.67	Highly level
10.	Teachers allowed students to study real-life issues/ real-events.	4.5	0.51	Highly level
11.	Teachers allowed students to take chance for choosing real-life issues/ real-events to study.	4.40	0.59	Highly level
12.	Teachers allowed students to consistently involve themselves in groups doing activities based on issues.	4.33	0.48	Highly level

TABLE 39 (continued)

No.	Item of considerations	N = 42		Interpretation
		Mean	S.D.	
13.	Teachers allowed students to raise questions.	4.36	0.48	Highly level
14.	Teachers allowed students to discuss and share ideas.	4.24	0.62	Highly level
15.	Teachers allowed students to report the progress often.	4.26	0.73	Highly level
16.	Teachers allowed students in each group to present tasks / projects.	4.52	0.59	Highest level
17.	Teachers advised and helped students in each group.	4.57	0.59	Highest level
18.	Teachers observed students working in each group.	4.38	0.49	Highly level
19.	Teachers allowed students to take chance for searching knowledge and information from various sources.	4.40	0.59	Highly level
20.	Students preferred to study and do activities in groups.	4.24	0.76	Highly level
21.	Students did activities very well and collaborated with peers in groups.	4.33	0.72	Highly level
22.	Students actively shared ideas and discussed with peers in groups and in class.	3.95	0.76	Highly level
23.	Students searched additional knowledge more often over what was studied in class.	3.88	0.83	Highly level
24.	Students understood very well the problem of study.	3.93	0.75	Highly level
25.	Students created and designed activity, experiment or project in order to solve the problem very well.	4.0	0.66	Highly level
26.	Students understood the content better from discussion than in the classroom.	4.10	0.66	Highly level
27.	Students gained more scientific process skills.	4.31	0.64	Highly level
28.	Students gained knowledge and understood content from studying on their own and from classmate presentations.	4.14	0.61	Highly level
29.	Students gained direct learning experience on their own.	4.38	0.54	Highly level
30.	Students could apply knowledge very well in their daily lives.	4.43	0.59	Highly level
	The whole views	4.23	0.63	Highly level

TABLE 40 THE RESULT OF ANALYSIS ON STUDENT OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM ACCORDING TO CLASSROOM II

No.	Item of considerations	N = 43		Interpretation
		Mean	S.D.	
1.	Studying science related to real-life issues (liked this research), students were interested and would like to learn more.	4.49	0.55	High level
2.	Students were satisfied to learn their own interesting topic more than topic given by teacher.	4.47	0.50	High level
3.	Students preferred this student centered instruction more than the teacher centered instruction.	4.42	0.50	High level
4.	Studying science by finding and solving problems promoted better student understanding.	4.37	0.49	High level
5.	Science curriculum related to real-life issues and based on inquiry cycle approach (as this research study) promoted student creative thinking.	4.19	0.45	High level
6.	Science curriculum as related to real-life issues and based on inquiry cycle approach (as this research study) enabled students to develop their thinking skills.	4.09	0.37	High level
7.	Science curriculum as related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to express their actions more.	4.26	0.44	High level
8.	Science curriculum as related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to be more responsible.	4.14	0.41	High level
9.	Science curriculum as related to real-life issues and based on inquiry cycle approach (as this research study) encouraged students to have more self-confidence.	4.26	0.49	High level
10.	Teachers allowed students to take chance for studying real-life issues/ real-events.	4.12	0.32	High level
11.	Teachers allowed students to choose real-life issues/ real-events to study according to their interests.	4.09	0.29	High level
12.	Teachers allowed students to consistently involve themselves in groups doing activities based on issues.	4.12	0.32	High level

TABLE 40 (continued)

No.	Item of considerations	N = 42		Interpretation
		Mean	S.D.	
13.	Teachers allowed students to raise questions.	4.02	0.15	High level
14.	Teachers allowed students to discuss and share ideas.	4.02	0.15	High level
15.	Teachers allowed students to report their progress often.	4.05	0.21	High level
16.	Teachers allowed students in each group to present the task / project.	4.05	0.21	High level
17.	Teachers advised and helped students in each group.	4.05	0.21	High level
18.	Teachers were involved in observing students working in each group.	4.02	0.15	High level
19.	Teachers allowed students to search for knowledge and information from various sources.	4.02	0.15	High level
20.	Students preferred to study and do activities in groups.	4.02	0.34	High level
21.	Students could do activities very well and collaborated with peers in groups.	4.0	0.31	High level
22.	Students actively shared ideas and discussed with peers in their groups and in class.	4.05	0.21	High level
23.	Students searched for additional knowledge more often over what was studied in class.	4.07	0.26	High level
24.	Students understood very well the problem of study.	4.05	0.30	High level
25.	Students created and designed activity, experiment or project in order to solve the problem very well.	4.0	0	High level
26.	Students understood content better from discussion than in the classroom.	4.05	0.21	High level
27.	Students gained more scientific process skills.	3.98	0.27	High level
28.	Students gained knowledge and understood content from their independent study and classmate presentations.	4.0	0	High level
29.	Students gained direct learning experience on their own.	4.33	0.47	High level
30.	Students could apply knowledge very well in their daily lives.	4.23	0.43	High level
	The whole views	4.13	0.31	High level

TABLE 41 THE RESULT OF ANALYSIS ON TEACHER OPINION TOWARD SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH AFTER USING THE SCIENCE CURRICULUM

No.	Domain consideration item	N = 2				Interpretation
		T1	T2	Mean	S.D.	
	Content domain					
1.	Content was consistent to the learning purposes.	5	4	4.5	0.71	Highly level
2.	Content in each topic was in order and related.	4	4	4.0	0	Highly level
3.	Content was appropriately difficult for students.	5	4	4.5	0.71	Highly level
4.	Content was enough for student to use as learning sources for searching and reference.	4	5	4.5	0.71	Highly level
5.	Content was related to real-life issues or real-events.	5	5	5.0	0	Highest level
6.	Content in each topic was appropriate for using inquiry cycle approach.	4	4	4.0	0	Highly level
7.	Content of science curriculum was appropriate for student to use in daily life.	5	4	4.5	0.71	Highly level
	Mean of content domain	4.57	4.28	4.43	0.41	Highly level
	Instruction domain					
8.	You allowed students take chance to study the real-life issues/ real-events.	5	4	4.5	0.71	Highly level
9.	You enhanced students to show theirs potentially ideas.	4	4	4.0	0	Highly level
10.	You allowed students take chance to study the real-life issues/ real-events by their interests.	4	4	4.0	0	Highly level
11.	You allowed students take chance to involve in doing activities in the problem consistence.	5	4	4.5	0.71	Highly level
12.	You allowed students to raise questions.	4	4	4.0	0	Highly level
13.	You allowed students to discuss and share ideas.	4	4	4.0	0	Highly level

TABLE 41 (continued)

No.	Domain consideration item	N = 2				The appropriate level
		X1	X2	Mean	S.D.	
14.	You allowed students to report their learning progress.	3	4	3.5	0.71	Medium level
15.	You allowed students in each group to present their tasks/ projects.	4	4	4.0	0	Highly level
16.	You advised and helped students in each group.	5	5	5.0	0	Highest level
17.	You involved in observe students working in each group.	4	4	4.0	0	Highly level
18.	The instruction periods by using the inquiry cycle approach in this science curriculum were appropriate.	4	3	3.5	0.71	Medium level
	Mean of instruction domain	4.18	4.0	4.10	0.26	Highly level
	Instructional media domain					
19.	The instruction media/ learning sources were appropriate with learning substance (content).	4	3	3.5	0.71	Medium level
20.	The instruction media/ learning sources were appropriate for using to develop students learning.	5	3	4.0	1.41	Highly level
21.	The instruction media/ learning sources were appropriate for students to apply in doing activities/ projects/ experiments.	4	3	3.5	0.71	Medium level
22.	You promoted students to search more knowledge from various sources and including internet.	5	4	4.5	0.71	Highly level
	Mean of instructional media domain	4.5	3.25	3.88	0.89	Highly level
	Assessment domain					
23.	The assessment in with the instructional plan was consistent to the learning purposes.	4	4	4.0	0	Highly level
24.	The assessment in with the instructional plan was consistent to the content.	5	4	4.5	0.71	Highly level
25.	The assessment in with the instructional plan was consistent to teaching-learning activities.	4	4	4.0	0	Highly level

TABLE 41 (continued)

No.	Domain consideration item	N = 2				The appropriate
		X1	X2	Mean	S.D.	level
26.	The assessment in with the instructional plan was covered with three learning domains: knowledge; awareness and skills.	5	4	4.5	0.71	Highly level
27.	You had assessed students all along instruction in order to develop students' abilities.	5	4	4.5	0.71	Highly level
28.	The assessment method and tools could be used to assess students with different personalities.	5	3	4.0	1.41	Highly level
	Mean of assessment domain	4.66	3.83	4.25	0.59	Highly level
	Application domain					
29.	Teaching science as inquiry cycle approach helped teachers in their teaching responsibility.	5	4	4.5	0.71	Highly level
30.	You spent time to prepare your teaching less than usual.	5	4	4.5	0.71	Highly level
31.	Teaching science as inquiry cycle approach promoted student creative thinking.	5	4	4.5	0.71	Highly level
32.	Teaching science as inquiry cycle approach promoted greater student responsibility.	5	4	4.5	0.71	Highly level
33.	Students gained direct experience by learning this method.	5	4	4.5	0.71	Highly level
34.	Students had chance to show theirs abilities.	5	4	4.5	0.71	Highly level
35.	Students had chance to learn in working with peers.	5	4	4.5	0.71	Highly level
	Mean of application domain	5.0	4.0	4.5	0.71	Highly level

TABLE 42 THE RESULT OF ANALYSIS ON CLASSROOM OBSERVATION ACCORDING TO THE BOTH CLASSROOMS

No.	The observation list	Class I	Class II	The results
		Frequency	Frequency	
	The learning process			
	Teacher's role			
1.	Encouraged students to raise question and discussion.	16	16	Teacher encouraged students in each group to express their potentialities, to raise questions and discussion in often.
2.	Promoted students to study the problems related to real-life issues.	5	5	In the engagement stage, teacher allowed students to study the problems related to real-life issues at the local area and showed some articles or news about the environmental pollution problems occurred in everyday life and encourage students to discuss and share ideas in the class.
3.	Allowed students to select the topic study according to their interest.	5	5	Teacher allowed students take chance to study the real problems/ issues by their interest.
4.	Allowed students to search data from various sources.	16	14	Teacher allowed students to search data related to their topic study from various sources such as textbook, internet.
5.	Asked students' question and extended the scope of problem in order to discuss in the class.	12	10	Teacher asked students' question in often from their issue studies in order to discuss in the class.

TABLE 42 (continued)

No.	The observation list	Class I	Class II	The results
		Frequency	Frequency	
6.	Allowed students in each group present their tasks/ reports/ projects.	8	8	In each stage of inquiry cycle approach, teacher attempted students in each group to present their progress in work or present their tasks.
7.	Allowed students to raise questions	16	14	Teachers allowed students raise their questions to each other in often.
8.	Allowed students to discuss and share ideas.	16	16	Teachers allowed students to discuss and share ideas within group and in the class.
9.	Involved to observe students working in each group.	16	16	Teachers walked around in each group to observe students working and give students advice.
10.	Advised and helped students in each group.	16	16	Teacher collaborated to talk with students and raise questions in each group and advised students to solve their problems.
11.	Allowed students to report their progresses in work.	8	8	Teacher allowed students in each group to present their progresses in work all along in the class.
12.	Controlled the time for students' presentation.	8	8	Teachers allowed students in each group to present their task by the time setting.
	Students' role			
13.	Collaborated in working in group.	16	16	Students collaborated in working in group very well and the classroom atmosphere was not stress.

TABLE 42 (continued)

No.	The observation list	Class I Frequency	Class II Frequency	The results
14.	Planned and brainstormed ideas in group.	8	8	Students collaborated in planning and brainstorming with peers in group often.
15.	Provided the responsibilities and assigned tasks to peers in the group.	10	10	Students in each group provided and assigned tasks to peers in the group smoothly.
16.	Recorded data in working and kept for evidence.	10	10	Students in each group recorded and collected data as evidence for portfolio assessment.
17.	Discussed and shared ideas within group.	16	16	Students in each group discussed and shared ideas all along the learning.
18.	Discussed and shared ideas in the class.	10	10	Students in each group discussed and shared ideas with other groups in class more often when they had chance.
19.	Students also played attention in other groups' activities.	8	8	Most students in the class also played attention to other groups' activities. They were interested and involved in other groups' activities in some times.
20.	Presented the tasks and projects clearly.	8	8	Students in each group could be expressed and presented their learning in the class clearly.
21.	Presented the tasks and projects correctly.	8	8	Most students in each group could be expressed and presented their tasks and reports in the class clearly and based on principles.

TABLE 42 (continued)

No.	The observation list	Class I	Class II	The results
		Frequency	Frequency	
22.	Presented the tasks and projects appropriately and concisely.	6	6	Only some groups presented their tasks in longer and loosely and not follow with the plan.
23.	Used media/ equipments in order to make their presentations were interesting.	8	8	Students in each group presented their tasks very well and they also used media/ equipment for their presentation and including the use of information technology.
24	Presented the tasks and projects in the appropriate of time.	8	8	Most students in each group could be presented their tasks in the appropriate of time.

N = 16

APPENDIX D

The results of research materials analysis

The examining and verifying the quality of research materials

The five research materials were examined and verified the quality as follows:

1. An achievement test in concepts on natural resources and environmental pollution

Target group: An achievement test was used to evaluate the quality in one classroom of 46 high school science students at Tepleela school in Bangkok Metropolis, in the academic year of 2003.

2. An assessment of student portfolio

Target group: The portfolio assessment was used to evaluate the quality in three high school science teachers at Tepleela school in Bangkok Metropolis, in the academic year of 2003.

3. An assessment of student awareness toward science on natural resources and environmental pollution

Target group: The assessment of student awareness was used to evaluate the quality in one classroom of 46 high school science students at Tepleela school in Bangkok Metropolis, in the academic year of 2003.

4. An assessment of student opinion toward science curriculum

Target group: The assessment of student opinion was used to evaluate the quality in one classroom of 46 high school science students at Tepleela school in Bangkok Metropolis, in the academic year of 2003.

5. An assessment of teacher opinion toward science

Target group: The assessment of teacher opinion was used to evaluate the quality in three high school science teachers at Tepleela school in Bangkok Metropolis, in the academic year of 2003.

TABLE 43 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC), ITEM DIFFICULTY (P), AND ITEM DISCRIMINATION (r) OF AN ACHIEVEMENT TEST

The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze	The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze
Part I									
Item 1	1.00	0.50	0.42	Used	Item 20	1.00	0.80	0.12	Unused
Item 2	0.86	0.22	0.22	Used	Item 21	1.00	0.62	0.33	Improved and changed to item 15
Item 3	1.00	0.72	0.16	Unused					
Item 4	1.00	0.62	0.33	Improved and changed to item 3	Item 22	1.00	0.44	0.68	Improved and changed to item 16
Item 5	1.00	0.62	0.33	Improved and changed to item 4	Item 23	1.00	0.34	0.52	Improved and changed to item 17
Item 6	1.00	0.80	0.26	Improved and changed to item 5	Item 24	0.86	0.82	0.12	Unused
Item 7	0.86	0.50	0.42	Improved and changed to item 6	Item 25	0.86	0.76	0.36	Improved and changed to item 18
Item 8	0.86	0.34	0.52	Improved and changed to item 7	Item 26	0.86	0.34	0.52	Improved and changed to item 19
Item 9	0.71	0.62	0.33	Improved and changed to item 8	Item 27	1.00	0.76	0.28	Improved and changed to item 20
Item 10	1.00	0.74	0.28	Improved and changed to item 9	Item 28	0.71	0.72	0.08	Unused
Item 11	1.00	0.74	0.28	Improved and changed to item 10	Item 29	0.86	0.62	0.33	Improved and changed to item 21
Item 12	1.00	0.58	0.44	Improved and changed to item 11	Item 30	0.86	0.34	0.38	Improved and changed to item 22
Item 13	0.86	0.84	0.08	Unused	Item 31	1.00	0.58	0.44	Improved and changed to item 23
Item 14	0.71	0.18	0.12	Unused					
Item 15	1.00	0.50	0.30	Improved and changed to item 12	Item 32	1.00	0.50	0.28	Improved and changed to item 24
Item 16	0.71	0.20	0.16	Unused	Item 33	0.86	0.28	0.16	Unused
Item 17	1.00	0.44	0.68	Improved and changed to item 13	Item 34	0.86	0.85	0.12	Unused
Item 18	0.86	0.68	0.04	Unused	Item 35	1.00	0.74	0.28	Improved and changed to item 25
Item 19	1.00	0.50	0.42	Improved and changed to item 14					

TABLE 43 (continued)

The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze	The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze
Item 36	1.00	0.62	0.33	Improved and changed to item 26	Item 57	0.86	0.26	0.12	Unused
Item 37	1.00	0.44	0.52	Improved and changed to item 27	Item 58	0.86	0.66	0.42	Improved and changed to item 39
Item 38	1.00	0.74	0.28	Improved and changed to item 28	Item 59	1.00	0.70	0.18	Unused
Item 39	1.00	0.62	0.33	Improved and changed to item 29	Item 60	1.00	0.56	0.34	Improved and changed to item 40
Item 40	1.00	0.38	0.14	Unused					
Item 41	1.00	0.56	0.16	Unused					
Item 42	0.86	0.62	0.38	Improved and changed to item 30					
Item 43	0.86	0.58	0.30	Improved and changed to item 31					
Item 44	1.00	0.34	0.42	Improved and changed to item 32					
Item 45	1.00	0.38	0.24	Improved and changed to item 33					
Item 46	1.00	0.42	0.38	Improved and changed to item 34					
Item 47	1.00	0.9	0.12	Unused					
Item 48	0.71	0.24	0.08	Unused					
Item 49	1.00	0.56	0.26	Improved and changed to item 35					
Item 50	1.00	0.38	0.28	Improved and changed to item 36					
Item 51	1.00	0.50	0.04	Unused					
Item 52	0.86	0.34	0.52	Improved and changed to item 37					
Item 53	1.00	0.26	0.12	Unused					
Item 54	1.00	0.38	0.24	Improved and changed to item 38					
Item 55	1.00	0.24	0.08	Unused					
Item 56	1.00	0.34	0.04	Unused					

TABLE 43 (continued)

The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze	The test before evaluate and analyze	IOC	P	r	Improved the test after evaluate and analyze
Part II									
Item 1	0.86	0.44	0.04	Unused	Item 11	0.86	0.76	0.14	Unused
Item 2	1.00	0.56	0.34	Improved and changed to item 1	Item 12	0.86	0.28	0.04	Unused
Item 3	0.86	0.44	0.04	Unused	Item 13	1.00	0.44	0.38	Improved and changed to item 7
Item 4	1.00	0.66	0.42	Improved and changed to item 2	Item 14	1.00	0.38	0.24	Improved and changed to item 8
Item 5	0.86	0.44	0.04	Unused	Item 15	0.86	0.74	0.12	Unused
Item 6	1.00	0.44	0.38	Improved and changed to item 3	Item 16	0.86	0.78	0.16	Unused
Item 7	0.71	0.20	0.16	unused	Item 17	0.86	0.78	0.16	Unused
Item 8	1.00	0.68	0.34	Improved and changed to item 4	Item 18	0.86	0.78	0.16	Unused
Item 9	0.86	0.58	0.30	Improved and changed to item 5	Item 19	1.00	0.44	0.52	Improved and changed to item 9
Item 10	1.00	0.64	0.24	Improved and changed to item 6	Item 20	1.00	0.38	0.24	Improved and changed to item 10

TABLE 44 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC) OF AN ASEESMENT ON STUDENT PORTFOLIO ACCORDING TO THE EXPERTS' OPINION

Item	IOC	Interpretation	Item	IOC	Interpretation
1.1	0.71	Appropriate	3.3	0.71	Appropriate
1.2	0.71	Appropriate	3.4	0.85	Appropriate
1.3	0.71	Appropriate	3.5	0.85	Appropriate
1.4	0.57	Appropriate	3.6	0.85	Appropriate
1.5	0.57	Appropriate			
1.6	0.85	Appropriate			
1.7	0.85	Appropriate			
1.8	0.85	Appropriate			
1.9	0.71	Appropriate			
1.10	0.85	Appropriate			
1.11	0.71	Appropriate			
1.12	0.71	Appropriate			
1.13	0.71	Appropriate			
1.14	0.71	Appropriate			
2.1	0.71	Appropriate			
2.2	0.85	Appropriate			
2.3	0.85	Appropriate			
2.4	0.85	Appropriate			
2.5	0.85	Appropriate			
2.6	0.85	Appropriate			
2.7	0.57	Appropriate			
2.8	0.85	Appropriate			
2.9	0.85	Appropriate			
2.10	0.85	Appropriate			
2.11	0.85	Appropriate			
2.12	0.85	Appropriate			
3.1	0.85	Appropriate			
3.2	0.85	Appropriate			

TABLE 45 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC) OF AN ASEESMENT ON STUDENT AWARENESS TOWARD SCIENCE ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION ACCORDING TO THE EXPERTS' OPINION

Item	IOC	Interpretation	Item	IOC	Interpretation
1.	1.00	Appropriate	28.	0.85	Appropriate
2.	0.85	Appropriate	29.	0.85	Appropriate
3.	0.85	Appropriate	30.	0.85	Appropriate
4.	0.57	Appropriate	31.	0.85	Appropriate
5.	0.71	Appropriate	32.	0.71	Appropriate
6.	1.00	Appropriate	33.	0.85	Appropriate
7.	1.00	Appropriate	34.	0.57	Appropriate
8.	1.00	Appropriate	35.	0.71	Appropriate
9.	0.71	Appropriate	36.	0.85	Appropriate
10.	0.85	Appropriate	37.	0.85	Appropriate
11.	0.71	Appropriate	38.	0.85	Appropriate
12.	0.85	Appropriate	39.	0.85	Appropriate
13.	0.85	Appropriate	40.	0.85	Appropriate
14.	0.57	Appropriate			
15.	0.85	Appropriate			
16.	0.57	Appropriate			
17.	0.71	Appropriate			
18.	0.71	Appropriate			
19.	0.71	Appropriate			
20.	0.71	Appropriate			
21.	0.85	Appropriate			
22.	0.85	Appropriate			
23.	0.85	Appropriate			
24.	0.57	Appropriate			
25.	0.71	Appropriate			
26.	0.85	Appropriate			
27.	0.85	Appropriate			

TABLE 46 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC) OF AN ASEESMENT ON STUDENT OPINION TOWARD SCIENCE CURRICULUM ACCORDING TO THE EXPERTS' OPINION

Item	IOC	Interpretation	Item	IOC	Interpretation
1.	1.00	Appropriate	29.	0.85	Appropriate
2.	1.00	Appropriate	30.	1.00	Appropriate
3.	0.85	Appropriate			
4.	1.00	Appropriate			
5.	0.85	Appropriate			
6.	0.85	Appropriate			
7.	1.00	Appropriate			
8.	0.71	Appropriate			
9.	0.71	Appropriate			
10.	0.85	Appropriate			
11.	0.85	Appropriate			
12.	1.00	Appropriate			
13.	1.00	Appropriate			
14.	1.00	Appropriate			
15.	0.71	Appropriate			
16.	0.85	Appropriate			
17.	0.85	Appropriate			
18.	0.85	Appropriate			
19.	1.00	Appropriate			
20.	0.85	Appropriate			
21.	0.71	Appropriate			
22.	0.71	Appropriate			
23.	0.85	Appropriate			
24.	1.00	Appropriate			
25.	1.00	Appropriate			
26.	0.85	Appropriate			
27.	0.71	Appropriate			
28.	0.85	Appropriate			

TABLE 47 THE RESULT OF EVALUATING THE ITEM-OBJECTIVE CONGRUENCE (IOC) OF AN ASEESMENT ON TEACHER OPINION TOWARD SCIENCE CURRICULUM ACCORDING TO THE EXPERTS' OPINION

Item	IOC	Interpretation	Item	IOC	Interpretation
1.	1.00	Appropriate	28.	0.85	Appropriate
2.	1.00	Appropriate	29.	0.71	Appropriate
3.	1.11	Appropriate	30.	0.71	Appropriate
4.	0.85	Appropriate	31.	0.85	Appropriate
5.	0.85	Appropriate	32.	1.00	Appropriate
6.	0.85	Appropriate	33.	0.85	Appropriate
7.	0.71	Appropriate	34.	0.85	Appropriate
8.	1.00	Appropriate	35.	1.00	Appropriate
9.	1.00	Appropriate			
10.	1.00	Appropriate			
11.	1.00	Appropriate			
12.	1.00	Appropriate			
13.	1.00	Appropriate			
14.	0.85	Appropriate			
15.	1.00	Appropriate			
16.	0.85	Appropriate			
17.	0.85	Appropriate			
18.	0.85	Appropriate			
19.	1.00	Appropriate			
20.	0.85	Appropriate			
21.	0.85	Appropriate			
22.	1.00	Appropriate			
23.	1.00	Appropriate			
24.	1.00	Appropriate			
25.	1.00	Appropriate			
26.	0.85	Appropriate			
27.	0.85	Appropriate			

APPENDIX E

1. The high school science curriculum on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach

2. The instructional plan on natural resources and environmental pollution related to real-life issues and based on inquiry cycle approach

3. The achievement test

The High School Science Curriculum on Natural resources and Environmental Pollution Related to Real-Life Issues Based on Inquiry Cycle Approach

(If interest, please contact directly to the researcher)

The suggestion for using science curriculum

The use of high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach has suggested as follows:

1. The science curriculum in this research study is a school based curriculum which developed to promote students abilities at high school level. This science curriculum developed and based on real-life issues or real events at local, community, national, and global level on the topic of natural resources and environmental pollution.

2. The science curriculum is an additional science course and consists of learning standard, learning substance, course syllabus based on learning standard at level 4 (grade 10 – 12) according to Thailand Basic Education Curriculum B.E. 2544 (A.D. 2001). This science curriculum is focused on science sub-strand # 2 Life and the Environment and standard science # 2.2.

3. The learners are high school students at grade 10 – 12 who learned the basic science course of Life and the Environment according to the Basic Education Curriculum B.E. 2544 (A.D. 2001).

4. The instructional period of this science curriculum is 25 periods and conduct in the second semester of academic year 2003.

5. The teachers who taught this science curriculum must have basic knowledge of teaching and learning based on inquiry cycle approach.

6. This science curriculum use as the learning sources for students and consists of document and laboratory activities. The teachers who taught this science curriculum should be use together of an instructional plan, an achievement test, an assessment on student portfolio, an assessment on student awareness toward science on natural resources and environment, an assessment on student opinion toward science, and an assessment on teacher opinion toward science.

The Instructional Plan on Natural Resources and Environmental Pollution

Related to Real-Life Issues Based on Inquiry Cycle Approach

The Instructional Plan on Natural Resources and Environmental Pollution Related to Real-Life Issues Based on Inquiry Cycle Approach

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Learning Outcomes

After learning these lessons, students will be able to:

1. Explain water quality, sources of water, and discuss about water usage at local, national and global levels.
2. Explain the effects of water usage and changes in the environment resulting from effects of nature and human beings.
3. Search data related to water resources and water pollution.
4. Plan, investigate and design experiments in order to test water pollution.
5. Explain ways to save water and develop ideas to take for preventing and solving water problems.
6. Apply the scientific process and knowledge to solve water pollution problems in order to find ways to prevent, solve, and improve the environment at personal, local and national levels.
7. Explain the composition of air.
8. Explain the problem of air and air pollution at local, national, and global levels.
9. Explain the effects of air pollution and changes of the environment resulting from effects of nature and human beings.
10. Search data related to air resources and air pollution.
11. Plan, investigate, and design experiments in order to test air pollution.
12. Explain ways of caring for the air and develop ideas to take to prevent and solve air pollution problems.
13. Apply the scientific process and knowledge to solve air pollution problems in order to find ways to prevent, solve, and improve the environment at personal, local, and national levels.
14. Explain the quality of soil and sources of soil.
15. Explain the problems of soil and soil pollution at the local, national, and global levels.

Learning outcome (continued)

16. Explain the effects of soil usage and changes of the environment resulting from effects of nature and human beings.

17. Search data related to soil resources and soil pollution.

18. Plan, investigate and design experiments in order to test soil pollution.

19. Explain ways to conserve soil and prevent damage of soil quality.

20. Apply the scientific process and knowledge to solve soil pollution problems in order to improve the environment at personal, local and national levels.

Concept flow

Water and water pollution

1. Water is a non-exhausting natural resource that has specific properties such as density, flexibility, heat transfer, and heat absorption.

2. Water sources are from ground water, surface water, and precipitation. The world's water is recycled for usage in a process known as the water cycle.

3. Water that changes in quality and is not usable by human beings and other living organisms is called waste water or polluted water.

4. Water quality consists of physical, chemical and biological properties.

5. Water pollution comes from various direct and indirect actions of humans.

6. Polluted water or wastewater affects living organisms and the environment.

Air and air pollution

1. Air is a non-exhausting natural resource composes of various gases including oxygen, hydrogen, carbon oxide, nitrogen oxide, and sulfur oxide.

2. Air polluted by dust, smoke, smell, vapor, and toxic gases in certain amounts over a period of time, and which effects human beings and other living organisms is called air pollution.

3. Most air pollution comes from various direct and indirect actions of humans.

4. Air pollution has effects on living organisms and the environment.

Soil and soil pollution

1. Soil is a renewable natural resource with specific properties including soil density, soil absorption, and soil fertility.

2. Soil comes from the degradation of soil materials or sedimentation of organic materials from the surface area.

3. Soil that changes in quality and becomes a polluted substance not usable by humans and other living organisms is called waste soil or soil pollution.

4. Soil quality consists of physical, chemical, and biological properties.

5. Waste soil or polluted soil has effects on living organisms and the environment.

Prior knowledge and experience of student

Student should have prior knowledge in the following content:

1. Element and substance
2. Chemical bond and chemical reaction
3. Chemistry for life
4. The nature of living organisms
5. The equilibrium of living organisms

Instructional Process

Instructional process		period	Assessment
Teacher's role	Student's role		
Engagement stage			
1. Teacher introduces the lesson by showing video tape related to natural resources and environment or takes student to investigate the environment in school or around school.	1. Students analyze the problem of natural resources and environment from video tape, after those students collaborate to discuss and summarize the problem and cause of pollution. Students also classify the pollution problems.	5	Teacher assesses students prior knowledge by using pre-test before starting the class. The pre-test consists of 40 multiple choices questions and 10 open-ended questions.
2. Teacher encourages student to discuss and raise questions such as; - What is cause of environmental pollution?. - How are water, air, and soil polluted?. - What is the effect of water, air and soil pollution			
3. Teacher allows students to select the topic study related to natural resources and environmental pollution on water, air and soil.	2. Students select the topic study according to their own interests on water, air, and soil.		
4. Teacher allows student in each group search data related to water and water pollution, air and air pollution, and soil and soil pollution from library, internet or other sources. Teacher maybe assigns students in advance to study and search data and after that allows	3. Students collaborate to plan for searching data related to water and water pollution, air and air pollution, and soil and soil pollution. Students maybe search and study these topics in advance.		

Instructional Process (continued)

Instructional process		period	Assessment
Teacher's role	**Student's role**		
students in each group to present the topic study in the class.	4. Students collaborate to discuss searching data in groups and make decision to select the topic study in order present in the class.		
5. Teacher helps students to extend the issue study process in each group in order to encourage and guide them to find the answer.	5. Each group presents the topic study and explains the reasons why to study that topic. Students in class discuss and share ideas within their groups.		
Exploration stage			
6. Teacher allows students to search data, investigate, design and plan the experiment. Teacher also observes students working within each group.	6. Each group collaborates to plan for investigating, studying, and designing experiment or setting the unreal issues related to the topic of interest, then students collaborate to find the study method.	10	Teacher assesses students by using portfolio assessment.
7. Teacher allows student in each group to present the method of the study plan.	7. Each group presents the method of the study plan in the class.		
8. Teacher poses the question in each group in order to help students find the way to study and gives advise to students.	8. Students collaborate to discuss and share ideas about the study plan of each group in the class.		
9. Teacher assigns students in each group to do experiments following the study plan, and also to collect data with evidence from the study.	9. Each group does experiments following the study plan and collect data and study results.		

Instructional Process (continued)

Instructional process		period	Assessment
Teacher's role	Student's role		
Teacher involved to observe students working in each group.	10. Students record data from studying and report group progress to the class.		
Explanation stage			
10. Teacher allows students to analyze data, interpret data, develop conclusion and discussion, and also collaborate to observe students working in each group. Teacher advises students in each group and pays attention to ask students in their presentations.	11. Students in each group collaborate in planning to analyze data, interpret data conclusion, and discussion. 12. Students in each group presents their study in the class and collaborate to discuss and give suggestions.	4	Teacher assesses students by using portfolio assessment
11. Teacher asks students in each group and students explain the reasons and show the evidence in their explanation.	13. Students in each group evaluates their own tasks and the tasks of others.		
Elaboration stage			
12. Teacher setting the problem issues related to water pollution, air pollution, and soil pollution in various styles such as holding a debate, acting out situations or investigating experiments and then allowing students to select the style in order to solve or find the way to prevent water, air and soil pollution.	13. Students collaborate with peers in groups to select the style to prevent and solve the problem of water, air and soil pollution such holding a debate, acting out situations or investigating experiments including design experiments, and after that collaborating to discuss in the class to find the way to prevent and solve the	4	Teacher assesses students by using portfolio assessment.

Instructional Process (continued)

Instructional process		period	Assessment
Teacher's role	Student's role		
13. Teacher collaborates to discuss with students in order to encourage students to apply the knowledge to prevent and solve the problem of water, air and soil pollution. 14. Allow student to discuss about the way to prevent and solve the problem of water, air and soil pollution including show the data references and evidence to support their ideas.	the problem of water, air and soil pollution.		
Evaluation stage			
15. Teacher observes students in the class using of concepts and knowledge to solve the problem of water, air and soil pollution. 16. Evaluate students on the knowledge and skill of problem solving related to water and water pollution, air and air pollution, and soil and soil pollution. 17. Teacher observes students in using of prior knowledge link to the receiving of new knowledge. 18. Teacher allows students to assess by themselves about learning and group process skills.	14. Students collaborate to summarize knowledge related to water and water pollution, air and air pollution, and soil and soil pollution. 15. Students collaborate to summarize ways to conserve water, air and soil.	2	At the end of the class, Teacher assesses students as follows: 1. Assesses students knowledge by using post-test achievement test. 2. Assesses students by using portfolio assessment. 2. Assesses students by using awareness assessment. 3. Assesses students by using opinion assessment. 5. Assess teachers by using opinion assessment.

The achievement test on natural resources and environmental pollution

(If interest, please contact directly to the researcher)

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THE DEVELOPMENT OF HIGH SCHOOL SCIENCE CURRICULUM ON NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION RELATED TO REAL-LIFE ISSUES BASED ON INQUIRY CYCLE APPROACH

AN ABSTRACT

BY

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The purposes of this research were (1) to develop a high school science curriculum on natural resources and environmental pollution related to real-life issues based on inquiry cycle approach and (2) to study the implementation of this high school science curriculum. The research study was conducted through two stages: curriculum development, and curriculum implementation.

Following these stages and procedures, a draft of high school science curriculum on natural resources and environmental pollution was developed and based on the science strand (content) and sub-strand "Life and the Environment" of Thailand's Basic Education Curriculum, B.E. 2544 at grades 10-12. The science curriculum was verified for quality, appropriateness, and validity by experts.

The science curriculum draft was tried out in one classroom with 21 high school students of grade 10 at Sampran Wittaya School, Nakhon Prathom province in the second semester of the academic year 2003 (November-December, 2003). The period of instruction was 25 periods and during the pilot study, two other teachers of King's College at Nakhon Prathom province were prepared to observe in the classroom. The teachers implemented the science curriculum of this research study in the actual classroom. The findings of the pilot study indicated that the periods of each stage of the inquiry cycle approach in the instructional plan were revised in order to maximize appropriate use in the classroom.

The revised science curriculum was implemented in the classroom with a sample group of students from King's college. There were 85 students from two classrooms in grade 10 in the second semester of academic year 2003 (January - February, 2004) and the instructional periods were 25 periods. The results of the curriculum implementation indicated that student achievement scores of both classrooms after using the science curriculum were significantly higher at the .05 level than student achievement scores of students in the same group before using a science curriculum. In addition, scores of both classrooms of science students were significantly higher level beyond the .05 level of significance in portfolio score, awareness toward science score, and opinion toward the science curriculum score, after the science curriculum was implemented. The teacher opinion scores were also at a higher level beyond the .05 level of significance.

The research findings revealed that the science curriculum on natural resources and environmental pollution as related to real-life issues and based on inquiry cycle approach was effective and could be used into the classroom.

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(IPST)