A DEVELOPMENT OF THE CONSTRUCTIVIST THEMATIC SCIENCE PROGRAM AT CHIANGMAI ZOO

DISSERTATION

BY

KANCHULEE PUNYAIN

Presented in Partial Fulfillment of the Requirements for the

Doctor of Education Degree in Science Education

at Srinakharinwirot University

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A DEVELOPMENT OF THE CONSTRUCTIVIST THEMATIC SCIENCE PROGRAM AT CHIANGMAI ZOO

AN ABSTRACT

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The Constructivist Thematic Science Program at Chiangmai Zoo (CTSPZ) ,Thailand was developed, implemented and evaluated. The CTSPZ was based on Constructivist Learning Design with an informal setting to customize the needs of particular teachers and students by integrating the CTSPZ with a formal school science standard. The instructional materials were designed to support the Thailand National Science Standard for student grades 7-9. The CTSPZ was designed as an instructional resource for educators who want to introduce students to hands-on/minds-on activities that encourage constructivist approach. The activities in the CTSPZ were intended for using in both classroom and in a practicum setting. Moreover, the activities were easily adapted to meet the learning requirements for academic disciplines including science and environment.

The design of this study was a mixed method design in which the CTSPZ at the Chiangmai Zoo served as the independent variable. The measure of students' science process skills, attitude towards science, scientific attitude, attitude towards the environment, and constructivist learning environment were dependent variables. Therefore, authentic assessments, observations, surveys, and interviews were the primary means of qualitative data collection. Moreover, students' science process skills were measured by the Science Process Assessments for Middle School Students (SPAMSS). Attitude toward science was measured by Science Attitude Scale for Middle School Students. Scientific attitude was measured by Scientific Attitude Inventory (SAI II). Students' attitude toward the environment was measured by Children's Attitude toward Environment. Construcitivist learning environment measured by A Constructivist Learning Environment Survey (CLES).

The participants were level three students who volunteered to attend the CTSPZ from Chiangmai University Demonstration School (30 students) and Navamindarajudis Phayap school (30 students). The program was implemented on May – August 2007. In this study, the experimental group (60 students) and the control group (60 students) were observed over time. Both groups took a pretest posttest, and retention test. Only experimental group received the treatment.

Students' t-test was conducted with pretest, posttest, and retention scores. Student scientific attitude, attitude toward science, attitude toward the environment, and constructivist learning environment ($p < 0.05$) were higher after participating in the CTSPZ. However, it was found that the CTSPZ positively influenced on students who had low scores in science process skills ($p<0.05$). Meanwhile, the students who have high scores in science process skills the CTSPZ were not significantly influenced. Qualitative data including narrative description of students' perception as recorded in the interviews supported the findings of the quantitative research.

กานจุลี ปัญญาอินทร์. (2551). *การพัฒนาโปรแกรมวิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่.* ปริญญานิพนธ์ กศ.ด. (วิทยาศาสตร-ศึกษา). กรุงเทพฯ: บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ. คณะกรรมการควบคุม: รองศาสตราจารย์ ดร. สุนีย์ เหมะประสิทธิ์, รองศาสตราจารย์ นิภา ศรีไพโรจน์, ผู้ช่วยศาสตราจารย์ ดร. ปรินทร์ ชัยวิสุทธางกูร.

โปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบทตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่ ได้พัฒนาขึ้นจากแนวคิดปรัชญาสรรคนิยม (constructivism) ขั้นตอนในการพัฒนาโปรแกรมประกอบไปด้วยสามขั้นตอนคือ ขั้นพัฒนาโปรแกรม (program designing) ขั้นการใช้โปรแกรม (program implementing) และขั้นการประเมินผลโปรแกรม (program evaluating) ในขั้นการพัฒนาโปรแกรมนั้น โปรแกรมเรียนรู้จะประกอบไปด้วยหกขั้นตอนตามรูปแบบการเรียนรู้ที่Gagnon และ Collay ได้พัฒนาขึ้น (Gagnon;& Collay. 2001) โดยเน้นการเรียนรู้ในสิ่งแวดล้อมนอกห้องเรียน ซึ่งเป็นการเรียนรู้แบบบูรณาการในรูปแบบการเรียนรู้ตามอัธยาศัย ที่สอดคล้องกับมาตรฐานการเรียนรู้สาระการเรียนรู้วิทยาศาสตร์สำหรับนักเรียนช่วงชั้นที่ 3 โปรแกรมการเรียนรู้นี้ ถูกออกแบบมาเพื่อเป็นแหล่งเรียนรู้ให้กับนักการศึกษา ที่ต้องการมุ่งเน้นให้นักเรียนเกิดการเรียนรู้ผ่านการทำกิจกรรมตามแนวทฤษฎีสรรคนิยม แต่ละหน่วยกิจกรรมสามารถปรับปรุงกิจกรรมไปใช้ได้ทั้งในบริบทของห้องเรียนและนอกห้องเรียน โดยการผสมผสานระหว่างความรู้ด้านวิทยาศาตร์และสิ่งแวดล้อมเข้าด้วยกัน

ในงานวิจัยนี้ ใช้รูปแบบการวิจัยผสานวิธี (mixed method design) โดยผสานวิธีวิจัยเชิงปริมาณและวิธีวิจัยเชิงคุณภาพเข้าด้วยกัน ในส่วนของวิธีวิจัยเชิงปริมาณได้ทำการศึกษาโปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบทตามแนวทฤษฎีสรรคนิยมเป็นตัวแปรต้น และทำการวัดค่าตัวแปรตาม 5 ชนิด คือ ทักษะทางวิทยาศาสตร์ เจตคติต่อวิทยาศาสตร์ เจตคติเชิงวิทยาศาสตร์ เจตคติต่อสิ่งแวดล้อม และ บรรยากาศการเรียนรู้แบบสรรคนิยม โดยเครื่องมือวิจัยที่ใช้ในการเก็บรวบรวมข้อมูลได้แก่ แบบวัดทักษะทางวิทยาศาสตร์สำหรับนักเรียนช่วงชั้นที่ 3 (Science Process Assessment for middle School Students), แบบวัดเจตคติต่อวิทยาศาสตร์ (Science Attitude Scale for Middle School Students), แบบวัดเจตคติเชิงวิทยาศาสตร์ (Scientific Attitude Inventory (SAI II)), แบบวัดเจตคติต่อสิ่งแวดล้อม (Children's Attitude toward Environment), และแบบวัดบรรยากาศการเรียนรู้แบบสรรคนิยม (Constructivist Learning Environment Survey) ตามลำดับ โดยตัวแปรตามทั้งหมดได้ศึกษาในเชิงคุณภาพด้วยการประเมินตามสภาพจริง การสังเกต การสำรวจ และการสัมภาษณ์นักเรียน

กลุ่มตัวอย่างในงานวิจัยนี้ประกอบไปด้วยนักเรียนช่วงชั้นที่ 3 จากโรงเรียนสาธิตมหาวิทยาลัยเชียงใหม่ และโรงเรียนนวมินทราชูทิศ พายัพ จังหวัดเชียงใหม่ จำนวน 120 คน แบ่งเป็นกลุ่มควบคุมจำนวน 60 คน ซึ่งจะเรียนรู้วิทยาศาสตร์ในห้องเรียนตามปกติ และกลุ่มทดลอง 60 คน ซึ่งประกอบไปด้วยนักเรียนที่สมัครเข้าร่วมกิจกรรมโปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบทตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์ ทั้งนี้ผู้วิจัยได้ทำการศึกษาการใช้โปรแกรม (program implementing) ในระหว่างเดือนพฤษภาคม-สิงหาคม 2550 โดยศึกษาตัวแปรตามที่เกิดกับนักเรียนทั้งสองกลุ่มทั้งก่อนเรียน หลังเรียน และความคงทนของการเรียนรู้

ในขั้นการประเมินผลโปรแกรม (program evaluating) ข้อมูลที่รวบรวมได้ทั้งหมดจากการทดสอบก่อนเรียน หลังเรียน และความคงทนของการเรียนได้นำมาวิเคราะห์ทางสถิติโดยใช้ t-test สำหรับทดสอบข้อมูลที่เป็นอิสระต่อกัน (students t-test) ผลสรุปการวิเคราะห์ พบว่าเจตคติต่อวิทยาศาสตร์ เจตคติเชิงวิทยาศาสตร์ เจตคติต่อสิ่งแวดล้อม และบรรยากาศการเรียนรู้แบบสรรคนิยมของนักเรียนผู้เข้าร่วมโปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบทตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์ เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 สอดคล้องกันนี้ทักษะทางวิทยาศาสตร์ของนักเรียนกลุ่มที่มีผลสัมฤทธิ์ต่ำเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 ในขณะที่ทักษะทางวิทยาศาสตร์ของนักเรียนกลุ่มที่มีผลสัมฤทธิ์สูงไม่แตกต่างอย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 ทั้งนี้ผลการศึกษาข้อมูลเชิงคุณภาพได้สนับสนุนผลการวิเคราะห์ในเชิงปริมาณ

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Kanchulee Punyain

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CHAPTER 1

Introduction

Background

Academic knowledge and rapid technical advancement during the era of globalization has caused tremendous changes in the national, international, social and economic spheres. These changes necessitate the revision of the national education curriculum which is a fundamental mechanism for the development of national education quality. Thus in Thailand, the introduction of the so-called ‘Education reform act’ in year 1999, has changed the direction in Thai education. The ultimate goals are to foster morality, intellectual development, happiness, competitive potential and creative/ positive competition in the world arena (Ministry of education Thailand. 2002: 1).

Subsequently the National Education Act B.E. 2542 (1999) and amendments (Second National Education Act B.E. 2545 (2002)) defines education as a learning process that accelerates the prosperous growth of individuals and society. Moreover, the National Education Act stipulates the formulation of a basic curriculum to foster Thai-ness, good citizenship, and competency in the life skills, careers, and opportunities to further ones education. The basic education curriculum B.E. 2544 (A.D. 2001) is the national core curriculum that provides a framework for development of the school curriculum. It can be applied to formal, non-formal, and lifelong education systems, as well as education for special groups and talented children (Ministry of education Thailand. 2002: 1-3).

Science education in Thailand has also undergone changes so as to incorporate the modern philosophy of science education. It avails itself of an activity-based curriculum in which students play an active role in the learning process. Students need to learn how to search, to question, and to experiment (Sunee Klainin; & Pisarn Soydhurum. 2004: 3). Furthermore the goals of education have changed; memorization of facts is publicized as being less important than developing skills needed for problem solving and lifelong learning. Whereas theory and evidence are favoring a knowledge construction model over the information transmission model (Yarger; Thomas ; & Boysen. 2001: 19-23). Many reformers students are passive receptors of knowledge, towards a more student-centered understanding - based (constructivist) teaching that focuses on explorations and experimentation (Sermon; David; & Lee. 1999: 1).

Constructivist theories of learning emphasize an active and autonomous role for the learners to construct their own understanding through interacting in an environment in which the knowledge of the domain is not explicitly separated from the context in which it applies. The focus is on the process through which the learners experience the environment and interpret their experiences rather than on the acquisition of previously defined target domain knowledge. Learning thus needs to be student-centered and learners should be encouraged to make their own meaningful connections. As such, constructivism has become an intricate aspect of the current educational reforms and is included in national science education reform recommendations. Several educators have described various programs and studies in which teachers using constructivist teaching approaches have improved classroom discourse, increased achievement in science and altered misconceptions in science (Tobin. 1993: 53-62). In addition, it is suggested that thematic instruction in science offers many opportunities for students to actively engage in a constructivist approach to leaning (Fredericks. 1998: 17). Moreover, Hand (1997) found that students are not only appreciative of the opportunity to use their own ideas and knowledge but are also aware of the changing roles and responsibilities required of them within the constructivist classroom. It has been found that students preferred the constructivist teaching/learning approaches because they are allowed to think for themselves and they believed this is important when their own ideas are listened to and valued. They also felt that they had more input and involvement in lesson than was previously found in a tradition class (Hand; Treagust; & Vance. 1997: online). Therefore constructivism has become relatively well accepted in the science education community.

A commitment to constructivism is often inspired by the work of Dewey (1920), Piaget (1970) and Vygotsky (1962). These authors emphasize group learning as a factor in fostering knowledge construction because, for them, all learning takes place in a social context, and group learning per se is only one influence on the social construction of knowledge. Constructivism recognizes that; rather than knowledge being transfer from one individual to another, knowledge has to be constructed by each individual through his or her active engagement with the physical and/or social environment. Therefore, it is regarded in schools and other educational contexts as an appropriate milieu for learning in the vision of constructivism. Furthermore, Vygotsky (Vygotsky, 1978:130) regards schooling as the means of helping children develop scientific process and scientific knowledge. He purposed that science is not only the narrow stereotypical view of science as discipline but more generally to the notion of science as conventionally defined systems and processes of knowledge. Therefore scientific knowledge maybe constructed with practical knowledge that students develop through informal, everyday experience (Knuth; & Cunningham. 1993: 175-176). Constructivist theory suggests ways we can take advantage of the social nature of the classroom and provide meaningful experiences that may be more likely to transfer to the world outside the classroom for students.

Taking science outdoors is a natural step in this process. Children can gain a deeper understanding of science skills when they try an activity in a new setting. Through outdoor science activities, children build analytical as well as creative-thinking skills. They make predictions, test out hypotheses, and experiment with materials and ideas in variety of ways. With activities in informal settings, teachers will be helping children focus their natural curiosity and better understand the science process they are actually using (Early childhood today. 2003: 44). Moreover, it is found that science knowledge and attitude toward science develops as a result of children's expediencies both in and out of school. The importance of out-of-school experiences as a resource of scientific literacy has been widely acknowledged (Tamir. 1990: Online). Therefore learning that takes place in an informal setting may potentially address all three domains of learning, cognitive, effective and psychomotor (Beard. 1998. 1-4).

The classroom is no longer just a room with a four walls but the total environment has now become the classroom. Every area, whether near or far, holds numerous possibilities for observation, discovery and exploration. They are an inexhaustible resource for teaching science in any community (Gemake. 1980: Online). The environment, both formal and informal, exerts a powerful influence on learning. An informal learning environment refers to any setting outside the traditional classroom that provides an opportunity for interaction and exploration yet does not mandate learner participation (Crane. 1994: online). Consequently, the use of outdoor classrooms and informal education within the regular school curriculum has been supported academically by research and by educational philosophy (AAAS. 1989: online). Informal education can have a significant effect on academic achievement and it plays a vital role in the development of a child's mind and some may argue it could be more influential on their attitudes than formal education. Moreover, informal learning makes the students aware of their place in the environment thus helping them learn how to connect school learning to everyday situations. Thus, informal education can be utilized as a stimulating alternative instructional technique which can be used in conjunction with classroom learning (Messenger. 2000: 1-5). Furthermore informal education enables learners to learn by themselves according to their interests, potential, readiness, and the opportunities available from individuals, society, the environment, media or other sources of knowledge. It could be perceived that all ministries are involved in providing informal education to promote lifelong learning (Ministry of education royal Thai government. 2004: 30).

Learning that occurs in informal settings may enhance other learning when it is incorporated within instructional experience. Another benefit, gained form outdoor experiences, is that they provide a foundation for lifelong learning and leisure pursuits. More and more leisure activities take advantage of outdoor settings. Students who are learning in the outdoors are more apt to continue using the outdoor settings for active learning beyond their school years (The council for environmental education. 2004: online). According to section 25 of the national education act states that

> "the State will promote the running and establishment, in sufficient numbers and with efficient functioning, of all types of lifelong learning sources, namely: public libraries; museums; art galleries; zoological gardens; public parks; botanical gardens; science and technology parks; sport and recreation centers; data bases; and other sources of learning ".

Various efforts have been made to enable individuals to learn at all times and in all places from lifelong learning sources and the services provided including educational activities or academic and professional programs for different target groups relating to the responsibilities of each ministry. As these institutions expand, opportunities for children to learn also expand (Ministry of education royal Thai government. 2004: 84).

Informal learning has always been an integral part of environmental education. One specific location where environmental education has grown significantly is at accredited zoos. With the interdisciplinary and active learning possibilities of zoo education, it is only natural that there is a growing relationship between informal education and the environmental education resources available at accredited zoos.

Zoos are learning resources where education and learning are often expected outcomes. Many researches suggest that a zoo is a resource that can help students develop science knowledge, science skills, and a positive attitude (Carlin. 1999: 1-11). An important primary goal for many zoos is educating their visitors and increasing their visitor environmentally-friendly behaviors. White and Jacobson (1994) in their research *Evaluating Conversation Education Programs at a South American Zoo* found that knowledge and attitude about environment scores, of students whose teachers participated in the conservation education programs at a South American zoo, improved significantly (White; & Jacopson. 1994: online). In developed countries, research assessing the utility of environmental education programs has shown that students' active participation and the preparation and reinforcement of conservation information received during a field trip to a zoo, nature center, or museum influenced the cognitive and affective gains of school children (Koran; & et al., 1983: 325). Zoological parks, nature centers, natural history museums, and related institutions can play an important role in environmental education by improving understanding of human relationships with the natural world, fostering positive attitudes toward the environment, and promoting environmental action.

Over the years, little effort has been placed on meaningful integration of the resources found at informal settings into formal school curricular. However, little research has been conducted on using informal settings, especially zoos, for science education. Furthermore, few lesson plans or learning outcomes have been written for an excursion to any zoo in Thailand. Therefore, in this study the constructivist thematic science program at Chiangmai zoo (CTSPZ) was developed. The CTSPZ is based on constructivist learning design (CLD) and thematic science in an informal setting, the Chiangmai zoo, to customize the offering to the needs of particular teachers and students integrating informal with formal school science standards. The instructional materials were designed to support the national science standards appropriate for third level-secondary education grades 7-9 students. The

CTSPZ was designed as an instructional resource for educators who want to introduce students to hands-on/minds-on activities that encourage a constructivist approach and influence science process skills, attitudes toward science, scientific attitude, and attitudes toward the environment. The activities in the CTSPZ are intended for use in both classrooms and in informal settings. Moreover, the activities are easily to adapt in order to meet the learning requirements for academic disciplines including both science and environmental education.

Purposes of the study

The purposes of the study are summarized as follows:

1. To develop the CTSPZ for middle school students. The program development was based on a constructivism theory and thematic science.
2. To explore the use of the CTSPZ on students' science process skills, scientific attitude, attitudes toward science, and attitudes toward the environment by converging both quantitative (broad numeric trends) and qualitative (detailed views) data.
3. To evaluate the CTSPZ with emphasis on a constructivist learning environment

Research questions

The following primary research questions and associated hypothesis were formulated regarding middle school student's use of the CTSPZ at the Chiangmai zoo:

1. Does the use of the CTSPZ program designed by the investigator and offered at Chiangmai zoo, significantly influence student's science process skills?
2. Does the use of the CTSPZ program significantly influence students' scientific attitude?
3. Does the use of the CTSPZ program significantly influence students' attitude toward science?
4. Does the use of the CTSPZ program significantly influence students' attitude toward the environment?

5. Does the incorporation of the CTSPZ provide a constructivist learning environment?

Research Hypothesis

1. The designed CTSPZ program significantly influences student's ability to use science process skills.
2. The use of the designed CTSPZ program significantly influence students' scientific attitude.
3. The designed CTSPZ program significantly influence students' attitude toward science.
4. The designed CTSPZ program significantly influence students' attitude toward the environment.
5. The incorporation of the CTSPZ provides a constructivist learning environment.

Significance of the study

Scientific questions and environmental issues have been increasingly brought to the forefront of everyday life in Thailand however these issues are usually not included in the formal education. Therefore, the combination of formal school experiences, informal experiences (zoos, science and other museums, planetariums, etc.), and non-formal science experiences (scouts, science clubs, etc.) for youth is critical for improving their attitude towards science and attitudes toward environment (Carlson; & Maxa. 1997: Online).

Informal science education is still in its infancy in Thailand. Many educational issues simply have not been investigated, especially in the area of outdoor education. In other parts of the world, more studies had been conducted concerning informal science education. Tamir (1991) mentioned that informal science activities (discussions, watching TV, listening to the radio, reading and other activities, such as visits to museums and field trips) were found to be associated with a strong commitment to science and science learning. Moreover, the research "*Zoo as a source of free choice*" reported that the learning of science at zoos is not limited to general visitors and the learning of science for school children can be enhanced by pre- and post-visit activities and strong curricula links (Tofield; & et,al. 2003: 67-99).

The investigator who completed the research review found that there were a few studies that integrated informal education with formal education. The literature revealed a few studies that combined science process skills, scientific attitude, attitudes toward science, and attitude toward the environment. In Thailand specifically, there were a few studies that have integrated informal science with national science standards to be used in formal science classrooms. Although there is evidence that learning science in informal settings can influence science process skill, scientific attitude, attitude towards science, and attitude towards environment, no specific research has addressed a quantified assessment of their relationships.

The outcomes of this study provided information about relationship between students' science process skills, scientific attitude, attitudes towards science, and attitude towards the environment. These outcomes may be used by science educators to consider the relationships between informal science and formal science education. Educators will also be able to use the CTSPZ program to guide their thinking to developing teaching strategies for their students according to students' science process skills, scientific attitude, attitudes towards science, and attitudes towards the environment. Furthermore, this study provided a foundation of an introductory courses in science by integrating informal science education with formal science education.

Delimitations

Population of the study

The populations of this study were middle school students who enrolled in the CTSPZ.

Sample of the study

The sample of the study is limited to 120 students in level three's student population at 2 secondary schools located at the Chiangmai province as follows.

1. Chiangmai University demonstration school (Satit CMU)

   Experimental group 30 students

Control group from 30 students

2. Navamindarajudis Phayap school (NMP)

Experimental group 30 students

Control group from 30 students

Variables of the study

Independent variable

The constructivist thematic science program at Chiangmai zoo

Dependent variables

1. Science process skill
2. Scientific attitude
3. Attitude toward science
4. Attitude toward the environment
5. Constructivist learning environment

Conceptual framework of the study

The conceptual framework for this study evolved as a consequence of the literature review in the field of constructivism, thematic science, curriculum design and informal education. In FIGURE 1, the development of the constructivist thematic science program at Chiangmai zoo is based on constructivism and thematic science theory.

The constructivist approach has been evident in education research in a variety of ways; constructivist theory suggests way we can take advantage of the social nature of the classroom and provide meaningful (Smerdon; Burkam; & Lee. 1999. 5); constructivist teaching approaches have improved classroom discourse, increased achievement in science and science process skills (Tobin ,1993: 53-62); constructivist teachers build science curriculum on processes, themes and content that influence scientific attitude as well as scientific knowledge (Waite-Stupiansky. 1997: 141); constructivist research promises to illuminate attitude toward the environment (Roberston. 1994: 31). Consequently, thematic instruction in science offers many opportunities for students to actively engage in a constructivist approach to learn (Fredericks. 1998: 17).

FIGURE 1 is an attempt to describe the theoretical framework of the study and to identify the relationship between the CTSPZ at informal setting (Chiangmai Zoo) and science process skill, scientific attitude, attitude toward science, attitude toward the environment, as well as constructivist learning environment.

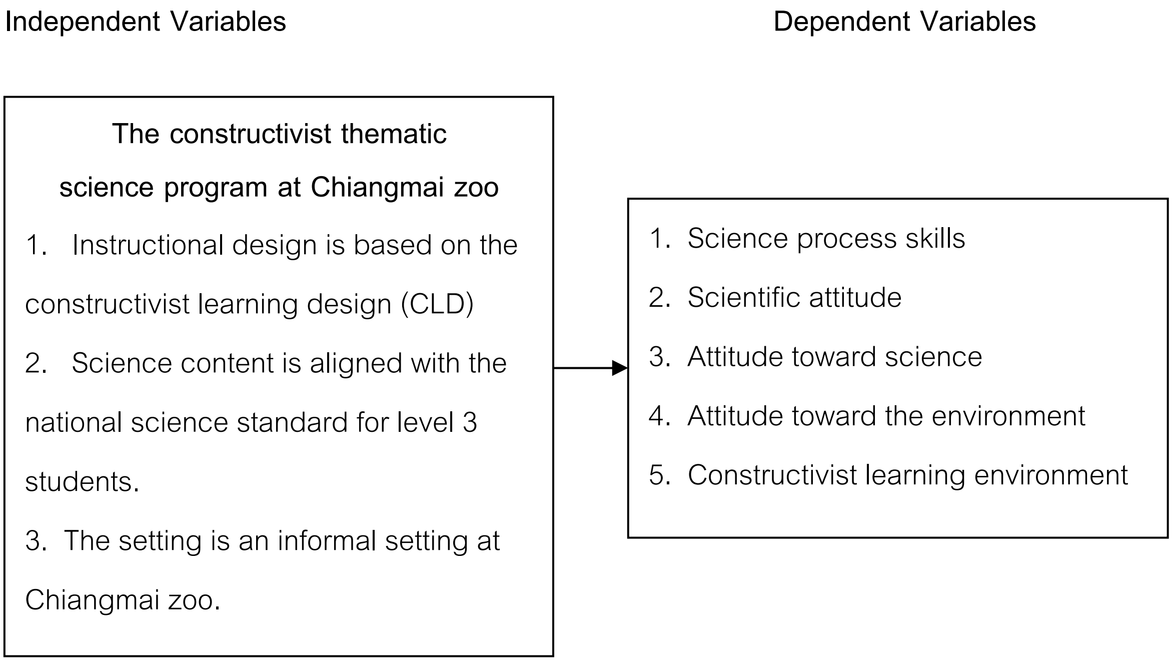

FIGURE 1 CONCEPTUAL FRAMEWORK OF THE STUDY

Framework of the Study

The framework for this study is evolved as a consequence of the literature review in the field of curriculum design, thematic science, and informal education. In FIGURE 2, the development of The CTSPZ is based on constructivist learning design, science standards, and informal education. It is hypothesized that students who attend in science programs are representing the increasing of science process skills, scientific attitudes, attitudes toward science, attitudes toward the environment, and constructivist learning environment.

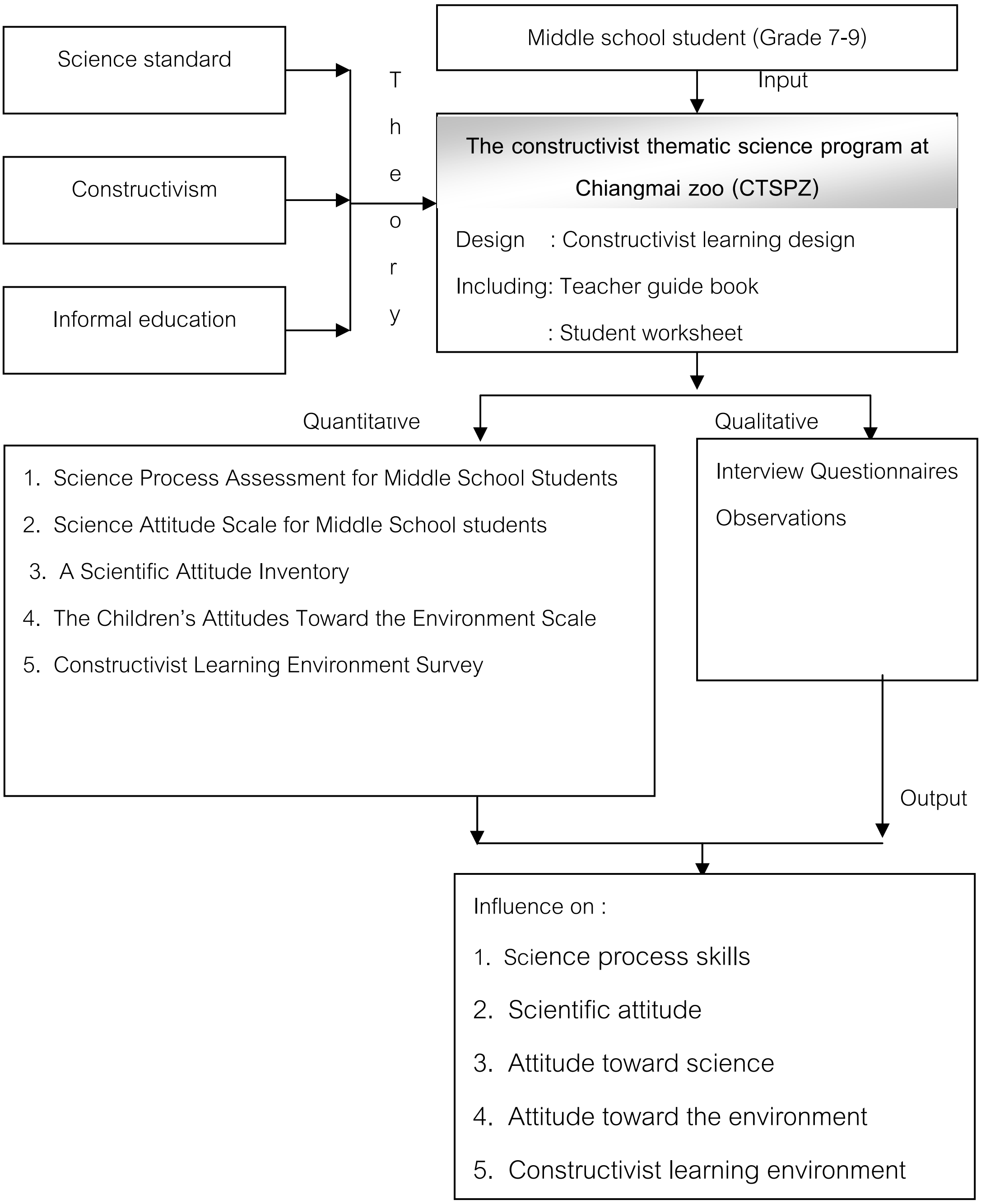

FIGURE 2 FRAMEWORK OF THE STUDY

Definition of the study

1. **The constructivist thematic science program at Chiangmai zoo (CTSPZ)** is a teaching-learning program that was developed based on constructivism and thematic science theory. It provides background information and activities for teaching basic science that incorporated the Thailand national science standards at the Chiangmai zoo. The CTSPZ

was created to provide students with hands-on/minds-on activities that are crucial to taking theoretical learning into the real world. The activities in the CTSPZ are ready-made for student grades 7-9. Informational materials include teacher guide book and student's worksheet that include pre-and post- visit activities, on-ground activities, and data sheets to be used at the Chiangmai zoo.

2. **The constructivist learning design** was developed by Gagnon and Collay (2001). When using this model, teachers implement a number of steps in their teaching structure. The model consists of six basic steps that flow back and forth into one another as the lessons proceed (Gagnon; & Collay. 2001: 2).

2.1 **The situation** frames the agenda for student engagement by delineating the goals, tasks and forms.

2.2 **Groupings** are the social structures and group interactions that will bring students together in their involvement with the tasks and forms of the learning episode.

2.3 **Bridge** refers to the surfacing of students' prior knowledge before introducing them to the new subject matter. The bridge is at the heart of the constructivist methodology; students are better able to focus their energies on new content when they can place it within their own cognitive map, values, attitudes, expectations, and motor skills.

2.4 **Questions** aim to instigate, inspire, and integrate students thinking and sharing of information. Questions are prompts or responses that stimulate, the student to extend or synthesize their thinking and to communication throughout the learning episode.

2.5 **Exhibition**, in this phase the teacher asks students to publicly present what they have learned. This social setting provides a time and place for students to respond to queries raised by the teacher, by peers, or by visitors.

2.6 **Reflections** offer students and teachers opportunities to think and speak critically about their personal and collective learning. This encourages all participants to synthesize their learning, to apply learning artifacts to other parts of the curriculum, and to look ahead to future learning episodes.

3. **Constructivist learning environment** refers to the place where learners may work together and support each other as they use a variety of tools and informational resources in their guided pursuit of learning goals and problem-solving activities.

4. **Thematic science** refers to a combination of experiments, activities, hands-on/minds-on projects, and materials use to expand a scientific concept or idea in all 8 principal sub-strands of the National Science Curriculum Standard. It is built on the idea that learning can be integrative and multifaceted.

5. **Formal education** is the traditional way of education that most Thais' visualize school. It takes place within a classroom consisting usually of one teacher and several students. Formal education shall specify the aims, methods, curricula, duration, assessment, and evaluation conditions to its completion.

6. **Informal education** is education that takes place outside the classroom in an environment absent from some of the classroom's limitations. It encourages learners to assume responsibility for their learning and to monitor their learning as it occurs.

7. **Science process skills** refer to the process of doing science. Science process skills are classified as basic skills and integrated skills. These skills can be assessed by applying them to a series of learning episodes.

8. **Scientific attitude** refers to a way in which scientist believe in and conduct their work. Scientific attitude includes the characteristics of scientists that are believed to be desirable in the study of science, such as open-mindedness and objectiveness.

9. **Attitude toward science** refers to a person's positive or negative response to the enterprise of science. In addition, it refers specifically to whether a person likes or dislikes science.

10. **Attitude toward the environment** refers to the learner's predisposition to respond consistently in favorable or an unfavorable manner with respect to the environment and the reorganization of the importance of ecologically sustainable development and the conservation value of nature environment.

CHAPTER 2
Review of the Literature

Introduction

Calls for the reform of education, particular in science education, are growing and often strident. Many reformers advocate a move away from teacher-center towards student-center learning (Smerdon; Burkam ; &Lee. 1999: 6). The resistance to change from those in authority within the educational culture has often been strong. Nevertheless, the revolution has progressed steadily and there is evidence, of widespread acceptance of constructivism (Tobin. 1993: 3). In addition human resource development has become a central feature of most national development strategies. Within this very important process is the need for a constant development of life-long learning to ensure sustained successes in life (IPST. 2004: Online). Lifelong learning is the integrated scope of education which covers the formal, non-formal and informal education (The nation. 2000: Online). Thus in Thailand, with the 1999 education act, the government is determined to launch educational reforms with the aim of developing Thailand into a knowledge-based society. The reform provides the Thai public with equal access to lifelong education (Ministry of foreign affair. 2000: Online).

The culture of life-long learning needs to be reinforced as it opens up many more avenues and opportunities for members of society. Nevertheless, lifelong learning in Thailand, in the past, concerning formal, non-formal and informal education, has encountered major obstacles such as - education opportunities not being allocated equally; the present education system does not aid under-represented groups; and the content was not practical in real life. People were negligent concerning lifelong learning as well as lacking the motivation and needed support systems; the community received insufficient participation on lifelong learning activities due to the misconception that education was only provided in schools (The Nation. 2000: Online). Toward this end, in this study I developed the constructivist thematic science program at Chiangmai zoo based on constructivism. The purpose was to link formal and informal science education and provided a teaching-learning program for level three students in the informal setting at the Chiangmai zoo.

This chapter is a review of the available literature dealing specifically with:

1. National education act B.E. 2542 (1999) and amendments (second national education act B.E. 2545 (2002)
2. Science education in Thailand
3. Constructivism: an underpinning philosophy of science education reform
4. The thematic approach to science learning
5. Informal science education
6. Education at zoos
7. Chiangmai zoo

1. National education act B.E. 2542 (1999) and amendments (second national education act B.E. 2545 (2002)

Thailand's current education reform (1999) initiates steams from the shock of the Asian economic crisis. Thus, Thailand as part of its strategic path of economic discovery, initiated new education reforms. Another attempt at this education reform emphasized Thailand's need to adapt to the challenger of globalization and internationalization. The basic premise was that, for Thailand to be internationally competitive, it needs to internationalize Thailand's educational system to prepare Thai young people for and increasingly intercultural global era (Fry. 2002: 3).

With the national education act B.E. 2542 (1999) and amendments (second national education act B.E. 2545 (2002), there is a shift in the philosophical underpinning. The key motifs of the education reform are stated in section 4 of the act "Education means the learning process of personal and social development through imparting of knowledge… by creating a learning environment and a learning society and the availability of factors conductive to continuous lifelong learning." (Office of the national education commission. 2003: 10).

From the promulgation as stated in section 4, it is advocated, as in other recent reform in many countries, that these recent education reforms move away from teacher-center, direct instruction towards student-centered, understanding-base teaching. This student-center, student-active instruction is often called constructivism (Smerdon; Burkam; &Lee. 1999: 6). The main ideas about constructivism are suggested for reformers shown in section 22 (Office of the national education commission. 2003: 10-12) “Education shall be based on the principle that all learners are capable of learning and self-development... The teaching-learning process shall aim at enabling the learners to develop themselves at their own pace and to the best of their potentiality”. Subsequently, the national education acts also provide a starting point for informal education as stated in sections 23, 24 and 25 (Office of the national education commission. 2003: 10-12).

Section 23: Education through formal, non-formal, and informal approaches shall give emphases to knowledge, morality, learning process… scientific and technological knowledge and skills, as well as knowledge, understanding and experience in management, conservation, and utilization of natural resources and the environment in a balanced and sustainable manner.

Section 24: In organizing the learning process, educational institutions and agencies concerned shall: enable instructors to create the ambiance, environment, instructional media, and facilities for learners to learn and be well-rounded persons. In so doing, both learners and teachers may learn together from different types of teaching-learning media and other sources of knowledge; enable individuals to learn at all times and in all places. Co-operation with parents, guardians, and all parties concerned in the community shall be sought.

Section 25: The State shall promote the running and establishment, in sufficient number and with efficient functioning, of all types of lifelong learning sources, namely: public libraries, museums, art galleries, zoological gardens.

The national education act lays down guidelines for the provision of education, management of the learning process, and preparation of educational curricula at various levels. Recognizing the urgent need for education reform, the government, acting through the office of the national education commission (ONEC), has formulated policies and plans to bring about the necessary changes within the Thai educational system. Thus, the result of these provisions is the basic education curriculum B.E. 2544 (A.D. 2001) (The nation. 1999: online).

The basic education curriculum aims to produce learners who are good persons, possess knowledge and capability, and enjoy learning. The learning contents are classified into eight subject groups, namely:

1. Thai language

2. Mathematics
3. Science and technology
4. Social studies, religions and culture
5. Health and physical education
6. Visual arts, music and performing arts
7. Work and vocation
8. Foreign languages

Science is the principal subject group in the basic education curriculum of AD 2001. Curriculum, instruction and assessment all have to be considered in laying the foundation for science education of the learners at all levels. (IPST. 2001: Online).

2. Science education in Thailand

Incorporate with nation education act above, science education in Thailand also has undergone change. Visions for science learning, provided by the institute for the promotion of teaching science and technology (IPST), that in compliance with basic education curriculum are the following (IPST. 2001: Online):

- Learning of science should be a developmental process so that the learner acquires proper knowledge, process, and attitude.
- Science learning should be a lifelong process
- Basic science learning is for greater understanding, better appreciation of nature and the environment.

In reviewing the national science curriculum standards (the basic education curriculum B.E.2544), it was found that science education has two board purposes. The first purpose is to promote scientific literacy among Thai citizenship on matters directly affecting their own lives and the society so that they can make decision based on information and understanding. The second purpose is to build up the technological capacity by equipping the future workforce with essential science-based knowledge and skills and by preparing students for scientific disciplines in higher education and science-related careers. Given the potential benefits, the provision of quality science education to all children will have far reaching consequences on a country's development prospect (Musar; 1993: 3). Reforms also advocate use of the scientific process skills and as the basis for hands on science activities. Moreover practical activities in science education are regarded as one of the necessary elements to promote science, attitude toward science and a scientific attitude.

2.1 Science process skills

Science process skills are a means for learning and are essential to the conduct of science (Holt: & Winston. 2006: online). According to the curriculum project, science - a process approach (SAPA), these skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientists. SAPA grouped process skills into two types-basic and integrated. The basic (simpler) process skills provide a foundation for learning the integrated (more complex) skills (Padilla. 1990: online). These skills are listed and described below (AAAS. 2006: Online).

2.1.1 Basic skills

2.1.1.1 Observing: using the 5 senses (see, hear, touch, smell, taste) to find out about objects and events, their characteristics, properties, differences, similarities, and change.

2.1.1.2 Classifying: grouping or ordering objects or events according to similarities or differences in properties.

2.1.1.3 Measuring: comparing an unknown quantity with a known (metric units, time, student- generated frames of reference)

2.1.1.4 Inferring: interpreting or explaining observations.

2.1.1.5 Predicting: forming an idea of an expected result, not a guess, but a belief of what will occur based upon present knowledge and understandings, observations and inferences.

2.1.1.6 Communicating: using the written and spoken work, graphs, demonstrations, drawings, diagrams, or tables to transmit information and ideas to others.

2.1.1.7 Using number relationships: applying numbers and their mathematical relationships to make decisions.

2.1.2 Integrated skills

2.1.2.1 Making models: constructing mental, verbal, or physical representations of ideas, objects, or events to clarify explanations or demonstrate relationships.

2.1.2.2 Defining operationally: creating a definition by describing what is done and observed.

2.1.2.3 Collecting data: gathering and recording information about observations and measurements in a systematic way.

2.1.2.4 Interpreting data: organizing, analyzing, and synthesizing data using tables, graphs, and diagrams to locate patterns that lead to the construction of inferences, predictions, or hypotheses.

2.1.2.5 Identifying and controlling variables: manipulating one factor to investigate the outcome of an event while other factors are held constant.

2.1.2.6 Formulating hypotheses: making educated guesses based on evidence that can be tested through experimentation.

2.1.2.7 Experimenting: designing one's own experiment to test a hypothesis using procedures to obtain reliable data.

2.2 Scientific attitude

Scientific attitude has come to be known as a way in which scientist believe in and conduct their work (Simson; Koballa; &Olive. 1994: 211). Gardner (1975) mentioned that scientific attitude included the characteristics of scientists that are believed to be desirable in the study of science, such as open-mindedness and objectiveness (Gardner. 1975: 30).

Several reasons have been given for the need to study student science attitudes. For example, it has been said that positive attitudes toward school subjects are important because they: enhance cognitive development; increase the learning of the subject both formally and informally after the direct influence of the teacher has ended; and attitudes are communicated to friends and peers (Mager; 1968: Online). Furthermore, it is important to study attitudes because positive attitudes result in increased enrollment in science courses, and influence science achievement and interest in scientific careers (Shamai. 1996: Online). Also, students with positive attitudes towards learning science are more likely to have intentions to engage in future learning behaviors (Norwich & Duncan. 1990: 312-321).

2.3 Attitude toward science

Attitude towards science or feelings toward science refers to a person's positive or negative response to the enterprise of science. In addition, it refers specifically to whether a person likes or dislikes science. Simpson & Troost (1982) and Simpson & Oliver (1990) designed a seven-item subscale to measure students' attitude toward science as follows:

1. Science is fun.
2. I have good feeling toward science.
3. I enjoy science courses.
4. I really like science.
5. I would enjoy being a scientist.
6. I think scientists are neat persons.
7. Everyone should learn about science

Research into various aspects of attitude towards science has contributed a significant amount of literature throughout the past several decades. The studies of attitude have led researchers in science education to the understanding that there are many variables that correlate with attitudes about science such as achievement (Freedman. 1997: 343--357), behavior (Shrigley. 1990: 97-113), and grade level (Simpson & Oliver. 1985: 511-526). Still, another goal for some science educators has been to find ways to foster positive attitude toward science as an attempt to create a more scientifically literate populace (Simpson, Koballa, Oliver, & Crawley, 1994: 211-234)

Summary

The constructivism influence has extended beyond just the research and scholarly community: it has had an impact on a number of national curricular documents and national education statements (Matthews 2002: 121), including the national education act in Thailand. Similarity, in many nations around the globe, science education is currently going through the process of change. It appears that the reform efforts in different countries share some important characteristic, which is are apparently related to constructivism (Van; Beijaard; & Verloop. 2001: 137-158). Today, the objectives of science education are not only the phenomena of nature but are constructs that are advanced by science process skills, scientific attitude and attitude toward science.

3. Constructivism: an underpinning philosophy of science education

The view that knowledge cannot be transmitted but must be constructed by the mental activity of learners, which refers to constructivism, underpins contemporary perspectives on science education (Driver; &et.al. 1994: 5). Constructivism is not new, it has been explained by many scholars including, Jerome Burner, John Dewey, Jean Piaget, Lev Vygotsky, and Ernest Von Glaserfeld.

3.1 Theory of constructivism

3.1.1 Pragmatism constructivism

Jerome Bruner (1915 -)

Bruner's contribution to constructivism was the concept of discovery learning. He found that when students are presented with highly structured materials, they become too dependent on other people and they are likely to think of learning as something done only to earn a reward (Bruner. 1983: 183). In contrast, he mentioned the concept that when children arrive at on their own they are more meaningful than the purpose by others and that students do not need to be rewarded when they seek to make sense some of things. Therefore he suggested that teachers should confront children with problems and help them seek solutions either independently or by engaging in group discussion. So true learning will occur when students figured out how to use what they already know in order to go beyond the way they are already thinking.

Bruner argued that understanding the ways in which ideas connect with one other, the possibility of solving problems on our own, and how we already know is relevant to what we are trying to learn is the purpose of education and can best be achieved through personal discovery (Snowman; & Biehler. 2006: 311).

John Dewey (1859-1952)

For Dewey education depends on action, knowledge and ideas emerged only from a situation in which learners had to draw them out of experience. Then this new experience had a meaning and importance to learners (Dewey. 1966: 151). Furthermore these situations had to occur in a social context, such as a classroom. In classroom students joined in manipulating materials and, thus, created a community for learners who built their knowledge together. Dewey's conception suggested that knowledge and instruction should build on student's experience, rather than be viewed as fixed or determined (Dewey. 1902: 60).

Dewey mentioned there is always some stimulus or goal for learning in a learning environment that he terms as the problematic. The problematic leads to and is the organizer for learning (Dewey. 1938: 20). So the important point here is that the problematic situation of content is central to the learning process in constructivism.

3.1.2 Cognitive constructivism

Jean Piaget (1896-1980)

Piaget's constructivism is based on his view of the psychological development of children. This theory of development states that human beings develop through predicable stages, each of which is typified by the emergence of new cognitive structures that increase in the complexity of thinking (Tam. 2000: 3). These stages are described in TABLE 1.

Piaget described intelligence as how an organism adapts to its environment and it is controlled through mental organizations called schemes that the individuals use to present the designate action. This adaptation is driven by a biological drive to obtain balance between schemes and environment that he called equilibration. There are two processes that individuals use to adapt; assimilation and accommodation. Assimilation is the process of using or transforming the environment so that it can be placed in preexisting cognitive structure. Accommodation is the processes of changing cognitive structures in order to accept something from the environment. Both process are used simultaneously and alternately through life (Huitt; & Hummel. 2003: 1-2) Piaget suggested that educators should understand the steps, in the development of the child's mind, which children have to go through to accept ideas. Therefore in an autonomous activity, children must discover relationships and ideas in classroom situations that involve activities of interest to them.

Piaget's individualistic approach to constructivism epitomized that the learners are central to the learning process. It is the collaboration among learners that make constructivism not and example of solipsism, rather it encourages the construct of social context in which collaboration creates a sense of community (Tam. 2000: 3).

TABLE 1 PIAGET'S STAGE OF COGNITIVE DEVELOPMENT

Age factor	Characteristics
0-2 Years	**Sensorimotor stage**: Acquiring understanding primarily through sensor impression and motor activities; develop and use schemes for mental and physical trial-error behavior.
2-7 Years	**Preoperational stage**: Understanding the centers of the mastery of symbols; also use of imitation.
7-11 Years	**Concrete operational Stage**: Capable of mentally reversing actions; operational thinking is limited to objects that are actually present or directly experienced; mastery of conservation (ability to recognize that properties stay, despite change in appearance) of numbers, space, continuous quality and substance.
11+ Years	**Formal operational Stage**: Able to read with abstraction form, hypotheses; solve problems systematically, and engage in mental manipulation

3.1.3 Social constructivism

Ly Vygotsky (1896-1934)

Vygotsky's work has formed the foundation of social constructivism in educational setting. His emphasis is on the role of the other, or the social context. According to Vygotsky, learning is best understood in light of others within an individual's world. He described it as the zone of proximal development (ZPD). He defined ZPD as "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; 1978: 86).

Vygotsky thus attempted to ascertain the difference between what a child could achieve by themselves (their actual level of development), and what they could achieve with assistance (their level of potential development) (Rogoff; & Wertsch. 1984: 2). The ZPD is then defined as the intellectual potential of an individual when provided with assistance from a knowledgeable adult or a more advanced child. Therefore Vygotsky felt good instruction could be provided by determining where each child is in his or her development and building on that child's experience (Tam. 2000: 3).

3.1.4 Radical constructivism

Ernst von Glasersfeld (1917-)

Ernst von Glasersfeld is one of the leading advocates of a radical version of constructivism both as a theory of knowledge and as a guide for science education. He believed that knowledge is something personally constructed by individuals in an active way. It is the results of an individual subject's constructive activity, not a commodity that somehow resides outside the knower and can be conveyed or instilled by diligent perception or linguistic communication (Boudourides. 2003: 11). Staver criticizes von Lagerfeld's work into four principles which describe knowing and knowledge in their development, nature, function, and purpose:

1. Knowledge is actively built up from within by a thinking person; knowledge is not passively received through the sense or by any form of communication.

2. Social interactions between and among learners are central to the building of knowledge by an individual.

3. Cognitive and the knowledge it produces are a higher form of adaptation in the biological context, in which the functional concepts of fit and viability.

4. Cognition's purpose is to serve the individual's organization of his or her experiential world; cognition's purpose is not the discovery of and objective of ontological reality.

In conclusion, although constructivism began as a theory of learning, it has progressively expanded its dominion, becoming a theory of teaching, a theory of education, a theory of both personal knowledge and scientific knowledge (Driver; & et.al. 1986: 5). Another expanded form of constructivism is a constructivist approach to curriculum development in science by Driver that I have adapted to develop the science program at Chiangmai zoo.

3.2 A constructivist approach to science program development

Adopting a constructivist view of learning also has implications for a view of science education programs. From the constructivist perspective, the learner constructs their own knowledge and the meaning that they have constructed is dependent on their prior knowledge as well as the learning situation provided. Driver and Oldham, *A Constructivist Approach to Science Program Development*, (cite) mentioned that the setting of the learning experience can enable the learners to develop their understanding. They suggested many important views that apply to science program development as follows, (Driver; & Oldham. 1986: 112):

1. The science program is seen as the program of activities from which knowledge or skills can possibly be acquired or constructed and acknowledging that what is constructed by any learner depends to some extent on what they bring to the situation.

2. The process of science program development should lie in the status that is determined prior to teaching through negotiation between adults to something with a problematic status.

3. The program development from a constructivist perspective has to incorporate an empirical reflexive approach.

The general model for the development of new curriculum materials being follow by the project that were provide by Driver and Oldham is given in FIGURE 3. This model indicates the actual curriculum design has drawn on many types of input. First, content, we can specify the experience which students should be exposed to and what ideas they may construct from these experiences. Second, what the curriculum developer should bring to the learning situation. Third, knowing the perspective on the learning process that involves conceptual change and active construction of meaning by learners will guide the curriculum developer to the selection of activities. Fourth, the practical knowledge of the students' school and classroom will guide teachers in how to organize learners to learn; how to present a problem to be of interest to a learner and how to deal with time, resources, and instruments. After developing curriculum materials and strategies for these inputs, the curriculum developer needs to implement the curriculum to explore what students can learn from the curriculum. Finally, the evaluation of such implementation is not only leads to the modifying in the materials but also the review, refinement or change in theoretical perspective and assumptions.

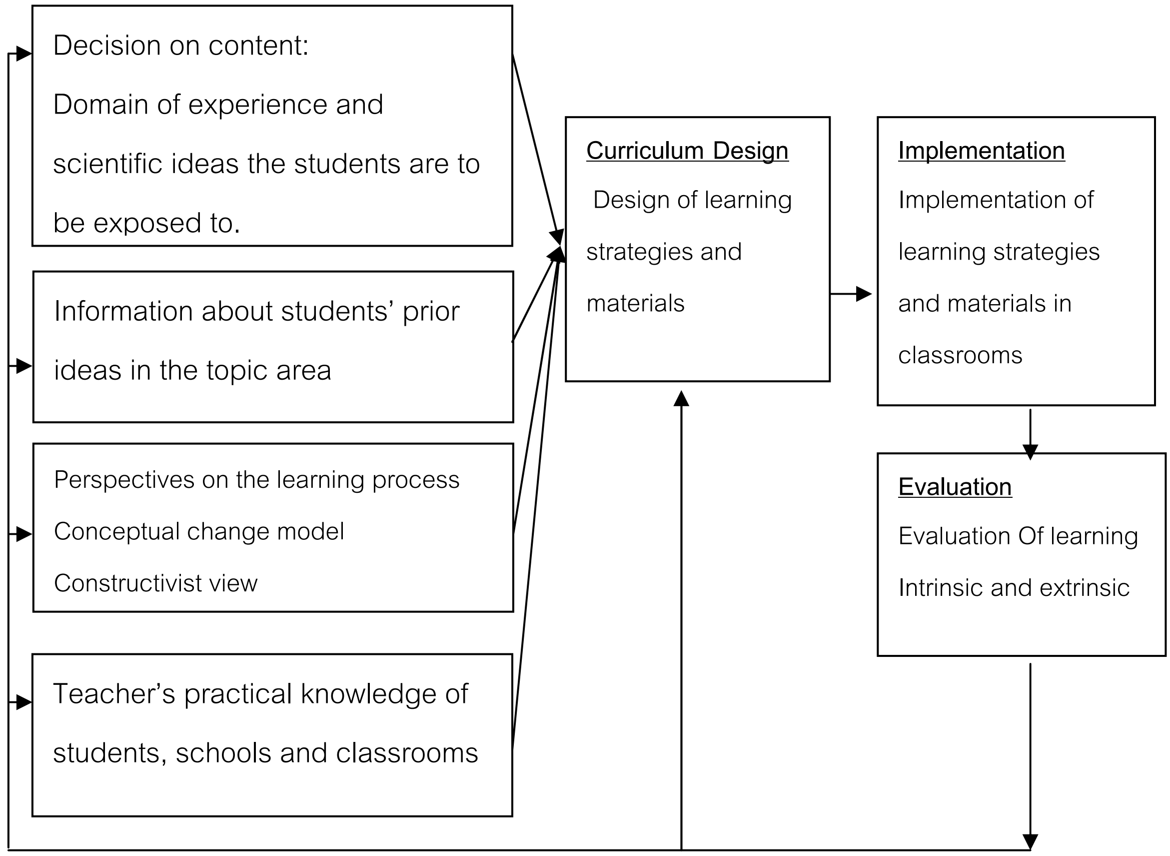

FIGURE 3 A CONSTRUCTIVIST MODEL FOR CURRICULUM DEVELOPMENT BY Driver and Oldham (1986)

3.3 The constructivist learning design (CLD)

The constructivist learning design (CLD) is developed by Gagnon and Collay. It is based on the assumptions and processes of constructivism theory and offers a different way of thinking about learning. The CLD emphasizes six distinct elements as follows (Gagnon; & Collay. 2000: 17-111)

3.3.1 Situation

A situation is a single task with a definite purpose that can define the entire learning episode. The situation elements focus on organizing learning episodes with specific purpose that stimulate students' power through the demands of a social situation.

A situation involves selecting a purpose for the learning episode and arranging a task for students to accomplish together that will fulfill this purpose. This task could be a problem to solve, a question to answer, a decision to make, a metaphor to create, a conclusion to draw, or a goal to set.

The teacher role is to present a challenging task for students to accomplish, support students in thinking together about doing the task, asking them to explain their thinking after completing the task, and guiding them in reflecting on their process of thinking and learning as they did the task.

3.3.2 Groupings

Groupings organizes students to accomplish the task framed in the situation and determines what materials they will use to explain their thinking. Grouping of students and materials are connected because the way students are grouped often depends on the situation that is arranged, the materials that are available, and the length of time that the groups will be together. Groups should be flexible and can range in size from dyads to a whole class depending on the purpose of the learning episode. Moreover, the groups should be small enough to allow students with divergent thinking styles to talk together effectively but large enough to represent different abilities and diverse perspectives. The basic principle for groupings is that students work together to construct shared meaning in the social construction of knowledge. A feeling of community develops between these students as they interact, think together to accomplish task, and present their thinking to peers.

3.3.3 Bridge

This element is critical to applying constructivist learning theory in a classroom. Before beginning any new learning, teachers can uncover the prior knowledge that the students bring with them; it serves as the foundation for a bridge between what students already know and the new learning theory they will engage in during a learning episode. To organize effective learning episodes, it is important to find out what current perception, construction, or misconceptions students bring with them. Teachers must understand what students actually know or think before introducing new learning. The bridge must link existing students' knowledge to new learning.

3.3.4 Questions

An open-ended and well-timed question will prompt learners to seek an answer and sets them off on a path to new knowledge. Usually, the best questions are those that learners ask themselves, those that prompt evaluative thinking. Moreover the questions that teachers ask and the way they ask them sustains or stifles learning for students.

3.3.5 Exhibits

We use the notion of an exhibit to describe student presentations of the artifacts they created to accomplish a task framed by the situation. As this process move from individual, private acts to more open and public exhibits, the power of social interaction shapes learning profoundly. Moreover, students will gain the basic social skills of critical thinking, communicating, and relating from an effective public presentation.

In this exhibit element, the groups of students will make a public presentations of the artifacts they have generate to document their accomplishment of a task during a learning episode. As students have an opportunity to show what they know to others, they take their accomplishment of tasks and the documentation of their learning more seriously. The product of their own thinking becomes a basis for their own thinking and becomes a basis for their presentations and provides an opportunity for peers to review their work. Students listen more attentively to one another and support one another in explaining their thinking when they present their work to peers. They also engage in more authentic work when they are preparing an explanation of their thinking for one another. This public presentation also provides a time and place for students to respond to questions from the teacher and from their peers about their artifacts or thinking.

3.3.6 Reflection

Reflection offers both learners and teachers the opportunity to think again about their individual and collective learning, to begin the integration of new learning with existing knowledge, to plan for the application of new knowledge and in many cases, to design strategies for the next learning episode. Reflections capture what student were actually thinking and learning, not what material was presented or covered.

Reflections have to parts. In the first part, the teacher engages the full group in interpreting and making sense of what has happened. Teacher review the learning episode with students to determine what concepts, process, and attitudes the student will take away with them. A primary purpose for this review is to give teachers a chance to perceive the student understandings that emerged during the learning episode. This process will assist teachers in evaluation of the purpose, flow and effectiveness of their learning design. Another purpose of teacher reflections is to allow teachers to revisit or restate concepts or understandings that were presented in a limited or inappropriate ways by the teacher or by student groups.

In the second part, students reflection on what they thought about while accomplishing the task and seeing the exhibit of presentations by other groups. Reflections include what students remember thinking, feeling, imagining, and processing through internal dialogue. Students might also reflect on what they learned today that they will not forget tomorrow or what they knew before, what they wanted to know, and what they actually learned.

Summary

According to the constructivists' perspectives above, learning is determined by the complex interplay among the learners existing knowledge, the social context, and the problem to be solved. Moreover, constructivism is a fundamental departure in both the nature of knowing, hence of teaching and learning. It is believed that knowledge and truth are constructed by people and do not exist outside the human mind (Duffy; & Jonassen. 1991: 9). The constructivists' perspective also describes learning as a change in a meaning constructed from experience (Newby; & et.al. 1996). Therefore constructivists suggest a set of instructional principles that can guide the practice of teaching and the design of the learning environments.

According to the study, *A Comparison between Traditional and constructivist Teaching in Environmental Science*, conducted by Lord found that student learning in an environmental science course can be considerably enhanced with constructivist-styled teaching (Lord,Thomas R., 1999. Moreover Classon and Lalik stated that the well-tested model of constructivism, science curriculum improvement study (SCIS), provides an excellent foundation on which to build constructivist-based lessons and these lessons encourages peer interaction in resolving instructor-generated problems as student to develop their understanding of science (Classon; &Lalik; 1993: 200). Because scientific knowledge is both symbolic in nature and also socially negotiated therefore the objects of science are not the phenomena of nature but constructs that are advanced by the scientific community to interpret nature (Driver; & et.al. 1994: 5). Thus in this study I focused on the way in which students' informal knowledge is drawed upon and interacts with the scientific way of knowing introduced in the informal science education based on constructivism and in the natural setting.

4. The thematic approach to science teaching and learning

A thematic approach to science is a combination of experiments, activities, children's literature, hands-on/minds-on projects, and materials used to expand a scientific concept or idea. Thematic teaching and learning is multidisciplinary and multidimensional, it has no boundaries and no limits. It is responsive to the interests, abilities, needs, and input of children and respects their developing aptitudes and attitudes. In essence, a thematic approach to science offers students a realistic arena within which they can learn and investigate scientific principles for extended periods of time (Fredericks; 1998: 16-17).

Thematic teaching in science is built on the idea that learning can be integrative and multifaceted. A thematic approach to science education provides children with a host of opportunities to become actively involved in the dynamics of their own learning. Therefore, they will be able to draw positive relationships between what happens in the classroom and what is happening outside of the classroom. Moreover thematic teaching promotes science education as a sustaining and relevant venture.

Thematic instruction in science offers many opportunities for students to be actively engaged in a constructivist approach to learning. It offers a variety of meaningful learning situations tailored to students' needs and interests. Children are given the chance to make important choices about what they learn as well as about how they learn it. Thematic instruction provides the means to integrate the science program with the rest of the school curriculum while involving students in a multiplicity of learning opportunities and ventures.

4.1 Advantages of thematic instruction

Thematic instruction in science offers a plethora of advantages for both teachers and students as follows:

1. Emphasizes and celebrates and individual's multiple intelligences in a supportive and creative learning environment.
2. Focuses on the processes of science rather than the products of science.
3. Reduces and/or eliminates the artificial barriers that often exist between

curricular areas and provides and integrative approach to learning.

4. Promotes a child-centered science curriculum, one in which students are encouraged to make their own decisions and assume a measure of responsibility for learning.

5. Stimulates self-directed discovery and investigation both in and out of the classroom.

6. Assist youngsters in developing relationships between scientific ideas and concepts, thus enhancing appreciation and comprehension.

6. More time is available for instructional purposes. Science instruction does not have to be crammed into limited, artificial time periods but can be extended across the curriculum and throughout the day.

7. The connections that can and do exist between science and other subjects, topics, and themes can be logically and naturally developed. Teachers can demonstrate relationships and assist students in comprehending those relationships.

8. Science can be promoted as a continuous activity not restricted by textbook designs, time barriers, or even the four walls of the classroom. Teachers can help students extend science learning into many aspects of their personal lives.

9. Teaches are free to help students look at a scientific problem, situation, or topic from a variety of view points, rather than the “right way” frequently demonstrated in a teacher’s manual or curriculum guide.

10. There is more emphasis on teaching students and less emphasis on telling students.

11. Teachers are provided with an abundance of opportunities of integration children’s literature into all aspects of the science curriculum and all aspects of scientific inquiry.

12. Teachers can promote problem solving, creative thinking, and critical thinking within all dimensions of a topic.

4.2 Building thematic units

Kucer (1993), cited by Fredericks (1998), has outlined a series of procedures that can assist teachers to develop the thematic units in science. His steps offer guidelines that can help instructors create and structure instructionally units effectively. In addition, this sequence of six stages provides the organizational framework for all of the thematic units. Procedures for thematic unit development are as follows (Fredericks. 1998: 21-23):

1. Identification of a thematic topic.
    a. The topic is relevant and of interest to the students.
    b. The topic is significant; it is important to know about.
2. Identification of major generalizations and/or principles upon which the thematic unit will be based.
    a. The generalizations and/or principles focus on big ideas rather than minor concepts, facts, or details.
    b. The generalizations and/or principle are interrelated.
3. Identification of key concepts that support the generalizations and/or principles.
    a. Each concept is related to several generalizations and/or principles.
    b. The concepts are critical to understanding the generalizations and/or principles.
4. Gathering of thematic materials.
    a. The materials focus on the same set of generalizations and/or principles.
    b. Materials include different types of source.
5. Brainstorming and generation of various activities related to the theme topic, generalization and/or principles, concepts, and materials.
    a. Activities are authentic in nature: linguistically, cognitively, developmentally, socioculturally.
    b. Activities engage students in the use of various communication systems to learn about the generalizations and/or principles and concepts in the theme.
    c. Activities engage students in the use of various thinking processes from different disciplines (science, social science, literature) to learn about the generalization and/or principles and concepts in the theme.
    d. Activities engage students in both collaborative and independent work.
    e. Activities provide students with opportunities for problem solving.
    f. Activities take advantage of differing intelligence.
    g. Activities help strengthen various intelligences.
6. Arrangement of thematic materials and activities.

a. There are opening activities that introduce students to the theme and closing activities that draw together and celebrate what has been learned and accomplished.

b. Materials and activities are arranged around particular generalizations and/or principles and related concepts

c. Materials and activities include the most simple/concrete to the most complex/abstract.

d. Materials and activities include the collaborative and the independent.

e. Throughout the thematic unit, activities require students to revisit priormeanings and to integrate them with current meaning.

5. Informal science education.

Science education reform documents always call for science to be thought in the manner that students learn best, by conducting hands-on, engaging, investigations using simple everyday materials. Often overlooked in the redesign of science education, informal science learning environments such as science centers, museums, and zoo can provide students with captivating science experiences that can be related closely to curricular objectives (Gassert. 1997: 433). Moreover, the minister of education in Thailand also suggested that all ministries are involved in providing informal education to promote lifelong learning. The services provided include educational activities or academic and professional programmers for different target groups relating to the responsibilities of each ministry.

Science teachers are in general willing to use field trips as a part of their pedagogy because they feel that their students need hands-on, real life experiences or to examine the applications of science which augments their classroom studies (Michie. 1998: 43-50).

Field trips that required hands-on activities seem to have a positive impact on student ability to recall information learned on the educational excursion, and students tend to enjoy this type of experience when compared to field trips that did not encompass hands-on activities (Pace; & Tesi. 30-40). Moreover, the study " Novelty and its relation to field trips, conducted by Hurd found that pre-visit agendas strongly influence students' positive attitudinal change and knowledge related to the trip (Hurd. 1997: 3).

Flak, Moussouri, and Coulson (1998), found that effective agendas for students' visit museum such as a pre-lesson on related material, or a specific list of exhibits to be viewed; correlated with an assignment to accomplish in museum or directly after field trip significantly influence on students' motivations of education and entertainment. They recommend that instead of taking a class to a museum and letting the students roam free, students should have a focus and they will appreciate the experience and gain more from it (Flak; Moussouri; & Coulson. 1998. 8). In addition, according to the study "Her world; for school children, field trips are a preview of life's yellow brick road", it is suggested that the purpose of the trip needs to be embedded in the curriculum. Therefore pre-visit and post-visit agendas should connect the material to the curriculum (Spano. 2002. 7).

5.1 Definition of informal science learning

Informal science learning is the most commonly applied term for the science learning that occurs outside the traditional, formal schooling realm (Dierking; & et al. 2002: 108). The National Science Teachers Association (NSTA) also recognized and encourages the development of sustained links between the informal institutions and schools. NSTA applied the term informal science education to programs and experience developed outside of the classroom by institutions and organizations that include (NSTA. online):

- Children's and natural history museums, science-technology centers, planetary, zoos and aquaria, botanical gardens and arboreta, parks, nature centers and environmental education centers, and scientific research laboratories
- Media, involving print, film, broadcast, and electronic forms
- Community-based organizations and projects, including youth organizations and community outreach services.

5.2 Characteristics of informal science learning environment.

Informal science education environments provide students with unique, engaging science learning opportunities and classroom teachers with a wealth of science teaching resources. Glassert (2003) suggested the characteristics of informal science learning environment as follows (Glassert. 2003: 435):

5.2.1. Motivational, engaging, enjoyable, and nonthreatening.

Informal learning environments have long recognized that learners are individuals arriving with differing interest, learning styles, and experiences in science.

Therefore Wellington (1990) concluded that the overall atmosphere of informal science learning areas, that are the most effective in developing learners interest and understanding of science, should include features such as voluntary, instructed, non-assessed, open-ended, and should be learning centered (Wellington. 1990: 247). Moreover, Semper (1990) added that informal learning environments provide a rich learning environment for learners with a variety of learning styles while implementing four themes in educational theory: curiosity or intrinsically motivated learning, multiple modes of learning, play and exploration during the learning process, and the existence of self-developed world views and models among people who learn science (Semper. 1990: 52).

5.2.2. Hands-on, experimental, and personal.

Informal science learning environments should provide free-choice, self-paced, multi-sensory and socially interactive spaces for learning-by-doing. Exploration and discovery are vital in fostering a child's natural curiosity, which lays the foundation for conceptual science learning (Bresler. 1991: 60). According to Sample, informal science learning environments allow students to observe and investigate natural objects and phenomena and live specimens in way that textbooks cannot (Semper. 1990). Moreover, Resnick (1897) indicated that when in-school programs draw on real-world relevance and are connected with outside-of-school learning it aids student in finding personal meaning in cognitive activity (Resnick. 1987: 15).

5.3 The influence of informal learning

Science museums, zoos and aquariums are places where informal learning can occur naturally and logically, creating an exemplary model for other types of museums. Bitgood (1994) stated that affective, and cognitive learning experiences are fused, not separately structured activities or objectives in informal exhibit environment (Bitgood. 1994: 63). Learning in informal settings depends less on verbal or written symbols for communication, thus permitting learners to interact with real-world objects without the additional learning of new or often confusing terminology. Informal science environments offer learners more direct nonverbal experiences, objects and visual displays, instead of discourse to relay information. Moreover, Gerber (2001) found that informal learning environments and classroom science teaching procedures showed significant effects on students' scientific reasoning abilities. Students with enriched informal learning environments had significantly higher scientific reasoning abilities compared to those with impoverished informal learning environments (Gerber, 2001: 535).

The studies focused on the effects of social interactions on learning in an informal science setting by Tuckey (1992) found that peer teaching was evident and students tended to recall the most information from exhibits that demanded their full attention and required active mental as well as physical involvement, whereas little was recalled of purely visual displays. Moreover NSTA strongly supports and advocates informal science education as below (NSTA, online):

1. Informal science education complements, supplements, deepens, and enhances classroom science studies. It increases the amount of time participants can be engaged in a project or topic. It can be the proving ground for curriculum materials.

2. The impact of informal experiences extends to the affective, cognitive, and social realms by presenting the opportunity for mentors, professionals, and citizens to share time, friendship, effort, creativity, and expertise with youngsters and adult learners.

3. Informal science education allows for different learning styles and multiple intelligences and offers supplementary alternatives to science study for non-traditional and second language learners. It offers unique opportunities through field trips, field studies, overnight experiences, and special programs.

4. Informal science learning experiences offer teachers a powerful means to enhance both professional and personal development in science content knowledge and accessibility to unique resources.

5. Informal science education institutions, through their exhibits and programs, provide an effective means for parents and other care providers to share moments of intellectual curiosity and time with their children.

6. Informal science institutions give teachers and students direct access to scientists and other career role models in the sciences, as well as to opportunities for authentic science study.

7. Informal science educators bring an emphasis on creativity and enrichment strategies to their teaching through the need to attract their noncompulsory audiences.

8. Local corporations, foundations, and institutions fund should support

informal science education in their communities.

9. Informal science education is often the only means for continuing science learning in the general public beyond the school years.

5.4 The influence of informal science education on environmental attitude

The use of outdoor areas for science instruction are advocated by science educators and curriculum theorist (Linda. 2000: 210; Aleixandre. 1996: 29; Stepath. 2004). The effectiveness of outdoor instructions was investigated focusing on varieties of environmental science content topics such as Zoology, Botany, Ecology and Geology. By reviewing these research studies, there is no doubt that students can learn about the environment from print, audiovisual materials, indoor lab activities and simulation activities but it is found that students can learn just as much or significantly more through outdoor environmental science instruction (Boger. 1998; Lisowski; & Disinger. 1991; Milton; et al. 1995; and Malone; & Tranter. 2003).

Several research studies also investigated the effect of outdoor environmental science instruction on environmental attitude in addition to the cognitive benefit associated with outdoor environmental science instruction. For example, from the study "*The Effectiveness of Schoolyards as Sites for Elementary Science Instruction*" conducted by Linda L. Cronin-Jones indicated that elementary students learn significantly more about selected environmental science topics through outdoor schoolyard experiences than through traditional indoor classroom experiences. Moreover these students also developed more positive environmental attitudes as a result of instruction (Linda; & Cronin. 2000: 203-211). In addition, many studies on the impact of long-term experiences in natural settings, such as summer camps or overnight filed trips, have documented positive shifts in students' environmental attitudes (Clinton L. Shepard; & Larry R. Speelman. 1986; Bogner. 1998; Dresner; & Gill. 1994; Kruse; & Card. 2004).

Summary

Informal learning in science will take place in a variety of contexts and through an increasing number of media. There is already evidence to suggest that factors outside of school have strong influence on students' educational outcomes (Schibeci. 1989: 13). According to the experts, informal science learning environments can engage and excite students to experience science in way uncommon to classrooms. I believe that informal settings have the potential to extended classroom science learning by providing students with a range of rich science process skills, scientific attitudes, a better attitude towards science, and improved attitudes towards the environment. Therefore learning outside of formal institutions, such as school, should are certain to be of growing importance in relation to the formal school curriculum and relevance to national science standards.

6. Education at zoo

A zoo is another learning resource capable of affording people opportunities to set their own learning agendas while exploring through contextually rich environments (Falk; & Dierking. 1998: 2). A zoo is the place that visitors have an experience with living animals, and provide the compelling experience necessary to attract and maintain personal connections with visitors of all motivations. Moreover it helps them to learn and reflect on their own relationships with nature (Povey; & Winsten. 2003: online). In addition zoos offer an opportunity for the children to experience wildlife – albeit in captivity.

Over the past few decades, many zoos have strengthened the educational focus of their mission. Traditionally the purpose was focused on influencing cognitive and affective variables by delivering animal facts and encouraging affection for the animals. However, in the past ten years there has been increasing sophistication within zoo education, with the focus on learning expanding from conveying facts about animals to influencing a broader public understanding about complex issues such as conservation and biodiversity. Similarly, the focus on affective impact has changed, as researchers have sought to understand the role of zoo experiences in the development of an environmental ethic. Even more recently, zoos have begun to address their role as facilitators of behavior change – seeking to influence their visitors' conservation-related behaviors (Groff; et al. 2005: 372)

Zoos can be ideal venues for developing emotional ties to wildlife and fostering an appreciation for the natural world as they offer a wide range of opportunities to engage in free-choice learning experiences through interactions with naturalistic exhibits. The heart of free-choice learning in zoos are certain perceptual strengths or preferred modes for processing information including auditory, kinesthetic, tactile and visual. It is through these that adults and children can effectively engage in learning in zoos. Beyond these, free-choice learning in the zoo is crucially dependent on individual motivation driven by unique intrinsic needs and by the interests of the child and by the duration of any interactive experiences, as well as the relevance, choice, discovery and context of the stimulating environment (Kola-Olusanya, Anthony. 2005: 300)

Zoos have also expanded their audience – from a traditional focus on school children to supporting the free-choice learning of the general public (Dierking & Saunders, 2004) and an increasing volume literature is focused on evaluating the long-term impact of visits to zoos (Holzer; & Scott. 1997; Adelman; *et al.* 2000; Dierking; *et al.*, Falk. 2002). A review of the research on zoos and an evaluation of the literature suggests that these experiences can positively influence guests' understanding regarding conservation (Adelman *et al.*,2000, 2001; Dierking *et al.*, 2002), as well as their attitudes and affect toward animals (Adelman, Falk; & James. 2000; Adelman; *et al.* 2001).

6.1 Conservation program

Much of the conservation education is being supported through zoological institutions around the globe. The resources that zoos are setting aside for this role are also increasing in an attempt to slow down the rate of extinction of our valuable species and habitats (WAZA. 2003. : Online). Efforts to preserve endangered species are vital in today's society and can be brought about through the conservation education mission of zoos. The role of modern zoos is represented in the unique niche of conservation education in teaching about biodiversity and conservation using hands-on techniques (Lindemann-Matthies. 2001: 194). The zoos' mission of today, according to Rosenthal (1991), is to promote an understanding of how basic ecological concepts relate to local natural resources. Through conservation education programs offered at zoos the public is encouraged to help preserve these natural resources (Rosenthal. 1991: 55).

Children are of the utmost importance in the future of natural resources preservation because their leisure pursuits are generally carried over into adulthood (Basile. 2000: 23). Conservation education is vital for encouraging youth to protect our resources now and in the future.If youth have a rewarding experience when visiting a zoo, then they may advocate for zoos and wildlife preservation in the future, that is, they may establish perceptions that may form the basis of their future attitudes (Marshdoyle; Bowman; & Mullins. 1982: 21).

Zoo conservation education programs include conservation education camps for youth. The idea behind these programs is to educate youth about the importance of wildlife, habitats, and behaviors so that they will be conservation advocates as youth and later as adults (Serrell. 1981: 41).

6.2 Education programs at zoo

6.2.1 Wildlife inquiry through zoo education (WIZE) program

A well-known life science program for grades seven through ten, wildlife inquiry through zoo education (WIZE) program, takes a non-traditional, multi-disciplinary approach to learning at Bronx zoo, New York, New York, USA. The program content focuses on population ecology, wildlife conservation, and species survival. Students who participate in the program scored significantly higher on a content-area posttest and had significantly more knowledge of and interest in particular science areas than did students not exposed to the curriculum. (Mei, Dolores M. 1996: Online)

6.2.2 Learning experience outside the classroom

Auckland zoo provides an educational programs specifically designed to meet individual classes' requirement. The purpose is to support a variety of curriculum areas and objectives for use before, during and after the zoo experience. For example, *Chameleons are cool*, the aim of this program was to spark children's creativity and interest in wildlife and the environment, and encourage students to reach for excellence (Auckland zoo. 2008: online).

6.2.3 Interactive distance learning with the Lee Richardson zoo.

The Lee Richardson zoo provides the public with free distance learning programs from their interactive television studio. Students of any age can connect for a one-on-one visit with the education staff and some of the special animal ambassadors. Students can choose one of the pre-planned program topics, or let the zoo educator create a program to fit the student's interests. Programs can be adapted to most grade levels (Lee Richardson zoo. 2008: online). Programs list are as follows:

1. Sophisticated mammals
2. Awesome amphibians
3. Protection from predators
4. Animal adaptations

5. Snakes, lizards, and alligators, Oh my!
6. The lions of the bird world
7. Animals of the prairie
8. Spineless animals
9. For the birds

6.2.4. BRONX zoo is just a phone call away!

The program uses two-way videoconferencing technology, where the Bronx zoo can bring engaging programs for K-12 students right into the classroom—live! All distance learning expeditions include several live animal "guests" gorillas, alligators, owls and more. Programs are 45 minutes to an hour and all include extensive teacher support materials. These time-tested, teacher-endorsed programs are aligned with the National Science Education Standards (USA) and have received rave reviews from students and teachers alike. (BRONX zoo. 2008: online)

6.2.5. Birmingham zoo

The education department at the Birmingham zoo offers science based classes as well. These classes combine science education with conservation education for home schooled students. The classes build upon student's knowledge and enhance concepts by using the zoo as a living laboratory. Over the years, classes have consisted of animal visits, use of bio-facts, class discussions, in-class work, and homework.

Resources and references are made available for the different classes. Class materials are used in class and some sent home for extra reinforcement. The education department is dedicated to connecting students with nature and instilling an appreciation for the wildlife around them. Conservation education is an important aspect of the curriculum development at the Birmingham zoo (Birmingham zoo. 2008: online)

6.2.6 Taronga zoo

Situated on the foreshore of Sydney's magnificent harbour, the Taronga zoo showcases more than 350 different species of animals (Taronga zoo. 2008: Online). Education officers at the zoo can offer people of all ages a wildly different learning experience, allowing them to come face to face with the live animals. The zoo has already held a community education programs at Terry Hills, Live animals, audio recordings and photographs were used to educate visitors about the preservation of this precious local fauna.

The education program is the introductory level course for those who are interested in the animal care industry and/or pursing a career as a keeper in the animal care industry. The course is presented over a twelve-month period, with classroom sessions conducted once per fortnight at Taronga zoo. Students are also required to attend twelve practical industry days at Taronga zoo to perform the daily duties of an intern keeper under supervision. Students are also required to undertake course work in their own time.

Course assessments are a combination of written answers to questions, reports, projects, observations of students performing tasks, and supervisor reports. The program covers the essential duties of a keeper in the animal care industry. Included are the following topics:

1. Working in an animal care environment
2. Checking the general condition and health of animals
3. Animal handling techniques
4. Cleaning of animal housing/exhibits
5. Providing food and water for animals
6. Communicating effectively in the workplace
7. Basic first aid for animals
8. Food preparation for various animal species
9. Animal rescue and restraint processes
10. Presentations and tours

7. Chiangmai zoo

7.1 History

Chiangmai zoo was first founded by Mr. Harold M. Young, an American missionary who began collecting wild animals during his time teaching the Thai border police forest survival skills (Chiangmai zoo. 2006: Online) . He kept his menagerie in his large garden to be private zoo until it became too overcrowded. He then asked the Thai forestry department for land in order to open a zoo. In 1995 he was given 80 acres of land at the foot hill of the Suthep mountain and the animals were relocated. In 1974, Mr.Young passed away, the zoological park organization took over on 16 June 1977. The royal forestry department allowed the zoo to expand again in 1989 to 1327.5 acres. For over 20 years the site has been continuously developed and improved (Chiangmai zoo. 2006: Online).

Now Chiangmai zoo has 7,000 wild animals, the cages housing the animals have been made more occupant friendly, animals on view now include over 500 species and constant education programs for zoo personnel have made it the modern zoo it is today (20 Anniversary of Chiangmai zoo. 2006: Online).Today Chiangmai zoo is located on Suthep road near the Chiangmai University. Enclosed by flower gardens and surrounded by hilly terrain, it is home to thousands of species of wild plants and flowers adorning the natural landscape of valleys, streams and waterfalls. Chiangmai zoo is the first and only zoo in northern Thailand where visitors can experience the excitement and intimacy of various species of animals in their natural habitat

7.2 Fact sheet

Established	1977
Visitors	700,000/year
Size	212.4 acres
Animals	7,000 heads
Birds	4,965 heads
Mammals	475 heads
Reptiles	218 heads
Fish	1,190 heads
Open	08:00 - 21:00 hours
Entrance Fee	Foreigners - Adult: 100 Baht, Child: 50 Baht Thais - Adult: 50 Baht, College or University Student: 30 Baht, Child (over 135 cm.): 10 Baht

7.3 Chiangmai zoo map

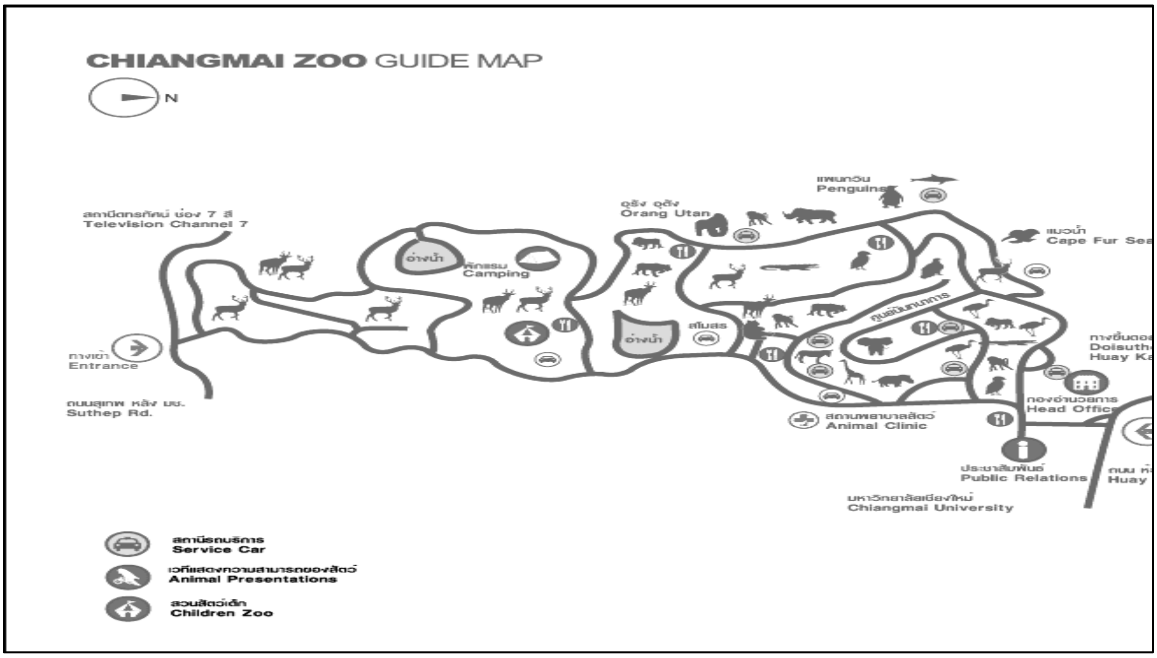

FIGURE 4 CHIANGMAI ZOO MAP (Chiangmai zoo. 2006: Online)

7.4. Attraction

7.4.1 Nakornping walk through aviary

Relaxation while walking and observing more than 800 birds in 2.5 Acres of land.

7.4.2 Fresh water aquarium

The collection of fresh water fishes includes more than 60 of tropical Freshwater fishes, featuring the giant Mekhong catfish and striped catfish, Siamese giant carp used for learning the life cycle of fishes.

7.4.3 Cape Fur seal exhibit

The building has 4 Cape Fur seal from Africa t present at the zoo.

7.4.4 Gibbon island

Animals live freely on this isle without nets, caging or any enclosure whatsoever. Gibbons live and breed happily at the zoo.

7.4.5 Camping area

The children can camp near the big reservoir, waterfall, adventurestation, the natural trail in order to learn about the animal's night life.

7.4.6 Star animals

Elephant family, hippopotamus, zebra, giraffe, ostrich, many birds species, cape fur seal, Humboldt penguin, Malayan tapir, barking deer and Indian rhinoceros make up the star attractions.

7.4.7 Open zoo

You will meet spotted deer, hog deer, barking deer, brow antler deer, alpaca, and peacocks which more than 200 animals that live with peacefully within an area of 40 acres. You can walk through the open zoo on the sky walkway for a close up view of the animals.

7.4.8 Twilight zoo

Chiangmai zoo is opened for every visitor to come to see many kinds of animals in the daytime. Naturally, most of animals would come out to eat and hunt at night. The animal life style at night is an interesting thing to study. Chiangmai zoo has the opened area which consists of the plenty of forests with a natural environment and at least 30 kinds of night animals. The concept of visiting night animal life is an idea that we would like to present as a new interesting and innovative zoo program to every visitor.

7.4.9 Giant panda live in Chiangmai zoo

In 2001, the vice-prime minister and minister of defense (a fullgeneral Chawalit Yongjaiyut) talked with the president and prime minister of the people's republic of china about the giant panda. He wanted to house a giant panda in Thailand. The government of China was glad to give a pair of giant pandas for friendship ambassadors and the celebration of her majesty the queen's 6 cycle birthday anniversary in 2004. The government of Thailand entrusted the zoological park organization to take responsibility for these very rare giant pandas. They are on display at Chiangmai zoo in Chiangmai province.

7.4.10 Koalas

In July 2006, Chiangmai zoo became the first zoo in Thailand to house koalas as Australia shipped four of the marsupials here to mark the 60th anniversary of his majesty the king’s accession to the throne. Koalas, which are native to Australia, weigh about 9 kilograms each, on average. “Koala” is an aboriginal word, meaning “no drink”. The animals get water from their chief food, eucalyptus or gum leaves. The koala is sometimes called “koala bear” although it is not a member of the bear family but a marsupial like the kangaroo and the wombat. The trait distinguishing marsupials from other mammals is that they carry their young in pouches. Female koalas take 2 to 3 years to reach productive age while males take 3 to 4 years. A healthy female koala can bear one offspring yearly for about 12 years.

7.4.11 Children's zoo

The children's zoo, covering the area of 1,442 sq.m. consists of the cognitive development center, a small and large animal exhibit, playground, adventure sector, sand area, rabbit exhibit, a performing stage, exhibit hall, fish exhibit, and lotus pond. All of these are situated atop a natural hill overlooking the city of Chiangmai. The children's zoo is covered with shady evergreen trees, a beautifully landscaped floral garden, and masses of green grass.

7.5. Service

7.5.1 Public relations

Located on the left just beyond the main zoo entrance, the public relations office of Chiangmai zoo will help answer any questions zoo guests might have. Zoo guests are also be able to search zoo information on computers.

7.5.1 Souvenir shop

Located opposite admission gate, the shop sells animal postcards, T-shirts, buttons, memorabilia, film and more.

7.5.2 Film booth

Zoo guests can purchase film for cameras at film booths in areas near the admissions gate or rest areas.

7.5.3 Service car

For more comfort, safety, saving time you can get some knowledge from the zoo guides in a service car.

7.5.4 Animals presentation

Joyful, recreation, meet the lovely behavior of many wild animals.

7.5.5 Recreation and activity center

In special events, very useful for everyone, children's zoo has a natural education room for children and the whole family.

Summary

Every year more than 1 million people visit Chiangmai zoo (The zoological park organization. 2005: 21). Although Chiangmai zoo seeks to entertain, it has more important functions as well; it is an excellent source of education, a place to gain greater understanding of nature and the environment.

Chiangmai zoo is surrounded by hilly terrain which is home to thousands of species of wild plants and flowers adorning the nature landscape of valleys, streams and waterfalls. These environments are very suitable for science's teaching and learning. With the interdisciplinary and active learning possibilities of Chiangmai zoo, children from both private and government run schools can have a wonderful opportunity to learn first hand about the many fascinating aspects of basic science. Increasingly, Chiangmai zoo has received requests from teachers wanting a well organize educational program (The zoological park organization. 2005: 23). Toward this end, the constructivist thematic science program at Chiangmai zoo (CTSPZ) was developed based on constructivist learning design (CLD) and thematic science, in an informal setting, the Chiangmai zoo, to customize their offerings to the needs of particular teachers and students integrating the informal with formal school science standards.

CHAPTER 3
Methodology

Introduction

The sections of this chapter presents the stages in the development of the constructivist thematic science program at Chiangmai zoo (CTSPZ) that influences science process skills, attitude towards science, scientific attitude, attitude towards the environment, and constructivist learning environment of middle school students. A constructivist model for curriculum development (FIGURE 5) as outlined by Driver, R. and Oldham, V. (1986) was adapted and used in the development of the program materials in this research. This research was conducted in three phases including program design, program implementation, and program evaluation.

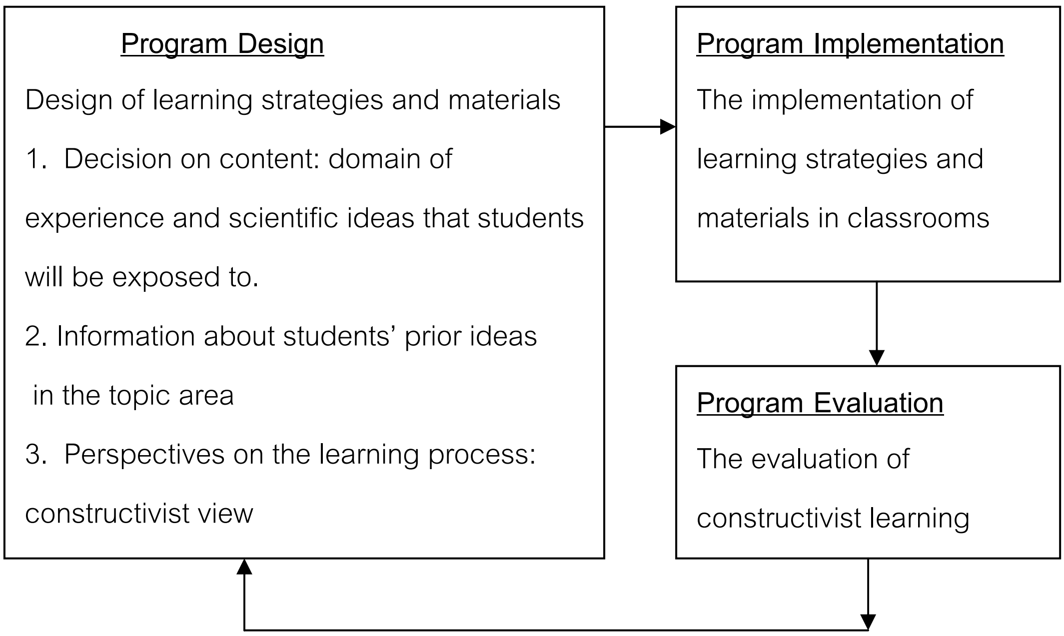

FIGURE 5 A CONSTRUCTIVIST MODEL FOR THE CTSPZ PROGRAM (adapt from constructivist model for curriculum development by Driver, R. and Oldham (1986)).

The instruments and procedures employed in this study are discussed in this chapter under the following headings:

1. Phase one: program designing
    1.1 Identifying learner needs
    1.2 Articulating curriculum intentions
    1.3 Planning instruction
    1.4 Consulting with curriculum experts
    1.5 Pilot study
    1.6 Revising the draft CTSPZ
2. Phase two: program implementation
    2.1 Research design
    2.2 The participants
    2.3 Setting
    2.4 Instrument for data collection
3. Phase three: program evaluation. (Data analysis)
    3.1 Quantitative data analysis
    3.2 Qualitative data analysis

1. Phase one: program designing

During the first phase, the constructivist thematic science program at Chiangmai zoo (CTSPZ) based on constructivist learning design (CLD) at an informal setting (Chiangmai zoo) was developed by integrating it with formal national science standards.

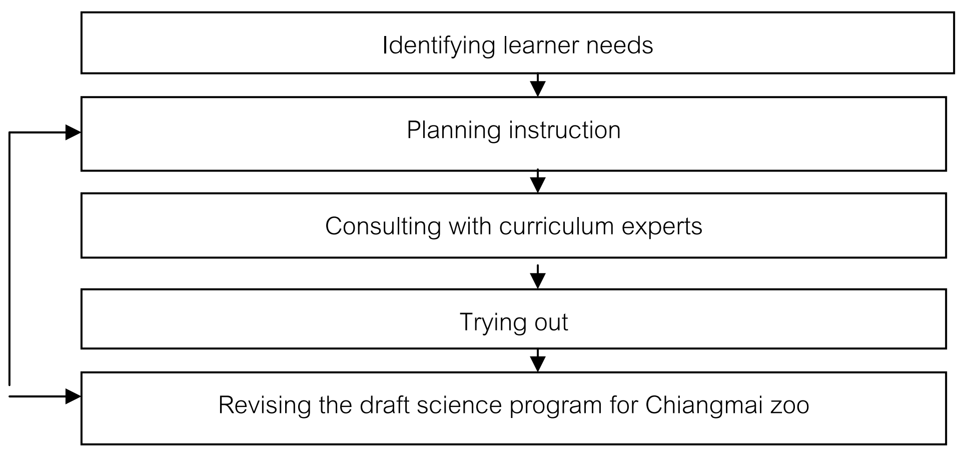

FIGURE 6 PROCESS FOR DESIGNING THE CTSPZ PROGEAM

The details for program designing are summarized as follows:

1.1 Identifying learner needs

There is general agreement among educators that curricula should be based on learner needs. In this research, needs were defined as a discrepancy between a present and a preferred state. Needs assessment is a set of procedures for gathering information about the learner's needs. These processes include consultation, collection of social indicators, and task analysis.

1 Opinion surveys

The basic reason for conducting a needs assessment prior to beginning to plan a curriculum are informational, ethical, and political. To meet these ends, two main groups of respondents were consulted.

1.1.1.1 Specialist

Telephone interviews were an effective means for reaching the two specialists:

1. Mr. Apidat Singhasanee educator at Kaowkeaw zoo.
2. Mrs. Jarunee Chaichana educator at Chiangmai zoo.

1.1.1.2 Clients

The clients of this program are students, teachers, and parents. Data information gathered from survey questionnaires conducted by a master plan of Thai zoo education, 2005 was used to ascertain their backgrounds, their interests, their aspirations and motivations, their preferences and aversions, their histories of success and failures.

1.1.2 Task analysis

Task analysis was needed to corroborate the subjective data produced by respondents in interviews, hearings, or surveys. Its function is to identify the important components of tasks that were in turn to become significant elements of the program. The directed observation of task performance was conducted by the researcher through the entire day with 10 students to monitor the nature, purpose, scope, frequency, sequence, and importance of tasks performed at Chiangmai zoo during their visit in January 2007.

1.2 Articulating program intentions

The process of program planning is a process of clarification and articulation of meaning and significance by specifying the major educational rationale, specific objectives, and science content that related them to the national science standards. Therefore this stage was about writing the program rationale, goals, and selected science content standards.

1.2.2 Program rationale

The program rationale justifies the commitment of resources to the pursuit of the program. It is essentially a brief essay that endeavors to persuade the reader to understand the significance and importance of the program. Moreover it illustrates how national science standards were used and described how classroom should be linked. It also addressed the broader learning context, such as how the teacher taught and how students were assessed.

1.2.2 Program goal

The program goals provide a sense of purpose and direction. It was stated in terms of intentions. These goals were written to communicate the overall purposes of the program to many audiences, including staff, parents, and policy makers. Goals used to guide the actions and decisions of teachers, administrators, and support staff as these personnel develop, implement, and support activities to improve the quality of science education.

1.2.3 Contents of science standards

A comprehensive set of content of science standards is the key component in the design of an effective program. A set of existing national science standards was used in this research, and then the science standards that were suitable for each unit were selected.

1.3 Planning instruction

Instruction refers to program content and teaching strategies. In this research, instruction was referred to as one part of the curriculum: the content or subject-matter and the methods or strategies. Therefore, the CTSPZ was designed as a micro curriculum. The principle focus of the CTSPZ is the development and operation of program-based activities. It was conducted through an articulation between classroom actions and includes 6 units, the design of lessons, the application of various teaching models, and the design of assessments.

1.3.1 Specifying instructional content

The goal of this step was to identify instructional content that best support the national science standards and were suitable for the Chiangmai zoo environment. This step was meant to organize and sequence the content to create coherence in the program across grade 7-9 in all units.

1.3.2 Integrating thematic units

In a field of science, at every level of education, biology, chemistry, physics, and earth science there are essential conections. These complementary subjects were intimately integrated into the CTSPZ by following a nested horizontal integration strategy. Moreover units offer educators a framework in which to impart scientific knowledge, skills, attitudes, and environmental education.

1.3.3 Specifying teaching strategies

In this step, instruction was characterized as a process in which teachers attempt to make learning sensible and students attempt to make sense of learning. Therefore, six elements of the constructivist learning design (CLD) developed by Gagnon and Collay were used as teaching strategies in this research.

1.3.4 Plan for assessment

An instructional plan also needs to include a plan for assessment. Both formative and summative assessments were use in this research.

1.3.4.1 Formative assessments provided data about how students are changing in science process skills and attitudes. Observation, records of work, and a questionnaire of self-assessment in small group discussion were used to provide feedback in an ongoing instructional situation.

1.3.4.2 Summative assessment intended to provide a final judgment on a learner as to whether there was a change on the students' science process skills, scientific attitude, attitude towards science, and attitude towards the environment. Both qualitative (interview) and a quantitative instrument, the science process assessment for middle school students, the scientific attitude inventory: a revision (SAI II), science attitude scale for middle school students, the children's attitude towards the environment scale (CATES), a constructivist learning environment survey (CLES) permission was given to use in this research and translated into Thai to use as an instruments in this step. The instruments in the Thai version was reviewed by four experts to check for content validity and tested for reliability with 40 students. Then the instruments were revised according to comments and suggestion from both experts and students.

1.4 Consulting with curriculum experts to examine and verify the draft CTSPZ

The key concept for this step is to comprehend in outlook and comprehend in instrumentation. In this step, five experts about the program validity and reliability were consulted. Any reliance on a single appraisal was subjected the evaluation to validity and reliability vulnerabilities. Content and construct validities have important roles in this step because they are foundation of making good measurements on achievement. On the other hand, reliability refers to the stability of instruments over time and in alternative forms. Once the program was designed, it was evaluated by an internal evaluation, expert appraisal and confidential review.

1.5 Pilot study

1.5.1 Pilot testing

Small scale pilot testing was conducted to explore students' experiences while they attended the CTPSZ at Chiangmai zoo. It was conducted on part of the curriculum with 40 students from Chiangmai university demonstration school in January 2007.

1.5.2 Collection and evaluation of the pilot study data

The purpose of pilot study evaluation was to understand a summative phenomenon that occurs and to obtained feedback on the program experience after completion of some logical plane of instruction.

1.6 Revision of the draft science program for Chiangmai zoo

Revisions of the draft program occurred after the program had been adopted and implemented for the pilot study. The nature of this step was to provide feedback on changes that might be needed. The program revision also needed to direct some attention to the elements of the program that affect its implementation. Program revision was conducted following the guidelines below:

Program revising guide

1. Need Assessment
   - Was a need assessment conducted?
   - Are the methodology and results described?
   - Are the results used appropriately in the design of the program?
2. Rationale
   - Is the justification for the program given?
   - Are all the important arguments for the program included?
   - Does the rationale document current evidence on which the curriculum is based?
   - Are the arguments valid and rigorous?
   - Is the rationale eloquently written and convincing?
   - Are the main objections anticipated and dealt with?
   - Does the rationale deal appropriately with the social and personal significance of the program?
3. Goals
   - Are all the main intentions of the program identified?
   - Do the goals reflect student needs?
   - Do the goals go beyond the cognitive?
   - Are the goals written in a clear and consistent style?
4. Assessment
   - Are appropriate means suggested to assess attainment of each goals?
   - Are of mastery measures valid, reliable, and efficient?
   - Where appropriate, are standards of mastery clearly indicated?
5. Context
   - Is it clear how this program fits or links with a science course in school?
   - Is the relationship of the program to science standards shown?
6. Instruction
   - Does the instruction match student needs?
   - Does the instruction match the program goals?

- Is instructional content appropriate and interesting?
- Does the instruction ensure early significant success?
- Is the sequence and pacing of instruction appropriate?
- Are teaching strategies varied, interesting and challenging?
- Do strategies involve a constructivist leaning environment?

7. Pilot study
   - Is there provision for pilot and field testing?
   - Are the results of the pilot of field testing described?

2. Phase two: program implementation

2.1. Research design for the study

The design of this study was a mixed method, control group interrupted time series design in which the CTSPZ at the Chiangmai zoo served as the independent variable and the measure of students' science process skills, attitude towards science, scientific attitude, and attitude towards the environment served as dependent variables. In this design, the experimental group (A) and the control group (B) were observed over time. Both groups took a pretest and posttest. Only the experimental group received the treatment. Moreover both quantitative and qualitative methods were used. The use of survey instruments (quantitative) provided the data to reveal patterns and interview questionnaires (qualitative data) were added, supported and extended the quantitative relationships. Both quantitative and qualitative methods of the study used to explore the following questions.

Does the use of the science program, designed by the investigator and offered at the Chiangmai zoo, scientifically influence;

1. student's science process skill?
2. student's scientific attitude?
3. student's attitude towards science?
4. student's attitude towards the environment?
5. constructivist learning environment?

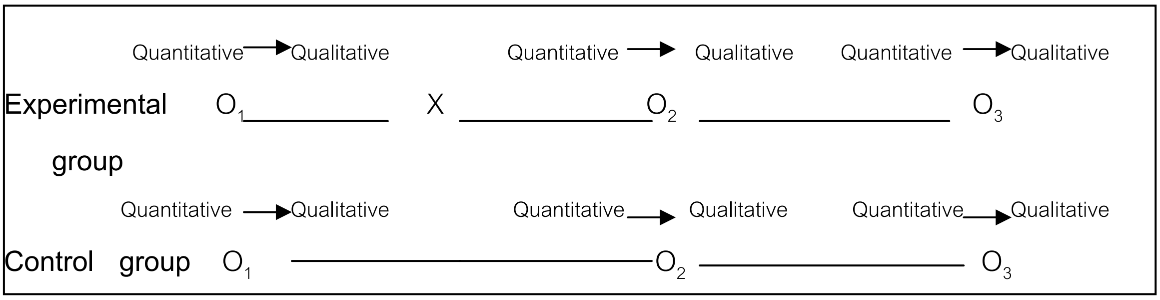

FIGURE 7 MIXED METHOD, CONTROL GROUP INTERRUPTED TIME SERIES

The symbols indicate as follows.

O_1 is observations (or pretest)

X is the treatment (The CTSPZ)

O_2 is an additional observation (or posttest) after using the CTSPZ.

O_3 is an additional observation (or posttest) after O_2 for 1 month.

An experimental group received the treatment (The CTSPZ) while they visited the zoo.

A control group was not received the treatment.

The research design (FIGURE 7) was developed using t-test to answer the following questions;

1. Whether difference in science process skills exists between pretest and posttest.

2. Whether difference in attitude towards science exists between pretest and posttest.

3. Whether difference in scientific attitudes exists between pretest and posttest.

4. Whether difference in attitude towards the environment exists between pretest and posttest.

This design includes a pretest followed by a treatment and a posttest in a single group. Students' science process skills were measured by the science process assessments for middle school students (SPAMSS) (Smith & Welliver Educational Service. 1994). Attitude towards science was measured by the science attitude scale for middle school students (Misiti.; Shrigely.;& Hanson. 1991). Scientific attitudes were measured by the scientific attitude inventory (SAI II) (Moore.; & Foy. 1995.). Students' attitude towards the environment was measured by the children's attitude towards environment (Musser.; &Malkus. 1994). The constructivist learning environment was measured by a constructivist learning environment survey (CLES)(Taylor; Fraser; & Fisher. 1997: 293). Simultaneously, the science process skills, attitude towards science, and attitude towards the environment were explored using the interview questionnaires.

2.2 Participants

The participants were level three students who volunteered to attend the CTSPZ from Chiangmai University demonstration school and Navamindarajudis Phayap School. An activity for learner development is a teaching-learning activity required for self-development in accordance with the students' potential. Students are encouraged to happily participate in undertaking activities in accordance with their tendency and interest.

2.3 Setting

All the units in the CTSPZ were designed for the Chiangmai zoo setting where students learned in the informal setting. The Chiangmai Zoo is located on Suthep road nearby Chiangmai University. It was established by the zoological park organization, Thailand in 1974, situated on 1327.5 acres of verdant forest land at the foothill of Doi Suthep Mountain. The zoo is surrounded by hilly terrain, home to thousands of species of wild plants and flowers adorning the natural landscape of valleys, streams and waterfalls (Chiangmai zoo. 2006: Online). Therefore, the Chiangmai zoo is highly appropriate to study science.

2.4 Instruments for data collection

2.4.1 Quantitative data collection

2.4.1.1. Science process assessment for middle school students

The Science process assessment for middle school students (SPAMSS) was used to identify the student proficiency in the use of science process skills. This instrument measured 13 science process skills: observing, classifying, inferring, predicting, measuring, communicating, using space/time relations, defining operationally, formulating hypotheses, experimenting, recognizing variables, interpreting data and formulating models. The instrument is based on a comprehensive study of process skills conducted by a science curriculum advisory committee of the Pennsylvania department of education.

The instrument is 50 multiple-choice test items, accompanied by a list of appropriate indicators of student behaviors. All behaviors would demonstrate competency in each particular process skill from the 13 process skills listed. The test items will engage students in problem solving situations which require them to apply an appropriate process skill to answer each question. This test can be administered to students in a 40-50 minute class session (Smith & Welliver Educational Service. 1994).

There are two key factors that are important for this instrument. The first factor is the reliability, that is, whether the test score is accurate, precise, consistent and reproducible. The SPAMSS has a reliability coefficient of 0.88. The second factor to consider is validity, that is, whether the test measures what you actually want to measure. Strong confirmations of this instruments validity come from the results of a project conducted by the Far West laboratory for educational research and development at Stanford University. The result was that the SPAMSS is indeed valid as a measure of an ability to use science process skills.

2.4.1.2 The scientific attitude inventory: a revision (SAI II)

The scientific attitude inventory: a revision (SAI II) was developed by Richard W. A revised version of the scientific attitude inventory: a revision (SAI II) was developed and field tested in 1983. The SAI II has 40 five-response Likert-Scale type attitude statements to assess students' scientific attitudes. The SAI II is scored by assigning point values to each of the attitude items. Point values are assigned as shown in Table 2. Scores for the various subscales can be determined by adding the scores for the respective items. Scores may be determined for the 12 subscales, a total for the positive, a score for the negative items, and a total for the entire SAI II. The range of scores for each of the Scales 1-A through 5-B is 3-15 (1-5 x 3 items). The range of scores for scales 6A and 6B is 5-25 (1-5 x 5 items). The range of scores for the entire SAI II is 40-200 (1-5 x 40 items) (Richard ; & Foy. 1997).

A split-half reliability coefficient for SAI II was computed for the entire group of 557 respondents. Application of the Spearman Brown correction of split-half to the correlation coefficient yields a reliability coefficient of 0.80. Cronbach's alpha reliability coefficient is 0.781 for this group. The results of an administration of the SAI II to 557 students indicated that the scales of the instrument can distinguish between those who have more positive attitudes toward science and those who have less positive attitudes as determined by the total score on the SAI II. The t-test comparison of the high and low scores is evident in that the various subscales contribute positively to the total score of the instrument. Coupled with judgments that the items of the instrument are related to the scientific attitudes it is supposed to assess, validity is claimed for the SAI II.

TABLE 2 POINT VALUES FOR POSITIVE ITEMS AND FOR NEGATIVE ITEMS

	Positive Items	Negative Items
Strongly agree	5	1
Mildly agree	4	2
12 neutral/undecided	3	3
Mildly disagree	2	4
Strongly disagree	1	5

2.4.1.3. Science attitude scale for middle school students

The science attitude scale for middle school students (SASMSS) was developed by Frank L. Misiti, Robert L. Shrigley, and Lylee Hanson in 1991. There are 23 statements to assess students' attitudes toward science that are divided into 5 subcomponents of the attitude object as follows (Misiti; & Shrigely; & Hanson. 1991).

Subcomponent 1: Investigations - eight items

Subcomponent 2: Comfort/discomfort - six items

Subcomponent 3: Learning science content - four items

Subcomponent 4: Reading and talking about science - three items

Subcomponent 5: Viewing films on TV -two items'

The SASMSS has passed several tests suggesting some degree of validity. For the internal consistency, the coefficient alphas for the 23 items on the two set of data were 0.96 and 0.92, respectively, strongly suggesting that the items are interconnected.

TABLE 3 THE RESULTS OF TESTING EACH SUBCOMPONENT AS A SINGLE

Subcomponent	Coefficient alpha	Number of items
1. Using science materials (Investigative processes)	0.81	8
2. Comfort-discomfort related to classroom science	0.68	6
3. Learning science content	0.73	4
4. Reading or talking about science	0.04	3
5. Viewing science films on TV specials	0.66	2
Total Scale	0.91	23

2.4.1.4. The children's attitude toward the environment scale (CATES)

The children's attitude toward the environment scale (CATES) was developed by Musser, Lynn M. in 1994. This instrument is used to measure environmental attitudes of grade school children. The scale items reflect children's knowledge of environmental issues, and the scale uses an age-appropriate format. The 25 items that make up the scale were selected through item analysis from a larger pool of items. The internal consistency reliability of the scale (Cronbach's alpha) ranged from 0.70 to 0.85. Test-retest reliability was 0.68.

The CATES describes two different groups of children. When scales are administered, children are first instructed to choose which of the two groups of children described in the statements they are most like. Under each statement are two boxes (one large, one small) for marking an answer. Children check the larger box if they think they behave like the children described in the statement. They check the smaller box if they believe that they do not behave like the children described in the statement.

2.4.1.5 Constructivist learning environment survey (CLES)

The constructivist learning environment survey (CLES) was developed from the perspective of critical constructivism which recognizes that the cognitive constructive activity of the individual learner occurs within, and is constrained by, a socio-cultural context (Taylor. 1994: 30). The CLES comprised 30 items each of which was designed to obtain measures of students' perceptions of key aspects of their classroom learning environment. The version of the CLES had a 5-point Likert-type frequency response scale which comprises the categories: Almost always (5 points), often (4), sometimes (3) seldom (2), and almost never (1). Of particular interest in this study are the Cronbach alpha reliability coefficients which provide a measure of the internal consistency of each of the five CLES scales. In learning environment research, alpha coefficient values in excess of 0.70 are regarded generally as indicating satisfactory degrees of internal consistency.

2.1.4.6 The reliability for instruments in Thai version

The reliability for each instruments in Thai version are summarized as in TABLE 4.

TABLE 4 RELIABILITY FOR THE INSTRUMENTS IN THAI VERSION

Instrument	Reliability (r)
Science Process Assessment for Middle School Students	0.81
The Scientific Attitude Inventory: A revision (SAI II)	0.81
Science Attitude Scale for Middle School Students (SASMSS)	0.91
The Children's Attitude Towards the Environment Scale (CATES)	0.80
Constructivist Learning Environment (CLES)	0.83

The content validity index (CVI) for each instrument in Thai version was analyzed. Each answer from the questionnaire of three level rating scales is weighed by the four experts as follows (Reinard. 2006: 137-139):

Consistent	is weight as	+1
Unsure	is weight as	0
Inconsistent	is weight as	- 1

The formula used to calculate the CVI is

$$CVI = \frac{\Sigma R}{N}$$

Where CVI means the content validity index

ΣR means Summation of expert' opinion marks

N means A number of expert

CVI indicating the consistency of the instruments' item was over 0.25.

2.4.2 Qualitative data collection

In addition to the evaluation of the science program by using the quantitative instruments listed above, the phenomenological study was conducted to explore student's science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment. In the conduct of phenomenological study, the focus was on the essence of the students' experience when they participate in the science program (Merriam, 1998: 15). Therefore, the meaning of the student's science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment were determined using a comparative case study of their experience before and after they participated in the science program. By comparing and contrasting the results of this study, the effectiveness of the implementation of the science program were evaluated. The qualitative data were collected from both observation and interviews.

2.4.2.1 Observation

To evaluate the student's science process skills during the CTSPZ activities, the researcher gathered field notes by conducting an observation as an observer (Creswell. 1998: 121). In addition, data were collected from direct observation during the activity. The rating scale , science process skills observation instrument, records the degrees of behavior that is observed were developed to ensure that only the behaviors specified are the focus of observation.

2.4.2.2 Interview

The interview was conducted as a semi-structured interview. The interview was audio taped and transcribed to explore students' scientific attitude, attitude toward science, and attitude toward the environment. Following are interview questions for students.

Attitude toward science

1. How do you feel about science?
    - Do you like or don't like science?
    - What do you like (or don't like) about science?
2. Have you ever applied knowledge about science into your life?

- If so, when?
- How?
- Where?

3. Have you ever discussed science with friends or talk to your parents about science outside the classroom? Please explain your answer.
4. Do you think that what you learn in science is part of your life outside school? Please explain your answer.

Scientific attitude

5. Do you view science information and methods as unchangeable? Please explain.
6. On scale of 1 to 10, how important is science?
7. Would you like to be a scientist after you finish school? Why or why not?

Attitude toward the environment

8. Do you leave water running while you brush your teeth? Why?
9. Please explain how you use a paper when you draw or write something. Is it important to use both sides of the paper?
10. Are people and animals equally important?

3. Phase three: program evaluation.

3.1 Quantitative data analysis

Upon completion of all instruments; science process assessment for middle school students (SAMSS), the scientific attitude inventory: a revision (SAI II), science attitude scale for middle school students(SASMSS), the children's attitude towards the environment scale (GATES), a constructivist learning environment survey (CLES), and the collected quantitative data were analyzed using the following procedure:

1. Descriptive statistic, mean, standard deviation, and variance was calculated for all instruments.
2. The t-test of significance was performed using the results data from SAMSS ,SAI II, SASMSS ,CATES, and CLES before and after using the science program.

3. 2 Qualitative data analysis

The specific approach to phenomenological analysis as advanced by Moustakas (1994) was used to analyze qualitative data. In this study, six steps from the Stevick-Colaizzi-Keen method (Creswell. 1998. 179) were used as follows.

1. Full description of students' own experiences while they are participating in the science program was explored.

2. The statements (in the observation and interview) about how students have experienced the topic were described. These significant statements were listed and each statement was treated as equal. Lists of non repetitive, non overlapping statements were developed.

3. These statements were then grouped into "meaning units". A description of the texture of the experience (what happened)including verbatim examples were written.

4. Structural description of all possible meanings, and divergent perspectives, various frames of reference about the phenomenon, and how the phenomenon was experienced, were reflected.

5. Overall description of the meaning and the essence of the experience were constructed.

6. This process was followed first for my accounts of the experience and then for that of each participant. After this, "composite" descriptions were written.

CHAPTER 4
Results

The purpose of this study was to develop the constructivist thematic science program at Chiangmai zoo (CTSPZ). This chapter contains the results of program design, program implementation, and program evaluation in the form of statistical data. Various tables are presented in this chapter along with brief explanations of the data. The research study was completed in the public arena at the Chiangmai zoo with middle school students.

The following is a summary of the findings from the data collected.

1. Phase one: program designing

1.1 Identification of learner needs

1.1.1 Specialist

Today the zoological park organization is comprised of 3 departments the administrative and supply department, development and planning department, the technical department and there are 5 zoos: Dusit zoo, Chiangmai zoo, Nakhonratchasima zoo, Khao kheow zoo and Songkhla zoo. Development of a zoo guide is one of the important concepts for all zoos. However, only one educational curriculum has been developed for the visitor at Khao kheow zoo. The structure of that curriculum has more emphasis on animal behaviors and its nature. Although the curriculum was developed as an interdisciplinary curriculum, none of its contents is relevant to the national science standards. Therefore, a science curriculum for the education at all zoos is needed.

1.1.2 Clients

From the study of a master plan of Thai zoo education in 2005, it was found that there are about one million visitors at Chiangmai zoo each year. The highest numbers of the visitor in each category were as follows:

Age	10-15 years old	52.10%;
Time spent	3-4 hours	28.92%;
Purpose	education	37.36%;
Educational area	science	30.36%;

Needs educational materials 30.71%.

Task analysis

Ten students who visited Chiangmai zoo were observed by the researcher. Task analysis of the activities during their visits was rated. The importanceconditions, and using percentage in each activity and any omitted tasks are show in TABLE 5.

TABLE 5 TASK ANALYSIS: ZOO VISIT

Task	Conditions	Using Percentage	Importance
Reading information board	Animal cage	40%	Critical
Watching animal show	Any place	None	Critical
Asking question	Any place	None	Critical
Group working	Anyplace	60%	Critical
Science subject	Animal cage	None	Importance
- Biology	Any place	None	Critical
- Chemistry	Any place	None	Critical
- Physics	Any place	None	Critical
- Earth science	Any place	None	Critical

Summary

After determination of the learner needs, a constructivist thematic science program at Chiangmai zoo (CTSPZ) was developed for middle school students for ages 10-15 years old. The main purpose was to customize the needs of particular teachers and students and integrate with formal school science standards. The CTSPZ was designed to be an instructional resource for educators who want to introduce students to hands-on/minds-on activities that encourage a constructivist approach and influence science process skills, attitudes toward science, scientific attitude, attitudes toward the environment, and constructivist learning environments. Each unit takes 3 hours and provides informational materials including a teacher guiding book and student's activities book that include pre-and post- visit activities, on-site activities, and data sheets for use at the Chiangmai zoo.

1.2 Articulating program intentions

1.2.1 Program rationale

The rationale for designing this program was based on constructivism theory. Constructivism is a child-centered theory and the practice of education which encourages and prizes students' active participation in the learning process. Student-constructed knowledge is more useful to the learner than information which is passively received (cite?). A basic tenet of constructivist teaching is that students, when they are allowed to be self-directed learners, will learn in myriad, and often unexpected ways.

The rationale was written as a statement of how the subject has been interpreted and developed in a teaching, learning, and assessment program to suit a particular student and the zoo setting in a three-part structure as follows:

1. Describe the setting (e.g. student background and needs, resources, timetable);
2. Describe the intended teaching program (e.g. scope, themes, methods) and explain how it is designed to meet the needs of the particular student group;
3. Explain how the assessment outline is designed to provide an opportunity for the student group to succeed.

1.2.2 Program goals

Three program goals were written in order to influence the reader's feelings about the program as a whole.

1. To promote the CTSPZ as a model system linked with informal and formal science education based on the national science standards for level 3 students.
2. To enhance students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and the constructivist learning environment.
3. The CTSPZ was developed as a prototype for science teachers to adapt and use in the setting of each school.

1.2.3 Contents of science standard

A comprehensive set of national science standards was selected as follows:

1. Standard Sc 1.2: At the end of the highest grade of each level the

student should be able to explore, search for information and explain the regional biodiversity that has maintained an equilibrium of life forms, and the positive and negative impacts, especially, infectious and contagious diseases affecting large populations.

2. Standard Sc 2.1: At the end of the highest grade of each level the student should be able to explore and analyze the status of various local ecosystems, explain relationships between components within the eco-system, energy transfer, cycles of substances and change of population size.

3. Standard Sc 3.1: At the end of the highest grade of each level the student should be able to investigate homogeneous substances, discuss and explain acid-base properties, pH values and apply the notion of acid-base of substances.

4. Standard Sc 4.2: The student should be able to understand types of motion of natural objects, have experienced investigative processes and possess of a scientific mind, communicate and make good use of knowledge acquired.

5. Standard Sc 4.1: At the end of the highest grade of each level the student should be able to discuss and explain that forces are vector quantities, experiment to determine the resultant of several coplanar forces on the object.

6. Standard Sc 6.1: At the end of the highest grade of each level the student should be able to investigate, discuss and explain soil profiles, soil properties, soil quality improvement and its uses.

1.3 Planning instruction

1.3.1 Specifying instructional content

The CTSPZ program is comprise of 6 units as shown in FIGURE 8.

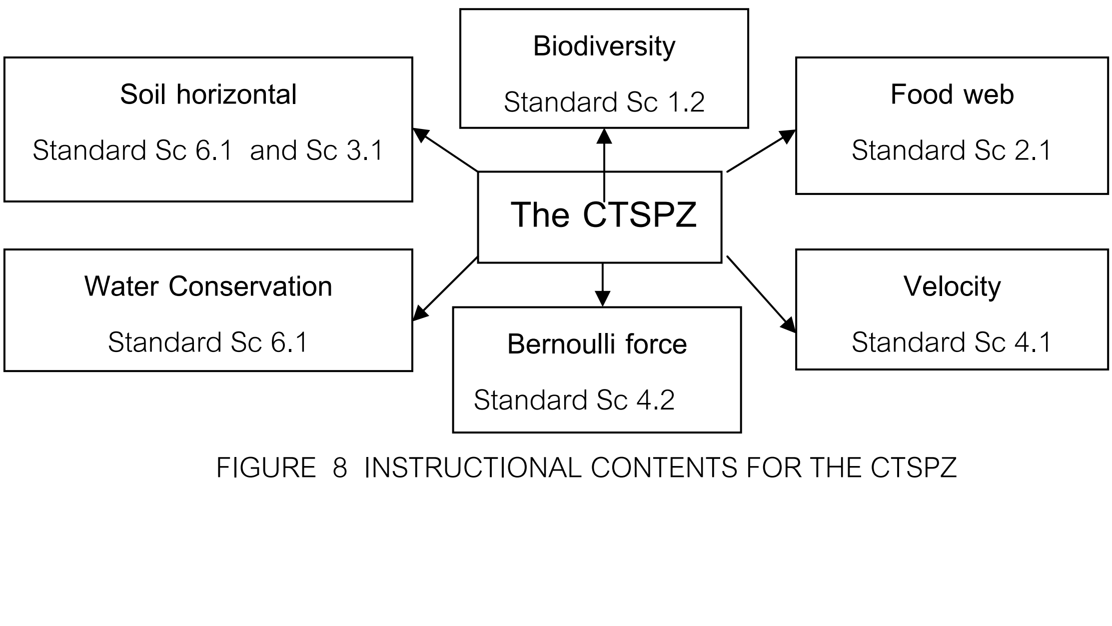

FIGURE 8 INSTRUCTIONAL CONTENTS FOR THE CTSPZ

Each unit contains background information, science standards, science content, teaching strategies, student activities, and assessments that have been developed around a variety of scientific themes.

The themes and science process skills were categorized in TABLE 6.

TABLE 6 A CATEGORIZATION OF SCIENCE PROCESS SKILLS IN THE CTSPZ

Process of science	Unit					
	Soil horizontal	Biodiversity	Water	Food Web	Bernoulli force	Velocity
1. Observing	✓	✓	✓	✓	✓	✓
2. Classifying	✓	✓	✓			
3. Inferring	✓	✓	✓	✓	✓	✓
4. Predicting	✓			✓	✓	✓
5. Measuring	✓					✓
6. Communicating	✓	✓	✓	✓	✓	
7. Using space/ time relationship						✓
8. Defining operationally						✓
9. Formulating hypothesis						✓
10. Experimenting	✓					✓
11. Recognizing variables						✓
12. Interpreting data	✓	✓	✓			✓
13. Formulating Models		✓				

1.3.2 Integrating thematic units

These complementary subjects were intimately integrated into the CTSPZ as is shown in Appendix 3.

1.3.3 Specifying teaching strategies

The constructivist learning design (CLD) developed by Gangnon and Collay was selected as a teaching strategy to present a constructivist perspective on how to arrange the events of students learning. CLD is composed of six basic parts flowing back and forth into one another in the actual operation of learning.

1. The situation frames the agenda for student engagement by delineating the goals, task, and forms the learning episode.
2. Groupings are the social structures and group interactions that will bring students together in their involvement with the tasks and forms of the learning episode.
3. Bridge refer to the surfacing of students' prior knowledge before introducing them to the new subject matter. The bridge is at the heart of the constructivist methodology; students are better able to focus their energies on new content when they can place it within their own cognitive maps, values, attitudes, expectations, and motoric skills.
4. Question aim to instigate, inspire, and integrate students thinking and the sharing of information. Questions are prompts or responses that stimulate, extend, or synthesize student thinking and communication during a learning episode.
5. An exhibit asks students to present publicly what they have learned; this social setting provides a time and place for students to respond to queries raised by the teacher, by peers, or by visitors about the artifacts of learning.
6. Reflections offer students and teachers opportunities to think and speak critically about their personal and collective learning. This encourages all participants to synthesize their learning, to apply learning artifacts to other parts of the curriculum, and to look ahead to future learning episodes.

1.3.4 Planning for assessment

A questionnaire for self-assessment in small-group discussions (Pratt, D. 1994: 118) was used in this study. The student responsibility for their work was assessed by the observer, and observation records were use as formative assessment. In addition, five instruments were used to study the dependent variables.

1.4 Consulting with curriculum experts to examine and verify the draft CTSPZ

Five experts reviewed the instrument against the goals and table of specifications in order to establish an estimate of content validity. These persons were identified on the basis of their expertise in the fields of the zoo and the science curriculum. Each specialist was sent a copy of the directions and draft of (a) the cover letter, (b) goals, (c) the table of specifications, and (d) questions comprising the program. The specialists worked independently and forwarded their findings back to the researcher. The returns were collated and reviewed and items were revised as per the recommendations of the specialists.

1.4.1 The suitability of the draft program is presented as a basic statistic of mean (M) and standard deviation (S.D.). Each answer from the questionnaire of the five level rating scales is weighted as follows (adapted from Chabawat Bunnang, 2005):

5 means the most suitable

4 means very suitable

3 means suitable

2 means not very suitable

1 means the least suitable

Results of the suitability were categorized into 5 levels

4.51 – 5.00 means the most suitable

3.51 – 4.50 means very suitable

2.51 – 3.50 means suitable

1.51 – 2.50 means not very suitable

1.00 – 1.50 means the least suitable

TABLE 7 LEVEL OF SUITABILITY OF THE DRAFT PROGRAM

Items	N=5		Level of suitability
	X	S.D.	
1. The program rationale is suitable.	3.60	0.55	Very suitable
2. The program rationale is relevant to necessity in daily life.	3.60	0.55	Very suitable
3. The program rationale is suitable for learners' development.	4.00	0	Very suitable
4. The program goals are clear.	3.60	0.45	Very suitable
5. The program goals are feasible and practical.	3.80	0.89	Very suitable
6. The program content appropriate to level three learners.	3.60	0.71	Very suitable

TABLE 7 (continued)

Items	N=5		Level of suitability
	X	S.D.	
7. The program contents are feasible and practical			
Units of learning			
Soil component and soil horizontal	3.80	0.45	Very suitable
Food chain and food web	3.60	0.55	Very suitable
Force and motion	3.60	0.55	Very suitable
Water conservation	3.40	0.55	Very suitable
Biodiversity	3.60	0.55	Very suitable
Bernoulli force	3.40	0.55	Very suitable
8. The content structure in each unit of learning meets the objectives.	3.80	0.45	Very suitable
9. The content is suitable for the learners' development	3.40	0.55	Very suitable
10. The duration of the implementation is suitable.	2.80	0.84	Suitable
11. Content classification (in each unit) is suitable.	3.60	0.55	Very suitable
12. Content prioritization is suitable.	3.60	0.55	Very suitable
13. Learning activities are appropriate to level three learners.	3.60	0.55	Very suitable
14. Learning activity encourage constructivism approach	3.40	0.55	Very suitable
15. The zoo settings are suitable for the program content.	3.60	0.89	Very suitable
16. The informal learning at Chiangmai zoo is suitable for the program content.	3.60	0.89	Very suitable
17. Teaching strategies in each activity of learning are suitable.	3.60	0.55	Very suitable
18. Instructional media and learning materials for appropriate for level three learners.	3.40	0.89	Very suitable
19. Instructional media and learning material are suitable for the content.	3.40	0.89	Very suitable

TABLE 7 (continued)

Items	N=5		Level of suitability
	X	S.D.	
20. Instructional media and learning material encourage learning	3.60	0.55	Very suitable
21. Evaluation in each unit of learning is appropriate for level three learners.	3.40	0.89	Very suitable
22. Composition of the curriculum is suitable.	3.40	0.89	Very suitable

1.4.2.2 The content validity index (CVI) for each instruments in the Thai version was analyzed. Each answer from the questionnaire of the three level rating scales was weighed by the four experts as follows (Reinard. 2006: 137-139)

Consistent	is weight as	+1
Unsure	is weight as	0
Inconsistent	is weight as	- 1

The formula used to calculate the CVI is

$$CVI = \frac{\Sigma R}{N}$$

Where	CVI	means	The content validity index
	Σ R	means	Summation of expert' opinion marks
	N	means	A number of expert

CVI indicating the consistency of the instruments' item was over 0.8.

TABLE 8 CONSISTENCY OF THE DRAFT PROGRAM

Items	N=5
	CVI
1. Rationale and goal	0.80
2. Rational and instructional strategies	0.80
3. Goal and instructional strategies	0.80

TABLE 8 (continued)

Items	N=5 CVI
4. Rationale and goal	0.80
5. Rational and instructional strategies	0.80
6. Goal and instructional strategies	0.80
7. Goal and instructional content	0.80
8. Goals and learning activity	0.60
9. Instructional content in each unit	0.80
10. Instructional content and instructional strategies	0.80
11. Learning activity and instructional plan	0.80
12. Instructional plan and learning materials	0.80
13. Instructional plan and assessment	0.60
14. Instructional content and assessment	0.80
15. Learning material and assessment	0.60
16. Learning activity and assessment	0.80

Suggestions from the experts

In addition to the evaluation shown above, the experts also gave suggestions for the program improvement as follows:

1. Each unit should be also organized in the form of concept map in order to make it more clear for the reader to understand the overview in each unit.

2. The CTSPZ should emphasize more on wild life and the resources at the Chiangmai zoo.

3. The learning process should have more emphasis both on education and entertainmentfor the students to learn in the informal setting.

4. The activities in the CTSPZ should be in various forms, such as, using role play, inviting experts in each area to meet students, and using a story tale.

5. Instructional material should be more attractive to students in order to gain their attention and motivate them to learn.

1.4 Pilot study

1.5.1 Pilot study

According to the experts' suggestions, the CTSPZ was revised and a pilot study was conducted on part of the program. Two groups of ninth grade students from Chiangmai University demonstration school participated in the pilot study in January 2007. Experimental group had a sample size of 40 while a control group had a sample size of 42.

1.5.2 Collection and evaluation of the pilot study data

One day prior to the experimental group traveling to the zoo, the students' in both groups were administered a pretest (science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment). The next day the experimental group attended a two hour CTSPZ program at the zoo conducted by researcher during their regular formal school day. Meanwhile the control group attended the regular classes at the school. The following day a posttest was administered to all students in both groups.

The results of the differences between the pretest and posttest in both groups were analyzed to assess the effectiveness of the CTSPZ program. The results revealed that there was a positive change in scientific attitude, attitude towards science and, and attitude towards the environment for the experimental group students who experienced the CTSPZ as their outdoor field trip. However, there was no scientifically different on science process skills in the experimental group. The experimental group gained higher scores in scientific attitude, attitude towards science and, attitude towards the environment, and constructivist learning environment than that of the control group. There were some problems during the pilot study as follows.

1. Time management

- Students took more than 2 hours in order to finish the activities in each units.
- In regular school day, it was hard to get the students back to school on time. Therefore, it affected the timetable of other class periods.

2. Informal environment

Although students learned in the informal setting at the zoo, they still wore the formal student uniforms. As a result, the students didn't feel as relax as they should have in the informal learning environment. Moreover, students' movement and some activities were limited by the uniforms.

3. Instructional materials

There were too much instructional materials used in each activity. Moreover, some instructional materials were not handy, so it was not convenient for using them in the informal setting of the zoo.

1.6 Revision the draft science program for Chiangmai zoo

Some of CTSPZ units were tried out to check for the possibility of using them in the learning activities. The results from the pilot study revealed the problems of the CTSPZ program; therefore, the CTSPZ was revised on the following topics.

1.6.1 The organization in each unit

- A concept map was added in each unit in order to give an overview on the unit content.
- The CTSPZ was revised regarding a wildlife and resources at the Chiangmai zoo.
- Cartoon pictures were added in the instructional materials such as a student work sheet and student handouts, in order to gain the student's attention and motivate them to learn.
- Story tale was added in some units as a variety of learning.

1.6.2 Instructional material

Instructional materials were designed to be more handy in the field study such as plastic cups were used instead of glass beakers.

1.6.3 Time management

The time period in each unit is expanded to 3 hours in order to give students more time in each of the activities.

1.6.4 Evaluation

Various forms of evaluation were added in order to provide formative and summative assessments.

2. Phase two: program implementation

After revising the program according to the experts' suggestion, the mixed method, control group interrupted time series design was used in this study to evaluate the effectiveness of the program. The program was implemented with level 3 students from Chiangmai University demonstration school (Satit CMU) and Navamindarajudis Phayap school (NMP) during May – August 2007. The numbers of the subjects in both schools were classified as show in TABLE 9.

TABLE 9 CLASSIFICATIONS OF SUBJECTS BASED ON TWO SCHOOLS

	Number of students							
	Experimental group				Control group			
School Grade	7	8	9	Total	7	8	9	Total
Satit CM	10	10	10	30	10	10	10	30
NMP	10	10	10	30	10	10	10	30
Total	**20**	**20**	**20**	**60**	**20**	**20**	**20**	**60**

The experimental group students were attended the CTSPZ in all six units during May-June 2007. The details in each unit are shown below:

Unit	Period (hours)
Biodiversity	3
Food web	3
Soil horizontal	3
Water conservation	3
Bernoulli force	3
Velocity	3

3. Phase three: program evaluation

The data were collected from both quantitative and qualitative forms to test the research hypotheses as follows:

1. The designed CTSPZ program significantly influences student's ability to use science process skills.

2. The use of the designed CTSPZ program significantly influence students' scientific attitude.

3. The designed CTSPZ program significantly influence students' attitude towards science.

4. The designed CTSPZ program significantly influence students' attitude towards the environment.

5. The incorporation of the CTSPZ provides a constructivist learning environment.

The results of the program implementation are presented below.

3.1 Quantitative data analysis

3.1.1 Science process skills

The science process assessment for middle school students (SPAMSS) was used to identify the student proficiency in the use of the science process skills. The instrument is 50 multiple-choice test items, accompanied by a list of appropriate indicators of student behaviors. The range of scores for the science process skills is 0-50 (0-1 x 50 items).

3.1.1.1 Comparison of the pretest scores of student's science process skills.

The independent sample t- test was used to analyze the difference between experimental and control groups. The t-test results of pretest scores of the experimental and control groups are presented in TABLE 10. It was shown that the *p*-value of all participants (0.648) was higher than the 0.05 level indicating the mean pretest scores of students' science process skills between the experimental and control groups were not significantly different at the 0.05 level.

The *p*-values of Satit CMU (0.703) and NMP (0.387) were also higher than the 0.05 level, indicating the mean pretest scores of the students' science process skills between the experimental and control groups were not significantly different at the 0.05 level in both schools. However, there was a difference in mean scores between students from Satit CMU (42.37 and 42.87) and NMP (27.87 and 25.87) in both the experimental group and the control group, respectively. Therefore, on the posttest, Satit

CMU indicated as a high score on science process skills and NMP indicated as a low score on science process skills, were analyzed separately.

TABLE 10 T-TEST RESULTS OF PRETEST SCORES OF STUDENT'S SCIENCE PROCESS SKILLS

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			42.37	4.82	11.38		
		58	50				0.383	0.703
Control group	30			42.87	5.28	12.32		
NMP								
Experimental group	30			27.87	10.13	36.35		
		58	50				0.872	0.387
Control group	30			25.87	7.42	28.68		
All participant								
Experimental group	60			35.26	10.87	30.82		
		118	50				0.457	0.648
Control group	60			34.37	10.68	31.07		

3.1.1.2 Comparison of the posttest scores of student's science process skills

The t-test results of pretest scores of the experimental and control groups are presented in TABLE 11. It was shown that the *p*-value of all participants (0.053) and Satit CMU (0.288) was higher than the 0.05 level indicating the mean posttest scores of the students' science process skills between the experimental and control groups were not significantly different at the 0.05 level. On the other hand, the *p*-value of NMP (0.035) was lower than the 0.05 indicating the mean posttest scores of the students' science process skills between the experimental (34.23) and control groups (29.50) were significantly different at the 0.05 level.

TABLE 11 T-TEST RESULTS OF POSTTEST SCORES OF STUDENT'S SCIENCE PROCESS SKILLS

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			42.80	3.48	8.13		
		58	50				1.072	0.288
Control group	30			41.23	7.13	17.29		
NMP								
Experimental group	30			34.23	8.13	23.75		
		58	50				2.153*	0.035
Control group	30			29.50	8.88	30.10		
All								
Experimental group	60			38.58	7.60	19.70		
		118	50				1.953	0.053
Control group	60			35.43	9.91	27.97		

* $p < 0.05$

For a low score in science process skills students (NMP), TABLE 12, it was found that the *p*-value of defining operationally (0.001) and interpreting data skills (0.006) were lower than the 0.01 indicating the mean posttest scores between the experimental (2.30, 4.37) and control groups (1.63, 3.43) were significantly different at the 0.01 level, respectively. In addition, it was found that the *p*-value of formulating models skills (0.013) were lower than the 0.05 level indicating the mean posttest scores between the experimental (2.87) and control groups (2.10) were significantly different at the 0.05 level.

TABLE 12 T-TEST RESULTS OF POSTTEST SCORES OF A LOW SCORE STUDENT'S IN SCIENCE PROCESS SKILLS

Skills	N	df	k	M	S.D.	CV	t	p
1. Observing								
Experimental group	30			1.93	0.69	35.75		
		58	3				0.338	0.737
Control group	30			2.00	0.83	41.50		
2. Classifying								
Experimental group	30			2.87	1.10	38.33		
		58	4				1.639	0.107
Control group	30			2.33	1.40	60.08		
3. Inferring								
Experimental group	30			2.90	0.88	30.34		
		58	4				0.642	0.523
Control group	30			3.07	1.12	38.32		
4. Predicting								
Experimental group	30			2.70	1.11	41.11		
		58	4				0.992	0.325
Control group	30			2.40	1.22	50.83		
5. Measuring								
Experimental group	30			4.17	1.26	30.22		
		58	6				1.830	0.072
Control group	30			3.57	1.27	35.57		
6. Communicating								
Experimental group	30			4.17	0.82	25.07		
		58	5				0.257	0.798
Control group	30			3.57	1.15	34.53		

TABLE 12 (continued)

Skills	N	df	k	M	S.D.	CV	t	p
7. Using space/ time relationship								
Experimental group	30			2.50	1.20	48.00		
		58	4				0.400	0.690
Control group	30			2.37	1.37	57.80		
8. Defining operationally								
Experimental group	30			2.30	0.70	30.43		
		58	3				3.653**	0.001
Control group	30			1.63	0.72	44.17		
9. Formulating hypothesis								
Experimental group	30			1.27	0.74	58.27		
		58	2				1.560	0.124
Control group	30			0.93	0.91	97.85		
10. Experimenting								
Experimental group	30			1.77	0.89	50.28		
		58	3				1.149	0.255
Control group	30			1.50	0.90	60.00		
11. Recognizing variables								
Experimental group	30			0.97	0.76	78.35		
		58	2				1.526	0.132
Control group	30			0.67	0.75	149.25		
12. Interpreting data								
Experimental group	30			4.37	1.24	28.35		
		58	6				2.834**	0.006
Control group	30			3.43	1.30	37.90		

TABLE 12 (continued)

Skills	N	df	k	M	S.D.	CV	t	p
13. Formulating models								
Experimental group	30			2.87	1.07	37.28		
		58	4				2.558*	0.013
Control group	30			2.10	1.24	59.04		

* $p < 0.05$

** $p < 0.01$

For a high score in science process skills students (Satit CMU), TABLE 13, it was found that the *p*-value of formulating hypothesis skills (0.035) was lower than the 0.05 level indicating the mean posttest scores between the experimental (1.77) and control groups (1.47) were significantly different at the 0.05 level.

TABLE 13 T-TEST RESULTS OF POSTTEST SCORES OF A HIGH SCORE STUDENT'S IN SCIENCE PROCESS SKILLS

Skills	N	df	k	M	S.D.	CV	t	p
1. Observing								
Experimental group	30			2.47	0.730	29.55		
Control group		58	3				0.891	0.377
	30			2.63	0.718	27.30		
2. Classifying								
Experimental group	30			3.03	0.927	30.59		
		58	4				1.109	0.272
Control group	30			2.76	0.935	33.88		
3. Inferring								
Experimental group	30			3.73	0.449	12.03		
		58	4				0.706	0.483
Control group	30			3.60	0.932	25.89		

TABLE 13 (continued)

Skills	N	df	k	M	S.D.	CV	t	p
4. Predicting								
Experimental group	30			3.07	0.785	25.57		
		58	4				0.000	1.000
Control group	30			3.07	0.691	22.50		
5. Measuring								
Experimental group	30			4.87	1.166	23.94		
Control group		58	6				0.649	0.519
	30			4.63	1.586	34.25		
6. Communicating								
Experimental group	30			4.03	0.668	16.57		
		58	5				1.356	0.180
Control group	30			3.80	0.664	17.47		
7. Using space/ time relationship								
Experimental group	30			3.43	0.727	21.19		
		58	4				0.935	0.354
Control group	30			3.20	1.157	36.15		
8. Defining								
operationally	30			2.63	0.490	18.63		
Experimental group		58	3				0.995	0.324
	30			2.47	0.776	31.42		
Control group								
9. Formulating hypothesis								
Experimental group	30			1.77	0.504	28.47		
		58	2				2.157*	0.035
Control group	30			1.47	0.571	38.84		

TABLE 13 (continued)

Skills	N	df	k	M	S.D.	CV	t	p
10. Experimenting								
Experimental group	30			2.50	0.777	31.08		
		58	3				1.161	0.250
Control group	30			2.70	0.535	19.81		
11. Recognizing variables								
Experimental group	30			1.87	0.571	30.53		
		58	2				0.000	1.000
Control group	30			1.87	0.507	27.11		
12. Interpreting Data								
Experimental group	30			5.56	1.104	19.86		
		58	6				1.195	0.237
Control group	30			5.17	1.461	28.26		
13. Formulating models								
Experimental group	30			3.44	0.783	22.76		
		58	4				0.088	0.930
Control group	30			3.47	0.819	23.60		

3.1.1.3 Comparison of the student's science process skills between posttest and retention score of the experimental groups.

The t-test results between posttest and retention scores of the experimental groups are presented in TABLE 14. It was shown that the *p*-value of all participants, Satit CMU, and NMP are 0.095, 0.392, and 0.080 respectively. These *p*-values were higher than the 0.05 level indicating the mean scores between posttest and retention of students' science process skills were not significantly different at the 0.05 level of significances in all groups.

TABLE 14 T-TEST RESULTS BETWEEN POSTTEST AND RETENTION SCORE OF STUDENT'S SCIENCE PROCESS SKILLS

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Posttest	30			42.80	3.48	8.13		
		58	50				0.863	0.392
Retention	30			43.53	3.08	7.07		
NMP								
Posttest	30			34.23	8.07	23.57		
		58	50				1.785	0.080
Retention	30			39.97	8.13	20.37		
All								
Posttest	60			38.58	7.60	19.67		
		118	50				1.683	0.095
Retention	60			40.78	6.68	16.38		

3.1.2 Scientific attitude

The scientific attitude inventory: a revision (SAI II) was developed by Richard W. Moore in 1995. A revised version of the scientific attitude inventory (SAI) was developed and field tested in 1983. The SAI II has 40 five-response Likert-type scale attitude statements to assess the students' scientific attitude. The range of scores for scales 6A and 6B is 40-200 (1-5 x 40 items). The range of scores for the entire SAI II is 40-200 (1-5 x 40 items).

3.1.2.1 Comparison of the pretest scores of student's scientific attitude

The t-test results of pretest scores of the experimental and control groups are presented in TABLE 15. For all participants, it was shown that the *p*-value (0.407) was higher than 0.05 indicating the mean scores of the students' scientific attitude between the experimental (135.10) and control groups (133.15) were not significantly different at the 0.05 level.

The *p*-values of Satit CMU (0.965) and NMP (0.248) were also higher than 0.05 indicating the mean pretest scores of the students' scientific attitude between the experimental and control groups were not significantly different at the 0.05 level in both schools.

TABLE 15 T-TEST RESULTS OF PRETEST SCORES OF STUDENT'S SCIENTIFIC ATTITUDE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			136.97	11.32	8.26		
		58	200				0.044	0.965
Control group	30			137.10	12.06	8.79		
NMP								
Experimental group	30			126.43	6.44	5.09		
		58	200				1.167	0.248
Control group	30			124.47	6.61	5.31		
All participant								
Experimental group	60			135.10	12.78	9.46		
		118	200				0.832	0.407
Control group	60			133.15	12.89	9.68		

3.1.2.2 Comparison of the posttest scores of student's scientific attitude

The t-test results of posttest scores of the experimental and control groups are presented in TABLE 16. For all participants, it was shown that the *p*-value (0.018) was lower than 0.05 indicating the mean scores of the students' scientific attitude between the experimental (134.53) and control groups (129.83) were significantly different at the 0.05 level of significance.

The *p*-values of Satit CMU (0.001) and NMP (0.013) were also lower than the 0.01 and 0.05 levels respectively indicating the mean posttest scores of students' scientific attitude between the experimental and control groups were significantly different at the 0.01 and 0.05 level in both schools respectively.

TABLE 16 T-TEST RESULTS OF POSTTEST SCORES OF STUDENT'S SCIENTIFIC ATTITUDE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			144.57	7.67	5.30		
		58	200				3.532**	0.001
Control group	30			135.37	12.01	8.87		
NMP								
Experimental group	30			130.83	8.99	6.87		
		58	200				2.250*	0.013
Control group	30			125.63	6.62	5.27		
All participant								
Experimental group	60			134.53	10.92	8.12		
		118	200				2.409*	0.018
Control group	60			129.83	10.44	8.04		

* $p < 0.05$

** $p < 0.01$

3.1.2.3 Comparison of the student's scientific attitude between posttest and retention score of the experimental groups.

The t-test results between posttest and retention scores of the experimental groups are presented in TABLE 17. For all participants, the *p*-value of the experimental group (0.332) were higher than 0.05 indicating the mean scores between posttest (136.55) and retention score (134.53) of students' scientific attitude were not significantly different at the 0.05 level of significance.

The p-values of Satit CMU (0.913) and NMP (0.253) were also higher than 0.05 indicating the mean scores of the students' scientific attitude between posttest and retention were not significantly different at the 0.05 level in both schools.

TABLE 17 T-TEST RESULTS BETWEEN POSTTEST AND RETENTION SCORE OF STUDENT'S SCIENTIFIC ATTITUDE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Posttest	30			144.57	7.69	5.32		
		58	200				0.110	0.913
Retention	30			144.30	10.89	7.55		
NMP								
Posttest	30			130.83	8.99	6.87		
		58	200				1.155	0.253
Retention	30			134.07	12.42	9.26		
All								
Posttest	60			134.53	10.92	8.12		
		118	200				0.974	0.332
Retention	60			136.55	11.73	8.59		

3.1.3 Attitude toward science

The science attitude scale for middle school students (SASMSS) was developed by Frank L. Misiti, Robert L. Shrigley, and Lylee Hanson in 1991. There are 23 statements to assess students' attitudes toward science that are divided into 5 subcomponents of the attitude object. The range of scores for the entire attitude towards science is 23-115 (1-5 x 23 items).

3.1.3.1 Comparison of the pretest scores of student's attitude toward science.

The t-test results of pretest scores of the experimental and control groups are presented in TABLE 18. For all participants, it was shown that the *p*-value (0.491) was higher than 0.05 indicating the mean scores of the students' attitude towards science between the experimental (79.43) and control groups (78.08) were not significantly different at the 0.05 level.

The p values of Satit CMU (0.789) and NMP (0.320) were also higher than the 0.05 indicating the mean scores of students' attitude towards science pretest between the experimental and control groups were not significantly different at the 0.05 level in both schools.

TABLE 18 T-TEST RESULTS OF PRETEST SCORES OF STUDENT'S ATTITUDE TOWARD SCIENCE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			83.33	10.88	13.06		
		58	115				0.268	0.789
Control group	30			82.50	13.08	15.85		
NMP								
Experimental group	30			75.53	6.56	8.69		
		58	115				1.004	0.320
Control group	30			73.67	7.78	10.56		
All participant								
Experimental group	60			79.43	10.99	13.83		
		118	115				0.692	0.491
Control group	60			78.08	10.38	13.30		

3.1.3.2 Comparison of the posttest scores of student's attitude towards science.

The t-test results of posttest scores of the experimental and control groups are presented in TABLE 19. It was shown that the *p*-value (0.000) was lower than 0.01 indicating the mean scores of students' attitude toward science between the experimental (87.65) and control groups (77.93) were significantly different at the 0.01 level.

The p-values of Satit CMU (0.003) and NMP (0.000) were also lower than 0.01 indicating the mean scores of the students' attitude towards science posttest between the experimental and control groups were significantly different at the 0.01 level in both schools.

TABLE 19 T-TEST RESULTS OF POSTTEST SCORES OF STUDENT'S ATTITUDE TOWARD SCIENCE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			90.97	14.01	15.40		
		58	115				3.153**	0.003
Control group	30			80.30	12.12	15.09		
NMP								
Experimental group	30			84.33	7.45	8.83		
		58	115				4.613**	0.000
Control group	30			75.57	7.27	9.62		
All participant								
Experimental group	60			87.65	11.61	13.24		
		118	115				4.870**	0.000
Control group	60			77.93	10.19	13.07		

** $p < 0.01$

3.1.3.3 Comparison of the student's attitude toward science between posttest and retention score for the experimental groups.

The t-test results between posttest and retention scores of the experimental groups are presented in TABLE 20. The *p*-value of the experimental group (0.010) were lower than 0.01 indicating the mean scores between posttest (87.65) and retention score (99.13) of students' scientific attitude were significantly different at the 0.01 level of significance.

The *p*-values of Satit CMU (0.000) and NMP (0.000) were also lower than 0.01 indicating the mean scores of the students' attitude towards science between the posttest and retention were significantly different at the 0.01 level in both schools. Students in both schools gained a higher mean sore on their retention.

TABLE 20 T-TEST RESULTS BETWEEN POSTTEST AND RETENTION SCORE OF STUDENT'S ATTITUDE TOWARD SCIENCE

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Posttest	30			90.97	14.01	15.40		
		58	115				3.670**	0.000
Retention	30			106.13	27.65	20.05		
NMP								
Posttest	30			84.93	7.45	8.77		
		58	115				4.08**	0.000
Retention	30			92.13	7.36	7.99		
All								
Posttest	60			87.65	11.61	13.24		
		118	115				0.974**	0.010
Retention	60			99.13	21.26	21.45		

** $p < 0.01$

3.1.4 Attitude toward the environment.

The children's attitudes toward the environment scale (CATES) was developed by Musser, Lynn M. in 1994. This instrument is used to measure environmental attitudes of grade school children. The Scale items reflect children's knowledge of environmental issues, and the scale uses an age-appropriate format. The range of scores for the entire attitude towards science is 75-150 (3- 6x 25 items).

3.1.4.1 Comparison of the pretest scores of student's attitude toward the environment

The t-test results of pretest scores of the experimental and control groups are presented in TABLE 21. It was shown that the *p*-value (0.668) was higher than 0.05 indicating the mean scores of the students' attitude towards the environment between the experimental (129.77) and control groups (129.17) were not significantly different at the 0.05 level.

The *p*-values of Satit CMU (0.784) and NMP (0.342) were also higher than the 0.05 indicating the mean pretest scores of students' attitude towards the environment between the experimental and control groups were not significantly different at the 0.05 level in both schools.

TABLE 21 T-TEST RESULTS OF PRETEST SCORES OF STUDENT'S ATTITUDE TOWARD THE ENVIRONMENT

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			132.90	8.88	6.68		
		58	150				0.323	0.784
Control group	30			133.53	6.06	4.54		
NMP								
Experimental group	30			126.03	4.94	3.92		
		58	150				0.431	0.342
Control group	30			124.80	5.02	4.02		
All participant								
Experimental group	60			129.77	8.16	6.29		
		118	150				4.870	0.668
Control group	60			129.17	7.06	5.46		

3.1.4.2 Comparison of the posttest scores of student's attitude toward the environment.

The t-test results of posttest scores of the experimental and control groups are presented in TABLE 22. It was shown that the p value (0.000) was lower than 0.01 indicating the mean scores of thestudents' attitude toward the environment between the experimental (135.32) and control groups (129.48) were significantly different at the 0.05 level.

The p values of Satit CMU (0.000) and NMP (0.000) were also lower than 0.01 indicating the mean posttest scores of the students' attitude towards the environment between the experimental and control groups were significantly different at the

0.01 level in both schools.

TABLE 22 T-TEST RESULTS OF POSTTEST SCORES OF STUDENT'S ATTITUDE TOWARD THE ENVIRONMENT

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Experimental group	30			140.13	7.67	5.47		
		58	150				4.261**	0.000
Control group	30			131.37	8.26	6.29		
NMP								
Experimental group	30			131.59	5.00	3.80		
		58	150				3.709**	0.000
Control group	30			126.97	4.56	3.59		
All participant								
Experimental group	60			135.32	7.53	5.56		
		118	150				4.247**	0.000
Control group	60			129.48	7.50	5.79		

** $p < 0.01$

3.1.4.3 Comparison of the students' attitude toward the environment between posttest and retention score for the experimental groups.

The t-test results between posttest and retention scores of the experimental groups are presented in TABLE 23. For all participants, the *p*-values of the experimental group (0.883) were higher than 0.05 indicating mean scores between posttest (135.32) and retention score (135.52) of the students' attitude towards the environment were not significantly different at the 0.05 level of significances.

The *p*-values of Satit CMU (0.672) were also higher than the 0.05 level of significances. This means the mean scores of the students' attitude towards the environment between the posttest and retention were not significantly different at the 0.05 level. Meanwhile, the p value of NMP is 0.017 that is lower than the 0.05 level of significances. This means the mean scores of the students' attitude towards science between the posttest and retention were significantly different at the 0.05 level. The experimental group students at NMP gained a higher mean score on retention.

TABLE 23 T-TEST RESULTS BETWEEN POSSTEST AND RETENTION SCORE OF STUDENT'S ATTITUDE TOWARD THE ENVIRONMENT

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Posttest	30			140.13	7.67	5.47		
		58	150				0.428	0.672
Retention	30			139.33	6.77	4.56		
NMP								
Posttest	30			131.59	5.00	3.80		
		58	150				2.466*	0.017
Retention	30			134.94	5.48	4.06		
All								
Posttest	60			135.32	7.53	5.56		
		118	150				0.148	0.883
Retention	60			135.52	7.28	5.37		

* $p < 0.05$

2.1.5 Constructivist learning environment

The constructivist learning environment survey (CLES) was used to gather the information about teacher behaviors and the classroom environment at the end of the program. There are 30 statements with a Likert-scale type to explore the constructivist learning environments that are divided into 5 components. The range of scores for the entire attitude towards science is 30-150 (3- 5 x 30 items).

The t-test results between pretest and posttest scores of the constructivist learning environment are presented in TABLE 24. For all participants, it was shown that the p-value of the experimental group (0.000) was lower than 0.01 indicating the mean scores of constructivist learning environment between the pretest (95.23) and posttest (104.07) were significantly different at the 0.05 level of significance.

The p-values of Satit CMU (0.001) and NMP (0.017) were also lower than the 0.01 and 0.05 levels respectively indicating the mean scores of the constructivist learning environment between the pretest and posttest were significantly different at the 0.01 and 0.05 respectively in both schools.

TABLE 24 T-TEST RESULTS BETWEEN PRETEST AND POSTTEST SCORES OF CONSTRCUTIVIST LEARNING ENVIRONMENT

Test	N	df	k	M	S.D.	CV	t	p
Satit CMU								
Pretest	30			96.33	11.67	12.11		
		58	150				3.518**	0.001
Posttest	30			107.23	12.32	11.49		
NMP								
Pretest	30			94.13	5.00	5.31		
		58	150				2.466*	0.017
Posttest	30			100.90	5.48	5.43		
All								
Pretest	60			95.23	11.09	11.64		
		118	150				3.887**	0.000
Posttest	60			104.07	12.97	12.46		

* $p < 0.05$

** $p < 0.01$

3.2 Qualitative data analysis

The qualitative data were also collected in this study. The qualitative data included narrative description of students' behaviors by the researcher observation and a semi-structured interview.

3.2.1 Students' behaviors observation

3.2.1.1 Science process skills

The instrument used, science process skills observation instrument (developed by Bijou, et. Al, 1969), was translated into Thai and field-tested in this study. It was used to evaluate the students groups' use of the science process skills of observing, measuring, predicting, communicating, forming hypothesis, experimenting, controlling variables, recording data, interpreting data, and applying and generalizing results. Scores for frequency and appropriateness of the student use of these skills and for group cooperation were recorded by the investigator. Moreover, students were required to keep portfolios of their implementation of the experiments they conducted during the CTSPZ.

Findings

Basic skills

Observing

When students make observations, they use all of their senses to gather information about objects or events in their environment. This is the most basic of all the process skills and the primary way in which young children obtain information. For example; a student described a rock as round or rough (soil horizontal unit); students can also use scientific instruments to aid in their observations such as thermometers, rulers and hand lenses

Classifying

Classification involves putting objects in groups according to some common characteristic or relationship. Students were encouraged to develop this skill by asking them to group or arrange animals by their observed properties in the biodiversity unit. It is more important that students were able to justify their arrangement or grouping than to replicate a scientific grouping scheme. Moreover, instead of only being able to put all the mammals in one group, students sorted them by size, shape, color, movement or some other observable characteristics.

Measuring

Measurement includes using both standard and nonstandard measures to describe the dimensions of objects or events. In the velocity units, student could identify length, width, mass, volume, temperature, and time correctly. Measuring also adds precision to the students' observations, classifications and communication. While students made measurements, they also considered what was the right type of measurement to be making and which measuring tool to use for the job. It is also important to note that the metric system is the measurement system used in science.

Prediction

In making predictions, students proposed the outcome of a future event using observations and previous discoveries. Students also began with making the content they learned in school relevant to their lives. After students viewed the information that they were learning as relevant, they were more open to additional learning. The use of a handout in each unit was also an effective instructional method to help create those meaningful connections.

Communicating

Many forms of communication including using words, actions, or graphic symbols occurred while the students described an action or event. Students put the information that they gathered from observations on a chart, and then shared this with others. For example, students were making observations of different kind of soils and rocks in the zoo. They were required to describe the soil and rock, first verbally, then in writing and sometimes record the properties of each of the soils and rocks, and then put this information in chart form.

Inferring

Making inference involves using evidence to propose explanations of events that have occurred or things that have been observed. In the biodiversity unit, students distinguished between what they were observing and their inferences. For example, students observed several characteristics different footprints. They noticed the size, shape, and direction of movement. Then they started to provide explanations; therefore, they were making inferences. For examples, Bernoulli force unit, students said that if the print is of a bird and it is going toward a fruit, it must be a herbivore.

Integrated skills

Through collaborative fieldwork, group discussions, presentations, and reflections, the students planned, implemented, and reported their own scientific investigations on both the environmental issues and science topics. The Students' investigation included a wide range of topics that dealt with plants, animals, soil and water, and the interactions and relationships between these variables. Findings from the students' reports and presentations indicated that the students' science process skills were shown when they demonstrated the ability to perform the following skills:

1. identify and pose research question
2. identify and formulate hypothesis
3. identify variables
4. define variables operationally
5. design investigations
6. implement investigations
7. collect analyze and interpret data
8. draw conclusions from data
9. report findings orally and/or in writing

At the end of the programs implementation, experimental group students were asked to express their experience of science in the classroom with their science experience while they attended the CTSPZ. The most frequently mentioned topics were that they were conducting more experiments; science was more fun, and they were learning more science in nature.

S1: "Science is different in the CTSPZ from the way it was at school because in the classroom we just opened a book and did the work. However, we learned science in the zoo on the same topic and we actually did the activities. We have lab, and group work, moreover we actually learn about science in nature and related it to our daily life".

Moreover, in their responses to the questions, students routinely used the language of science including hypotheses, scientific method, technology, safety rules, scientific instruments, observation, measurement, organization, comparison, data recording, mathematics, experiments, research, lab work, living organisms, habitat, problem solving, and systems. Students wrote about the importance of working in collaborative groups and discussed scientific ideas. Students responses clearly indicated that they were learning science, actively engage in science, and having fun doing science.

S2: "During When I attended the CTSPZ, I did a lot of exciting things. We set up an investigation and were now learning about fish and animals in the water resource. We have also done a finger print, I have learned about so many things that were hard to remember".

3.2.2 Semi-instructional interview

The students selected for both control group (6 students) and experimental groups (6 students) were contacted personally by the researcher and interview one week prior to the data collection. Following the data collection, the students were interviewed again this time to gather information about the students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and the constructivist learning environment. Finally, students were interviewed for a third time, one month after collecting the data, using the same questions. In all cases, the interviews were audio taped and transcribed by the researcher. The first interview was transcribed prior to the data collection, the second interviewed was transcribed following the collection, and the third interview were transcribed prior to the data analysis. Following are the results of the observations and the interviews.

3.2.2.1 Scientific attitude

The purpose of this qualitative study was to explore students' scientific attitudes over the period of time (pretest, posttest, and retention) while they attended the CTSPZ. Semi-structure interviews were conducted with a representative sub-sample of the survey respondents (n=12) to gain a deeper understanding of the information they provided on the scientific attitudes inventories: a revision of the SAI II survey. Each interview session lasted between 10-15 minutes. Three guide questions were included: (a) Do you view science information and methods as unchangeable? Please explain. (b) On scale of 1 to 10, how importance is science? (c) Would you like to be a scientist after you finish school? Why or why not?

Results

Question 1: Do you view science information and methods as unchangeable? Please explain

This question considered the way in which students view the nature of scientific knowledge. Most students view science information and methods as changeable. During the pretest interviews, students were trying to make aspects of their images of science explicit. One student gave the example of Columbus theory about the shape of the earth as she learned in school in order to explain her answer.

S1: “At the time Columbus put forward his theory that the earth is round, nobody believed him at all. Later his theory was accepted”.

On the posttest and retention interview, three students even give more Details about their views about science information as changeable while doing the activities in the CTSPZ. The following represents students’ discussions of how knowledge claims arise from and interact with experimental and observational data.

S2: “A scientist solves the problem by carrying out experiments to prove the theory is right. Many scientists usually have two different theories and they did experiments to prove those theories. The theory was proved by the scientist who eventually got the right experiment and the right time.

S2:“Well, it’s often that there are at least two or three theories to explain a phenomenon before it’s proved experimentally. However, people can change the idea about a theory if they use higher technology or instruments to do the experiment”.

Question 2: On scale of 1 to 10, how importance is science?

Qualitatively, this question measures individual differences in scientific attitudes, that is, from strongly believing that science is important and relevant to everyday life to strongly believing that science is not important or is irrelevant.

Findings from the interviews, pretest, posttest, and retention, showed that students who attended the CTSPZ program had more positive views on scientific attitudes. The average score for the these students’ opinion started from a position on the pretest (7), became more positive on the posttest (8) and felt that science was somewhat important and relevant to them on the retention interview (10). In addition, students also give their reasons in order to response to these questions such as:

S1: “science being useful in one’s everyday life”

S2: “Some people may think that science isn’t used very much in everyday life unless you are a scientist. However, it is not true, I learned science at the zoo and science is used in all different fields.”

Question 3: Would you like to be a scientist after you finish your school? Why or why not?

In this question, students’ stereotype of scientist and the scientific attitudes were explored. The resulting images of the scientist revealed students’ scientific attitude. Most of the students prefer science related professions such as medical doctor, dentist, science teacher, or an architect.

S1: "I would like to be a dentist because I would like to help people with their teeth and I would like to find cures for different kinds of diseases".

S2: "I personally want to become many things and some day I'll narrow them down. One career is teaching because I like correction and teaching".

There were only two students who wanted to be scientists.

S1: I want to be a scientist when I grow up. I like to think about problems and then solve them. In school I like science most. I must study hard and learn things."

S2: "When I grow up I want to be a scientist. I haven't really decided yet on which part of science I will concentrate on but I love to build and experiment with different things, to find out how they work. Unfortunately, I don't think I have enough ability to be a scientist."

3.2.2.2 Attitude toward science

For the qualitative portion of the study, the interview questionnaires were used to interview 12 students to investigate the developed experience associated with students' attitude towards science. The aim was to allow students talking about science in their own terms. Students had widely different attitude towards science. The qualitative studies about attitude toward science involve four stimulus questions as follows:

<u>Results</u>

Question 1: How do you feel about science?

- Do you like or don't like science?
- What do you like (or don't like) about science?

Most of the students stated that they love science. Some of the details included, what student's like or dislike about science is often affected by science class and social factors. Almost all of them liked science as they said:

S1: "I feel that science is fun. It is interesting to read and write about science."

S2:" When I actually did the experiment instead of drawing it and writing about it like other subjects. That made me love science."

Although most students like science, there were also some things that they dislike about science such as:

S1:" I hate too much lecture. I mean when teacher lectures you, she just goes on and on."

S2: "My teacher is boring. Some teacher yelled at us and gave us tons of work. I also hate when I have to memorize things in science".

Question 2: Have you ever applied knowledge about science into your life? If so, when? How? Where?

There were nine students who felt that they never applied science outside of the school on the pretest interview. There were four students who thought that they probably used their science knowledge and skills outside of school, but they were unsure about how to use the knowledge or skills. Later, on the posttest and retention interview, the majority of the students said they used of science knowledge outside of school and experience. Students cited specific school activities that they applied such as:

S1: "I mixed vinegar in water in order to get rid of ants, as I learn that from science class at school."

S2: "I applied the knowledge about acid-base and the notion about a universal indicator as I learned from the CTSPZ in my science class."

Only one student was able to connect skills and knowledge gained from science class to everyday activities. The student said that she use observation and inferences to identify the electricity problem in her home and help her dad to solve it.

S1: "While the electric bulb didn't work at my home, I told my dad how to check the electricity circuit whether it was caused by the bulb, wire, or fuse."

Question 3: Have you ever discussed science with friends or talk to your parents about science outside the classroom? Please explain your answer.

The interview results have shown that there was little in the conversation about science between students and their peers or their families. Only three students watch educational programs on television with their family and discuss it regularly. The science program on TV is a science quiz show (Mega clever) and an outdoor wildlife program. Six students stated that they discussed with friends about their science homework.

Question 4: Do you think that what you learn in science is part of your life outside school? Please explain your answer.

During the interview period, the evidence suggested that all students viewed science as a part of their life outside school.

S1: “Our society depends increasingly upon technology and science. Knowing about science will help us to become more inform about the causes of things.”

S2:”The technology that enriches my routine life was writing and researching over the internet, science-based technology.”

3.2.2.3 Attitude toward the environment

The interviews which were semi-structured in form were conducted on the pretest, posttest, and retention with 12 students. The interviews were conducted as a friendly conversation and were also audio taped and later analyzed. The question formulated to the students and the results were follows:

Question 1: Do you leave water running while you brush your teeth? Why?

This question was used to explore students’ attitude towards the environment and whether it changed after they participated in the CTSPZ program. In the pretest interview, only one student stated that he never turned the water off because it wastes his time to turn on and off the water while he brushed his teeth. Eleven students said that they turned off the faucet while they brushed their teeth. The main reasons they gave was related to the economic issues.

S1: “I Just wet my tooth brush . . . turns the water off . . . brush my teeth. I did that to save the money on my mom’s water bill.”

S2: “My parents taught my sisters and I about saving water since were young.”

On the posttest and retention interview, all students said that they turned off the water while they brushed their teeth. Moreover, they realized more about water conservation as related to the environmental issues.

S1. “You can save the water by turning it off when you brush your teeth. Simple things like this can help conserve.”

S2: “If we were more "water friendly" we would save plenty of water and have a better environment to live in and have water for tomorrow.”

Question 2: Please explain how you use a paper when you draw or write something. Is it important to use both sides of the paper?

This question also deals with students' attitude towards the environment regarding the use of paper. From the pretest, posttest, and retention, it was found that the use of paper depended on the purpose in each activity. Sometimes they only used one side of paper if they had to hand it in to a teacher. Almost all of the time they used both sides of the paper.

S1:"Most of the time I did. It depends on the paper, and the importance of what I am writing. If there is NO show through or bleed through, then I use both sides of paper. If there is minor show through, and what I am writing is not very important, then I used both sides of paper. This would save a lot of money I paid when I bought a paper."

S2: "I always write on both sides of the paper in journals and letters. The only exception to this is when I handed it in to the teacher".

Later on the posttest and retention, students add more explanation regarding to the environmental conservation.

S1: "To make the paper, trees are cut down, which hurts both forests and the animals that live around them. Cutting down forests even affects the earth's climate, since trees absorb carbon dioxide, one of the greenhouse gases that cause global warming."

S2: "Creating paper from trees requires a lot of natural resources: trees, water, and energy."

S3: "Once the paper has been made, it becomes a huge waste problem. It would decrease a lot of waste if I use both sides of the paper."

Question 3: Are animals and people equally important?

All students agree that people and animals are equally important in the pretest interview for the reasons that follow:

S1: "I know that we are all living species and deserve to be love and respected."

S2: "I don't believe that animals are more important than humans, but I think they are equally important."

S3: "I would say that all living things are equal. People and animals relate to each other in different ways."

However, one student changed her answer on the posttest.

S1: “I would say that an animal is more important that human. I love animals because animals are loyal, love unconditionally and don't leave you, etc. I wonder if people are loyal like the animals.”

3.2.2.4 Constructivist learning environment

From a social constructivist perspective, the development of understanding by writing and the discussion of ideas with peers is an essential element in learning. Students should be given more opportunities to speak and write about their science to better understand science as a community of discourse. The post-attendance surveys of the CTSPZ indicate that the students were very satisfied with the program. Moreover, students also commented on the collaboration of topics. Some of their comments included:

S1: “We all had different ideas, and we had to discuss which one was better. Eventually we came to a compromise which everyone agreed with.”;

S2: “We argued among ourselves because we could not do everything we all wanted”;

S3: “We had a lot of misunderstandings which we solved by lots of discussion and advice. We worked together through discussions”.

Chapter 5
Conclusion and discussion

Introduction

This chapter presents a summary of the study followed by a discussion of the conclusions, implications and recommendations based upon the findings of the investigation. Initially, the purposes of the study are summarized as follows:

1. To develop the CTSPZ for middle school students. The program development was based on a constructivism theory and thematic science.
2. To explore the use of the CTSPZ on students' science process skills, scientific attitude, attitudes towards science, and attitudes towards the environment by converging both quantitative (broad numeric trends) and qualitative (detailed views) data.
3. To evaluate the CTSPZ with emphasis on a constructivist learning environment.

This research was a study on the effects of the CTSPZ implementation on level three students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and the constructivist learning environment. Specifically, the research was designed to answer the questions as follows:

1. Does the use of the CTSPZ program designed by the investigator and offered at Chiangmai zoo, significantly influence student's science process skills?
2. Does the use of the CTSPZ program significantly influence students' scientific attitude?
3. Does the use of the CTSPZ program significantly influence students' attitude toward science?
4. Does the use of the CTSPZ program significantly influence students' attitude towards the environment?
5. Does the incorporation of the CTSPZ provide a constructivist learning environment?

The hypotheses of the research were:

1. The designed CTSPZ program significantly influences student's ability to use

science process skills.

2. The use of the designed CTSPZ program significantly influences students' scientific attitude.

3. The designed CTSPZ program significantly influences students' attitude toward science.

4. The designed CTSPZ program significantly influences students' attitude toward the environment.

5. The incorporation of the CTSPZ provides a constructivist learning environment.

Research methodology

The research procedures are presented under the three major phases; a) program design; b) program implementation; c) program evaluation.

1. Phase one: program designing

During the first phase, the constructivist thematic science program at Chiangmai zoo (CTSPZ) was developed to customize to the needs of particular teachers and students by integrating it with formal national science standards.

The details for program designing are summarized as follows:

1.1 Identifying learner needs

The program design was begun by identifying the learner needs. Therefore a needs assessments procedure; opinion survey; and task analysis were used to gather the information.

1.2 Articulation program intentions

The researcher wrote the program rationale, goals and selected contents of science standards based on a process of clarification and articulation.

1.3 Planning instruction

The CTSPZ was developed as program- based activities. Six elements of the constructivist learning design (CLD) were used as a teaching strategies in this research. Instructional contents that best support the national science standards and are suitable for the Chiangmai zoo environment, including 6 units; 1) biodiversity; 2) food web; 3) soil horizontal; 4) water conservation; 5) Bernoulli force; 6) velocity were used.

1.4 Consulting with curriculum experts to examine and verify the draft CTSPZ

In this step, five experts about the programs validity and reliability were consulted. In addition, the curriculum evaluation form was used to gather information regarding the suitability and consistency of the curriculum. The result of the curriculum suitability evaluation showed that the ranges of the mean score were between 3.40 – 4.20 and with a standard deviation of 0-0.89. This means the curriculum was very suitable. In addition, the results from consistency evaluation of each component of the curriculum showed the content validity index is 0.80. This indicated that the curriculum had consistency among its components.

1.5 Pilot study

Small scale pilot testing was conducted on part of the curriculum to explore the students' experience when they attended the CTSPZ. Then the information was used to evaluate the drafted CTSPZ program. Finally, all feedback was used to revise the program based on a program revising guide.

2. Phase two: program implementation

The research design was a mixed method, control group interrupted time series design. The experimental group for the study included students from two schools, Satit CMU and NMP. The control groups were comprised of students from the same school system who study science in a regular class at the schools.

Quantitative and qualitative studies were used in this research. The instruments used in this study are classified as follows:

Quantitative instruments

1. Science process assessment for middle school students (SPAMSS)
2. The scientific attitude inventory: a revision (SAI II)
3. Science attitude scale for middle school students
4. The children's attitude towards the environment scale (CATES)
5. The constructivist learning environment survey (CLES)

Qualitative instruments

1. Semi-structure interview questionnaires

2. Observation

3. Phase three: program evaluation.

By evaluating the CTSPZ, the researcher measured how effective the CTSPZ was for measuring the students' science process skills; scientific attitude; attitude towards science; attitude towards the environment; and constructivist learning environment. In order to arrange the data for analysis, each dependent variable was addressed as follows:

Quantitative data analysis

Upon completion of all instruments; science process assessment for middle school students (SAMSS), the scientific attitude inventory: a revision (SAI II), science attitude scale for middle school students(SASMSS) , the children's attitude towards the environment scale (CATES), and a constructivist learning environment survey (CLES), the collected quantitative data were analyzed using the following procedures:

1. Descriptive statistic, mean, standard deviation, and variance were calculated for all instruments.

2. The t-test of significance were performed using the results data from SAMSS , SAI II, SASMSS, CATES, and CLES before and after using the science program.

Qualitative data analysis

The specific approach to phenomenological analysis as advanced by Moustakas (1994) was used to analyze qualitative data.

Conclusion

The research findings were concluded as follows:

1. Phase one: program design

According to the needs assessment procedure (opinion survey and task analysis), the CTSPZ was developed based on the CTSPZ for level 3 students as an instructional resource for educator who want to introduce students to hands-on and minds-on activities. The program organization composes of program rationale, program goal, and content science standard, planning instruction, and planning for assessment.

The program documents were examined by five experts in different field (2 zoo educators, 2 teachers who had experience in science teaching for more than 10 years, and

1 science education professor). Then the program was then revised and implemented in one classroom as a pilot study. All information from the pilot study was used to revise the CTSPZ based on program a revising guide.

After all revising, the CTSPZ composed of six thematic units that are biodiversity, velocity, water conservation, Bernoulli force, soil component and soil horizontal, and food webs. Each unit is integrated within a different field of science such as biology, chemistry, physics, and earth science. It takes 3 hours for all activities in each unit to be accomplished.

The teaching strategy would follow the constructivist learning design (CLD) to present the constructivist perspective. CLD is composed of six basic parts; 1) situation; 2) grouping; 3) bridge; 4) question; 5) exhibition; and 6) reflection.

2. Phase two: program implementation

Program implementation was conducted based on a mixed method, control group interrupted time series research design. During which the CTSPZ was studied as an independent variable and with the dependent variables being the students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment. The participants in this study were a volunteer students from Satit CMU and NMP who study in level 3.

Firstly, both quantitative and qualitative instruments were used to explore students' science process skills, scientific attitude, attitude towards science, attitude towards the environment, and constructivist learning environment as a pretest. All participants were equally divvied into an experimental and a control group. Control group students were those who studied science in a regular science class in school. While the experimental group students attend the CTSPZ at the Chiangmai zoo for all 6 units. Secondly, the posttest was conducted using the same quantitative and qualitative instruments as in pretest. The purpose was to explore whether there were a changes on the dependent variables. Finally, one month after the CTSPZ implementation, the a retention study was conducted using the same quantitative and qualitative instruments. The purpose was to explore whether students' science process skills, scientific attitude, attitude towards science, attitude towards the environment were retained.

3. Phase three: program evaluation.

To thoroughly and accurately evaluate the CTSPZ, the researcher developed a full understanding of this program. The method of achieving this understanding was through developing a theory of the program that expresses the hypothesis. The evaluation was designed primarily to determine the degree to which the CTSPZ is effective in reaching the various research related hypothesis as follows:

Hypothesis one: the designed CTSPZ program significantly influences on student's ability to use science process skills.

According to the research hypothesis one it was expected that students who participated in The CTSPZ (experimental group) would gain a higher posttest score than a student who studied science in a formal regular class in school (control group). Before conducting the CTSPZ, the results from this study showed that the mean scores of pretest between experimental and control group from Satit CMU, NMP and all participants were not significantly different at the 0.05 level. It could be assumed that students' science process skills were not different.

Since the experimental group received a treatment (the CTSPZ), it was found that the *p*-value (0.035) of the students who had low scores in science process skills (NMP) was lower than 0.05. This means that the mean score of the posttest between experimental and control groups were significantly different at the level of 0.05. This showed that students who attended the CTSPZ had a higher mean score (34.23) than the students' who attended a formal regular science class in school (29.50). Moreover, in the experimental group, the *p*-value (0.080) between posttest and retention scores were higher than 0.05. It meant that the mean score of the science process skills between posttest (34.23) and retention (37.97) were not significantly different at a level of 0.05. This showed that there was retention on student science process skills in the experimental group. This supported hypothesis I.

In addition, for a low score in science process skills students (NMP), it was found that the *p*-value of defining operationally (0.001) and interpreting data skill (0.006) were lower than 0.01 indicating the mean posttest scores between the experimental (1.63, 3.43) and control groups (2.30, 4.37) were significantly different at the 0.01 level respectively. Moreover, it was found that the *p*-value of formulating models skills (0.013) were lower than 0.05 indicating the mean posttest scores between the experimental (2.10) and control groups (2.87) were significantly different at the 0.05 level. This shows that the CTSPZ had an influence on the integrated science process skills.

Meanwhile, the *p*-value of the students who had a high score in science process skills (Satit CMU) and all participants were 1.072 and 1.953 respectively. These mean that the posttest mean scores between experimental and control group were not significantly different at the level of 0.05. It showes that although a high score in science process skills for students attending the CTSPZ, their posttest mean score (42.80) was not much different than a student who attended a formal regular science class in school (41.23). This was not in support of hypothesis 1.

However, for a high score in science process skills students (Satit CMU), it was found that the *p*-value of formulating hypothesis skills (0.035) was lower than the 0.05 level indicating the mean posttest scores between the experimental (1.47) and control groups (1.77) were significantly different at the 0.05 level. This shows that the CTSPZ has influence on integrated science process skills.

The qualitative study revealed that students use different senses in science by touching, feeling, moving, observing, listening, smelling and sometimes testing materials in a controlled manner while they attendeing the CTSPZ. Subsequently, students showed that they developed more in basic science process skills such as observing, classifying, measuring, and prediction. However, students showed a few developments on the integrated skills such as identify and pose research questions, identify and formulate hypothesis, identify variables, define variables operationally, design investigations, implement investigations, collect analyze and interpret data, draw conclusions from data, report findings orally and/or in writing.

Hypothesis two: the use of the designed CTSPZ program significantly influence students' scientific attitude.

According to the research hypothesis two, it was expected that students who participated in the CTSPZ (experimental group) would gain a higher posttest score in scientific attitude than a students who studied science in a formal regular class in school (control group). Before conducting the CTSPZ, for all participants, the results from this study showed that the *p*-value of all participants, Satit CMU, and NMP are 0.407, 0.965, and 0.248 respectively. These *p*-values were higher than 0.05. That means the mean scores of pretest between experimental (135.10, 136.97, 126.43) and control group (133.15, 137.10, 124.47) were not significantly different at the 0.05 level. It could be assumed that the students' scientific attitudes between experimental and control group were almost at the same level.

Since the experimental group received the treatment (the CTSPZ), it was found that the *p*-value (0.018) was lower than 0.05 for all participants. This means that the mean score of the posttests between experimental and control groups were significantly different at the 0.05 level. This showed that the students who attended the CTSPZ had higher mean score (134.53) than the students' who attended a formal regular science class in school (129.83). Moreover, in the experimental group, the *p*-value (0.332) between posttest and retention scores were higher than 0.05. This means that the mean score of the scientific attitude between posttest (134.53) and retention (136.55) were not significantly different at a level of 0.05. This showed that there was the retention on student scientific attitudes in the experimental group. This was on support of hypothesis 2.

According to the findings of the qualitative collected data, the second research hypothesis has shown that when students attended the CTSPZ, it enables the development of positive scientific attitudes in level three students. The CTSPZ students' view of science information and methods as it is changeable. They also had a strongly belief that science is important and relevant to everybody's life. In addition, students prefer a science related career when they are grown up.

Hypothesis three: the use of the designed CTSPZ program significantly influence students' s attitude towards science.

According to research hypothesis three, it was expected that students who participated in The CTSPZ (experimental group) would gain a higher posttest score in attitude towards science than a student who studied science in a formal regular class in school (control group). Before conducteding the CTSPZ, the results from this study showed that the *p*-value (0.491) was higher than 0.05. This means the mean scores of pretest between experimental (79.43) and control groups (78.08) were not significantly different at the 0.05 value of significance. It could be assumed that the students' attitude towards science between experimental and control group were almost at the same level.

Since the experimental group received a treatment (the CTSPZ), it was found that the *p*-value (0.000) is lower than 0.01. This means that the mean score of the posttest between experimental and control groups were significantly different at the 0.05 level of significance. This showes that students who attend the CTSPZ had a higher mean score (87.65) than the students' who attended a formal regular science class in school (77.93). Moreover, in experimental group, the *p*-value (0.000) between posttest and retention scores were lower than 0.01 (TABLE 17). The mean score of the students' attitude towards science between posttest (87.65) and retention (99.13) were significantly different at a level of 0.01. The retention means score is higher than the posttest mean score. This showed that there was the retention on students' attitude towards science in the experimental group. This supports hypothesis 3.

The qualitative results showed that the CTSPZ activities based constructivism theory were more effective in improving students' attitudes towards science. The interview results suggested that positive attitudes toward science are formed by interactions of both student's perception and the CTSPZ activities. While they attended the CTSPZ, students viewed the use of science outside of school as an extension of their science knowledge. Students also discussed issues about science more with their family and peers.

Hypothesis four: The use of the designed CTSPZ program significantly influence students' s attitude towards the environment.

According to research hypothesis four, it was expected that studentswho participated in The CTSPZ (experimental group) would gain a higher posttest score in attitude towards the environment than a student who studied science in a formal regular class in school (control group). Before conducted the CTSPZ, TABLE 22, the results from this study showed that the *p*-value (0.668) was higher than 0.05. That means the mean scores of pretest between experimental (129.77) and control groups (129.17) were not significantly different at the 0.05 level. It could be assumed that the students' attitude towards the environment between experimental and control group were almost at the same level.

Since the experimental group received the treatment (the CTSPZ), it was found that the *p*-value (0.000) is lower than 0.01. This means that the mean score of the posttests between experimental and control groups were significantly different at the level 0.01 of significance. These data showed that students who attend the CTSPZ had higher mean score (135.32) than the students' who attended a formal regular science class in school (129.48). Moreover, in experimental group, the *p*-value (0.883) between posttest and retention scores were higher than 0.05. It means that the mean score of the students' attitude towards the environment between posttest (135.32) and retention (135.52) were not significantly different at level 0.05 of significance. This showed that there was retention on student scientific attitudes in the experimental group. This was in support of hypothesis 4.

Accordingly, to determine the change in attitudes toward the environment, the researcher looked at the change in how the students responded on interview questionnaires from pretest to the posttest. The qualitative results indicated that the CTSPZ students accepted that environmental conservation is a serious issue as they responded and answer about cause and effect relationships between human activity (brush their teeth) and the water conservation. Also they are aware of individual responsibilities for environmental conservationas their view of animals is equally important with humans.

Hypothesis five: the incorporation of the CTSPZ provides a constructivist learning environment.

According to the research hypothesis five, it wasexpected that students who participated in The CTSPZ (experimental group) would gain a higher posttest score in constructivist learning environment than a pretest score. The study presented that the *p*-value (0.000) is lower than 0.01. Meaning that the mean scores of the pretest (95.23) and the posttest (104.07) were significantly different at the 0.01 level. This supported the hypothesis 5 that the CTSPZ provided a constructivist learning environment.

In addition, the response to a semi-instructional interview students responses revealed that students showed positive perception of their preferred learning style and experiences while they attended the CTSPZ. Students discussed their own ideas and the ideas of their peers to help them to achieve their goal of understanding.

Discussions

1. **Phase one: program design**

One of the primary challenges facing curriculum developers today is how to design curricular innovations that are appealing and useful to teachers and at the same time bring about transformative practices (Kurt; Squire; & et.al. 2003: 468).

By purpose, the CTSPZ designing started by identifying the learner needs using task analysis (a master plan of Thai zoo education, 2005) and gathering data from opinion surveys (specialist and clients). Tyler (1994) indicated that curriculum planners should identify the general curriculum objectives by gathering data from three sources: the subject matter, the learners, and the society (Ornstein; & Hunkins. 1993: 267). The uniqueness of the CTSPZ is that the actual curriculum design was drawn on many types of input such as: decision on content, information about students' prior ideas, teacher's practical knowledge of students, schools and classrooms, and perspectives on the learning process. Specifically, a constructivist view of learning and thematic science also has implications for a view of the CTSPZ designing as described by Driver and Oldham (1986) indicated that the science program is seen as the program of activities from which knowledge or skills can possibly be acquired or constructed and acknowledging that what is constructed by any learner depends to some extent on what they bring to the situation (Driver; & Oldham. 1986: 112). Constructivism is undoubtedly a major theoretical influence in contemporary science education. Constructivist influence has extended beyond just the research and scholarly community. It has an impact on a number of national curricular documents and national education statements for example, the National Council for Teacher Mathematics in the U.S., the National Science Teachers Association, and the U.S. National Science Teachers Association standards. (Matthews. 2002: 122). In Thailand, Thailand national education act and IPST visions also suggested the main ideas about constructivism as a psychological influence on curriculum thinking in science.

In addition, the CTSPZ was designed to link informal science with formal science studied in the classroom. The CTSPZ program was introduced to the national science education standards as a mechanism for bridging formal and informal science education. Based on previous reports on student learning and educational effectiveness of science museums, specific science content from the standards is outlined as potentially useful in informal settings for increasing student learning (Hofstein; Bybee; & Legro. 1997: 31). Moreover, there is already evidence to suggest that factors outside schools have a strong influence on students' education outcome, perhaps strong enough to swamp the effects of variations in education practices (Schibeci. 1989: 3). One of the most common findings of casual visiting to the zoo is that the students are often framed as social experiences that encourage group learning. Informal settings such as science museums and zoos are popularly largely because many of the activities are socially mediated and involve social-group (Hofstein; & Rosenfeld. 1996: 102). These findings support the constructivist learning design as a teaching strategy in the CTSPZ.

2. Phase two: program implementation

Successful implementation of program was resulted from careful planning. The planning process address the needs and resources prerequisites for carrying out intended actions. Implementation requires planning, and planning focuses on three factors including participants, programs, and processes (Hofstein; Bybee; & Legro. 1997: 299). Therefore, a modified mix-method control group interrupted time series design was utilized in this study. The purpose of experimental research was to test cause and effect relationships among the variables. The researcher manipulated one variable to measure the effect of this manipulation upon three dependent variables. In order to have a true experiment, three things must be evident: (1) there must be at least two groups; (2) the researcher must manipulate the dependent variable; and (3) experimental units must be randomly assigned to the groups (Merrill. 2000: 42).

The CTSPZ research design; however, lacks at least one of the three items listed above. In this study, there were two different groups (control group and experimental group). The researcher manipulated the dependent variable; but could not randomly sample the subjects; therefore, subjects were the voluntary students. The modification of this design stemmed form the fact that the researcher used comparison groups rather than "true" control groups. Campbell and Stanley stated that this design is "one of the most wide spread experimental designs in educational research"(Campbell; & Stanley. 1963: 47).

In addition, an important variant of the basic quasi-experimental design is time design. A common research problem, especially in studies of the development and growth of children, involve the study of individuals and groups using time as a variable (Kerlinger; & Lee. 2000: 544). The use of this design allowed the researcher to make it possible to separate reactive effects form the effects of the treatment. It enabled the researcher to determine, if the measurements had a reactive effect, and whether the treatment was strong enough to overcome that effect.

One difficulty with time studies, especially with children, is the growth or learning that occurs naturally over time. Therefore, the qualitative instruments that were used incorporated the quantitative instruments. In quantitative instruments, the outcome is best addressed by understanding what factors or variables influence an outcome. In qualitative instruments, the researcher could describe a research outcome that can best be understood by exploring a concept or phenomena (Creswell. 2003: 74).

3. Phase three: program evaluation

Five main instruments were used to evaluate the CTSPZ with different prospective. All five instruments are research instruments validated to evaluate the CTSPZ and have been widely used. The details for each perspective are discussed as follows:

3.1 Science process skills

According to the findings, it was found that the CTSPZ influenced the student's ability to use science process skills differently. Considering the pretest score, the participants in this study were categorized into a high score in science process skills students and a low score in science process skill students.

For low score in science process skill students, the posttest mean score of the posttest between experimental (34.23) and control groups (29.50) were significantly different at the *p*-value of 0.05. This would support the hypothesis that the students who attend the CTSPZ gained higher mean scores than that of the control group students. This result supports the findings that when hands-on learning activities are undertaken along with student-centered teaching approaches, the science process skills of students develop better (Hofstein; & Lunetta. 2004: 50). In addition, through hands-on activities in the CTSPZ, students used different senses in science classes by touching, feeling, moving, observing, listening, smelling and sometimes testing materials in a controlled manner. This helps students to progress from concrete thinking levels to more complex thinking levels (Bilgin. 2006: 28).

On the other hand, the *p*-value (1.072) of the students with a high score in science process skills students was higher than 0.05. It means that the posttest means score between experimental (42.80) and control groups (41.23) were not scientifically different at level 0.05 of significance. For quantitative approach, this did not support the hypothesis that students who attended the CTSPZ should gain higher score on posttest than control group students. In addition, the qualitative approach, this finding could be discussed in different ways. Firstly, it could be assume from the pretest results that a high score in science process skills students scored high on pretest (almost 50); therefore, they could not score much further in posttest. This would suggest that, more than one instrument should be used to explore student science process skills. There are several evaluation approaches that science educators can use to evaluate student's science process skills. Harlen focused on an approach for process skills assessment in three purposes; formative, summative, and national and international monitoring. In all cases, the assessment of skills is influenced not only by the ability to use the skills but also by knowledge of and the familiarity with the subject matter with which the skills are used. Thus what is being assessed in any particular situation is a combination of skills and knowledge and various steps have to be taken if they are to be separated (Harlen. 1999: 129).

Similarly, in this research, formative assessment was gathered by researcher and by students assessing their own work. Information was gathered by; observing, using open ended questions, phrased to invite students to explore their ideas and reasoning; setting tasks in a way that it requires the students to use certain skills; and asking students to communicate their thinking through drawings, artifacts, actions, as well as writing.

3.2 Scientific attitudes

In this study, it can be seen that scientific attitudes have been the focus in the program evaluation Koballa. 1988: 119) described scientific attitude as the separation of individuals between the problems, events, situations, and feelings that they experience and comment on them based on logical data. In this study, scientific attitude refers to a particular approach a person assumes for solving problems, for assessing ideas and information, and for making decisions. It includes such scientific methods and predispositions as objectivity, suspended judgment, critical evaluation and skepticism (Gauld. 1982: 115).

According to the findings of the collected data, it has been determined that when students attended the CTSPZ, their scientific attitudes developed in a positive manner. This result agreed with the previous study indicating that educational activities based on social learning theory were more effective in improving students' scientific attitudes (Murat; & Rahmi. 2006: 363). Supportably, briefly giving life histories about famous scientists, museum or zoo visits, and activities on natural life will help students appreciate scientific education. Therefore, in the primary school period, the teaching activities might increase the effectiveness of general education by taking the scientific and affective aspects into consideration in order to develop scientific attitudes and planning.

Moreover, the CTSPZ as an informal learning program makes positive contributions to the development of students and provides permanency of their interest and desire to learn. At the first level the students were faced with the CTSPZ through basic activities during their zoo visit. During this period, the students were helped to become acquainted with science in a field setting, notice the basic principles of scientific methods, develop permanency of interest and a desire to learn, acquire the scientific process skills, and were provided with facilities to decide an appropriate field of study related to science. The evaluation of success in scientific teaching and learning is made through positive changes in behaviors.

3.3 Attitude toward science

The investigation of students' attitudes toward studying science has been a substantive feature of the work of the science educational research community for the past 30 to40 years. Consequently, the promotion of favorable attitudes towards science is increasingly a matter of concern. However, the concept of an attitude towards science is somewhat nebulous, often poorly articulated and not well understood (Osborne. 2003: 1049). This research offers; therefore, a review of current knowledge about attitudes towards science which was developed in an informal setting.

The collected data demonstrated that when hands-on learning activities at an informal setting were used with a constructivist learning approach in the CTSPZ, it enables the development of positive attitudes toward science in level three students compared to a formal science approach in science classrooms. There was also a rise and high retention in attitudes toward science in a social context after the visit. Although these students had clearly been influenced by the CTSPZ, some also talked about how they liked experiments in school. This result agreed with previous studies in that when hands-on learning activities are used in groups, the students' attitudes toward science develop positively (Hofstein;& Lunetta. 2004: 43).

In addition, the CTSPZ can address aspects of science educationthat might be missing in more formal, class-based science learning, to provide an awareness of the relevance of science to society. It can also generate a sense of wonder, interest, enthusiasm, motivation, and eagerness to learn, which are much neglected in traditional formal school science (Pedretti. 2002: 35; Ramey; & Walberg. 1994: 11). Attitudes not only influence views of science and aspirations for future careers, they can also influence attainment. Children with more positive attitudes toward science show increased attention to classroom instruction and participate more in science activities (Germann. 1988: 689). Learning science in an informal setting not only promotes positive attitudes, which may influence achievement in school, but some cognitive learning can occur as well (Hofstein; & Rosenfeld. 1996: 90)

3.4 Attitude toward the environment

Holahan described attitude toward the environment as "people's favorable feelings toward some features of the physical environment or towards an issues that pertains to the physical environment." In this study the researcher viewed and measured attitude towards the environment as attitude towards taking environmental actions, positive or negative reactions to activities related to the natural environment (Hines; & et al., 1987: 6).

The results of this study provide a strong support for the hypothesis that students who attended the CTSPZ in an informal setting scientifically improve in the positive attitude towards the environment more than the students who study in a formal science classroom. These findings are consistent with Milton, Cleveland, and Bennett-Gates who reported that outdoor activities requiring direct involvement with the natural environment help students improve more in positive attitude towards the environmental then indirect or noninteractive experience such as videotape, reading, or discussion (Milton; &Cleveland; & Bennett. 1995: 37). The findings of this study add to this body of knowledge by providing evidence that informal learning at the zoo can function as an easily accessible, familiar, natural setting for outdoor science inquiry and learning. It generally has been assumed that participation in outdoor recreation promotes environmental awareness simply by exposing people to environmental issues and concerns.

In addition, Baterson and Xin found the strong relationship between general positive attitude toward science and general positive attitude towards the environment. That is, the general positive attitude underlying the structure of attitude toward the environment correlated substantially with the general positive attitude underlying the structure of attitude towards science. Students who had a favorable attitude toward the environment also showed a favorable attitude towards science. This finding implies that environmental educators can predict attitude toward the environment from the attitude towards science if information is not available about students' attitude toward the environment. This relationship also indicates that attitude towards the environment and attitude towards science do influence each other (Ma; & Baterson. 1999: 30)

3.5 Constructivist learning environment

There is increasing evidence that to prepare students who will be better, more effective learners of science, different methods of preparing prospective learners are necessary. This study presents that theoretical and practical rationale for developing a constructivist-based informal science programs and reports on the findings for the program implementation.

The results of this investigation have shown that the CTSPZ activities provide a constructivist learning environment. In traditional teaching approaches, students are passive recipients, but in the CTSPZ learning approach students are in an active position. This approach allows students to work in groups and enables them to develop social interactions. According to Johnson and Johnson (1986), students who talk through course materials with peers will learn more effectively. The tasks requiring social interactions will stimulate learning and will enable students to recognize that an action should be taken with reference to others. In cooperative learning, students are provided with concrete experiences first hand.

According to the constructivist theory, learning is the interpretation of what is happening in the world from the point of view of the individual in planned experiences (Jaworsky. 1994: 18). Within the CTSPZ, students took part in the learning-based activities, felt the activity by using all possible senses, and reached a conclusion after thinking in terms of cause-effect relations. Therefore, students are not passive recipients of knowledge but they construct knowledge by participating actively in learning activities and by using cognitive processes (Wheatley. 1991: 11).

Recommendation

After interpretation of the results CTSPZ based on constructivist learning theory, the following concerns need to be considered when developing and implementing an informal science program:

For science teacher

The results of this investigation showed that the CTSPZ, positively influenced student's science process skills and attitudes toward science. It appears that science instruction that includes an informal experience is a viable and effective instructional method for science teachers. Based on the findings presented in this study, a hands-on activites, thematic units, and constructivist learning environment, as parts of the CTSPZ, offered a prescriptive method for raising science process skills levels and promoting positive attitudes toward science among science students, particularly for those who enrolled in CTSPZ. The model of CTSPZ proposed here appears to be effective with students of diverse backgrounds including both high scores and low scores in the science process skills. Therefore, teachers who are the operators of the science curriculum must be informed about this effective learning.

In addition, most of the research studies in theliterature showed that there were positive relationships between the students' science process skills and their achievements in science and also between the students' positive attitudes toward science and their achievements in science (Schibeci; & Riley, 1986). Therefore, science teachers should be aware of the importance of improving the students' science process skills and positive attitudes toward science, because they are strong predictors of the students' achievement in science.

According to Newman (1990), social conditions in a class are constructed actively by the teacher and students. The learning environment constructed in the CTSPZ are support interactive dialogue, discussion, and cooperation in activities. Hands-on activities and constructivist learning environment are the most important learning environments that provide the development of attitudes and cognitive levels in a positive manner that lead students to discover scientific facts and concepts in small groups as well as providing development of social relations through these activities. Due to these reasons, hands-on activities should be given more consideration in science teaching (Hofstein; &etta. 2004:95)

For school administrators

The emphasis in this research was on learning in informal settings in that the researchers examined the learning in a zoo, focused on using the school system to maximize the effectiveness of the educational interventions that took place outside of the school. In the light of the results of this study, the positive attitude towards science and the attitude towards the environment disposed students to engage in learning about science and the environment. Therefore, one would look to the richness of experiences in informal settings to develop understanding. Considering the amount of time that students spend in formal vs. informal settings, it would seem more appropriate to focus on how informal settings can enhance or improve school-based instruction. However, more work has to be done to illuminate, develop, and support the relationship between formal and informal settings, so as to maximize the strengths of each institution.

The primary goal of this study was to develop a model that can be easily applied to various diverse situations in which an informal education program could effectively enhance and expand formal education. This model would form sustainable relationships and links between informal and formal education. Sustainability is created by integrating the informal education program into the formal education program. The components of the model, setting, teachers, and classroom may change, but the linkages remain. The content could be easily be changed so that the CTSPZ could serve as a blueprint for other informal education programs.

For zoo administrators

With the shift in the zoo paradigm extending the goals of the zoo to include not only recreation but also education, conservation, and research, zoos need to take advantage of every opportunity to educate visitors. Based on the results of the present study, zoos can use the CTSPZ with interpretation to increase educational and recreational benefits and visitor perceptions of the zoo.

Future study

1. Replication of this study should be conducted with a larger sample of subjects through the full range of middle grade levels. In addition, the students should be tested several times over a period of at least one year. This would allow time for the habits of mind discussed, by Aldridge (1989), to develop and for difference between experimental and control groups to become more pronounced.

2. A qualitative study should be conducted to examine which of the science process skills are most often used and in what order students tend to use them. Moreover, the examination of pairs of skills which are closely related to one another, for example measuring and recording data, should be conducted.

3. A longitudinal study could be conducted to determine what the effect of the CTSPZ has on students. A study could be conducted school-wide to determine the effect of the CTSPZ, thematic teaching, or the naturalist have on the teachers.

4. A comparative study of other informal educational programs could also be conducted. Some of the questions might include;

- How was the CTSPZ developed and maintained?
- How is the CTSPZ being used?
- How does the model of the themes, constructivism, and values compare with other informal educational program?

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APPENDIX

Appendix 1

List of experts for research instrument

Experts for research instruments

1. Association Professor Dr. Prayoung Pongthongchareon	Srinakharinwirot University
2. Assistant Professor Dr. Verapong Saeng-xuto	Chiangmai University
3. Dr. Manat Boonprakob	Srinakharinwirot University
4. Dr. Numphon Koocharoenpisal	Srinakharinwirot University
5. Dr. Sompratana Wongboonnu	Srinakharinwirot University
6. Mr. Apidat Singhasanee	Kaowkeaw zoo
7. Miss. Jarunee Chaichana	Chiangmai zoo
8. Miss Kittaporn Puakanokhirun	Chiangmai university demonstration school
5. Mrs. Sunee Daroontham	Navamindarajudis Phayap school

Appendix 2

Research instruments

A Scientific Attitude Inventory (SAI II)

Instruction

There are some statements about science on the next two pages. Some statements are about the nature of science. Some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with other. That is exactly what you are asked to do.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. You may decide that you are uncertain or cannot decide. Then, mark on the table.

Items	Strongly Agree	Mildly Agree	Undecided	Mildly Disagree	Strongly Disagree
1. I would enjoy studying science.					
2. Anything we need to know can be found out through science.					
3. It is useless to listen to a new idea unless everybody agrees with it.					
4. Scientists are always interested in better explanations of things.					
5. If one scientist says an idea is true, all other scientists will believe it.					
6. Only highly trained scientists can understand science.					

Items	Strongly Agree	Mildly Agree	Undecided	Mildly Disagree	Strongly Disagree
7. We can always get answers to our questions by asking a scientist.					
8. Most people are not able to understand science.					
9. Electronics are examples of the really valuable products of science.					
10. Scientists cannot always find the answers to their questions.					
11. When scientists have a good explanation, they do not try to make it better.					
12. Most people can understand science.					
13. The search for scientific knowledge would be boring.					
14. Scientific work would be too hard for me.					
15. Scientists discover laws which tell us exactly what is going on in nature.					
16. Scientific ideas can be changed.					
17. Scientific questions are answered by observing things.					
18. Good scientists are willing to change their ideas.					

Items	Strongly Agree	Mildly Agree	Undecided	Mildly Disagree	Strongly Disagree
19. Some questions cannot be answered by science.					
20. A scientist must have a good imagination to create new ideas.					
21. Ideas are the important result of science.					
22. I do not want to be a scientist.					
23. People must understand science because it affects their lives.					
24. A major purpose of science is to produce new drugs and save lives.					
25. Scientists must report exactly what they observe.					
26. If a scientist cannot answer a question, another scientist can.					
27. I would like to work with other scientists to solve scientific problems.					
28. Science tries to explain how things happen.					
29. Every citizen should understand science.					
30. I may not make great discoveries, but working in science would be fun.					

Items	Strongly Agree	Mildly Agree	Undecided	Mildly Disagree	Strongly Disagree
30. I may not make great discoveries, but working in science would be fun.					
31. A major purpose of science is to help people live better.					
32. Scientists should not criticize each other's work.					
33. The senses are one of the most important tools a scientist has.					
34. Scientists believe that nothing is known to be true for sure.					
35. Scientific laws have been proven beyond all possible doubt.					
36. I would like to be a scientist.					
37. Scientists do not have enough time for their families or for fun.					
38. Scientific work is useful only to scientists.					
39. Scientists have to study too much.					
40. Working in a science laboratory would be fun.					

Science Attitude Scale for Middle School Students

Instruction

There are some statements about attitude towards science on the next three pages. You may agree with some of the statements and you may disagree with other. That is exactly what you are asked to do.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. You may decide that you are uncertain or cannot decide. Then, mark on the table.

Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. Getting science books from the library is a drag.					
2. I hate to keep records of science experiments in a notebook					
3. Science films bore me to death					
4. I wish science class lasted all day.					
5. I dislike watching science specials on television					
6. I hate science class					
7. Learning science facts is a drag.					
8. Working with science equipment makes me feel important					

Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
9. I would like to join a science club that meets after school.					
10. Looking trough a microscope is not my idea of fun.					
11. Knowing science facts makes me feel good.					
12. I don't mind doing an experiment several times to check the answer.					
13. I feel like day dreaming during science class.					
14. Sharing science facts that I know makes me feel great.					
15. I hate to study science out of doors.					
16. It's neat to talk to my parents about science.					
17. I like to make science drawings.					
18. I wouldn't think of discussing science with friends.					
19. I enjoy using mathematics in science experiments.					
20. I cannot wait until science class					

Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
21. I wish we didn't have science class so often					
22. Doing science projects at home is dumb.					
23. Science is one of my favorite classes.					

The Children’s Attitudes toward the Environment Scale

Instruction

There are some statements about attitude towards the environment on the next five pages. You may agree with some of the statements and you may disagree with other. That is exactly what you are asked to do.

After you have carefully read a statement, check the larger box ☐ if you think you are a lot like the children described in the statement. Check the smaller box ☐, if you belie that you are only a little like the children described in the statement

1. Some kids like to leave water running when they brush their teeth.	☐	☐
but other kids always turn the water off while brushing their teeth	☐	☐
2. Some kids use both sides of the paper when they draw or write.	☐	☐
but other kids use only one side of the paper when they draw or write.	☐	☐
3. Some kids think we should throw away things when we're done with them.	☐	☐
but other kids think we should recycle things.	☐	☐
4. Some kids think dams on rivers are bad because they hurt plants and animals.	☐	☐

but other kids think dams on rivers are good because they prevent floods. ☐ ☐

5. Some kids like to bring home plants or bugs they find outside. ☐ ☐

but other kids like to look at plants or bugs outside but they never bring them home. ☐ ☐

6. Some kids don't like to make bird feeders or bird houses. ☐ ☐

but other kids like to make bird feeders or bird houses. ☐ ☐

7. Some kids think outdoor lights should be turned off at night because they use electricity. ☐ ☐

but other kids think outdoor lights should be left on at night because they keep us safer. ☐ ☐

8. Some kids think people are more important than animals. ☐ ☐

but other kids think people and animals are equally important. ☐ ☐

9. Some kids are concerned about the rain forest. ☐ ☐

but other kids aren't concerned about the rain forest. ☐ ☐

10. Some kids think we should build more landfills to hold our garbage. ☐ ☐

but other kids think we should find other ways to deal with our garbage. ☐ ☐

11. Some kids like visiting national parks. ☐ ☐

but Other kids don't like to go to national parks ☐ ☐

12. Some kids don't worry about animals becoming extinct. ☐ ☐

but Other kids worry about animals becoming extinct. ☐ ☐

13. Some kids throw things away when they are done with them. ☐ ☐

but Other kids reuse things or give them to other people to use. ☐ ☐

14. Some kids think we should use chemicals and fertilizers in our gardens. ☐ ☐

but Other kids think we shouldn't use chemicals and fertilizers in. ☐ ☐

15. Some kids pick up trash and throw it our gardens. ☐ ☐

but Other kids don't like to pick up smelly trash. ☐ ☐

16. Some kids don't sort trash. ☐ ☐

but Other kids sort their trash and recycle it. ☐ ☐

17. Some kids like to live where there are lots of plants and animals. ☐ ☐

but Other kids like to live where there are lots of people ☐ ☐

18. Some kids touch or catch wild animals. ☐ ☐

but Other kids never touch or catch animals they find outside ☐ ☐

19. Some kids don't like carpool because they don't like being crowded in the car. ☐ ☐

but Other kids like to carpool even if it is a little crowded. ☐ ☐

20. Some kids are excited about solar energy. ☐ ☐

but Other kids don't care about solar energy ☐ ☐

21. Some kids believe people should be able to live wherever they want. ☐ ☐

but Other kids believe that people should be careful not to destroy animals' homes. ☐ ☐

22. Some kids worry about air pollution. ☐ ☐

but Other kids don't worry about air pollution. ☐ ☐

23. Some kids think we should be able to hunt all wild animals. ☐ ☐

but Other kids think that animals need protection ☐ ☐

24. Some kids turn off the lights when they leave.	☐	☐
but Other kids leave the lights on.	☐	☐
25. Some kids get their parents to drive them places they want to go.	☐	☐
but Other kids ride their bikes or walk when they can.	☐	☐

A Constructivist Learning Environment Survey

Direction for Students

1. This questionnaire asks you to describe this classroom that you are in right now. You will be asked how often each practice takes place.

2. There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Think about how well each statement describes what this class is like for you.

3. Do not write your name. Your answers are confidential and anonymous.

4. On the next few pages you will find 30 sentences. For each sentence, circle one number corresponding to your answer.

Draw a circle around

1.	if the practice takes place	Almost Never
2.	if the practice takes place	Seldom
3.	if the practice takes place	Sometimes
4.	if the practice takes place	Often
5.	if the practice takes place	Almost Always

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Sometime Statements in this questionnaire are fairly similar to other statements. Don't' worry about this. Simply give your opinion about all statements.

5. Please provide details in the box below:

   a. School:___________________ b. Teacher's Name:________________

   c. Subject:__________________ d. Grade Level:___________________

   e. Your Sex (please circle): Male or Female

6. Now turn the page and please give an answer for every question

Constructivist Learning Environment Survey

Items	Almost never	Seldom	Sometime	Often	Almost always
Learning about the world In this class…..					
1. I learn about the world outside of school.	1	2	3	4	5
2. My new learning starts with problems about the world out side of school.	1	2	3	4	5
3. I learn how science can be part of my out of school life	1	2	3	4	5
4. I get better understanding of the world outside of school.	1	2	3	4	5
5. I learn interesting things about the world outside of school.	1	2	3	4	5
6. What I learn has nothing to do with my out of school life.	1	2	3	4	5
Learning about science In this class…..					
7. I learn that science cannot provide perfect answers to problems.	1	2	3	4	5
8. I learn that science has changed over time.	1	2	3	4	5
9. I learn that science is influenced by people's values and opinions.	1	2	3	4	5

Items	Almost never	Seldom	Sometime	Often	Almost Always
10. I learn about the different sciences used by people in other cultures.	1	2	3	4	5
11. I learn that modern science is different from the science of long ago.	1	2	3	4	5
12. I learn that science is about creating theories.	1	2	3	4	5
Learning to speak out					
In this class…..					
13. It is OK for me to ask the teacher " Why do I have to learn this?'	1	2	3	4	5
14. It is OK for me to question the way I am being taught.	1	2	3	4	5
15. It is OK for me to complain about teaching activities that are confusing.	1	2	3	4	5
16. It is OK for me to complain about anything that prevents me from learning.	1	2	3	4	5
17. It is OK for me to express my opinion.	1	2	3	4	5
18. It is OK for me to speak up for my right.	1	2	3	4	5
Learning to learn					
In this class…..					
19. I help the teacher to plan what I am going to learn.	1	2	3	4	5

Items	Almost never	Seldom	Sometime	Often	Almost Always
20. I help the teacher to decide how well I am learning.	1	2	3	4	5
21. I help the teacher to decide which activities are best for me.	1	2	3	4	5
22. I help the teacher to decide how much time I spend on learning activities.	1	2	3	4	5
23. I help the teacher to decide which activities I do.	1	2	3	4	5
24. I help the teacher to assess my learning.	1	2	3	4	5
Learning to communicate					
In this class…..					
25. I get the chance to talk to other students.	1	2	3	4	5
26. I talk with other students about how to solve problems.	1	2	3	4	5
27. I explain my understandings to other students.	1	2	3	4	5
28. I ask other students to explain their thoughts.	1	2	3	4	5
29. Other students ask me to explain my ideas.	1	2	3	4	5
30. Other students explain their ideas to me.	1	2	3	4	5

APENDIX 3

A Constructivist Thematic Science Program at Chiangmai zoo

โปรแกรมวิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่

(A Constructivist Thematic Science Program at Chiangmai Zoo)

หลักการของโปรแกรม

หลักการของการพัฒนาโปรแกรมการเรียนรู้วิทยาศาสตร์ในสวนสัตว์เชียงใหม่นี้ ได้จากการศึกษาการเปลี่ยนแปลงของโลกปัจจุบันที่เรากล่าวกันว่าเป็นยุคโลกาภิวัฒน์ (globalization) ซึ่งพบว่าองค์ความรู้และเทคโนโลยีต่างๆ ได้มีการเปลี่ยนแปลงไปอย่างรวดเร็ว เนื่องจากองค์ความรู้และเทคโนโลยีนับเป็นรากฐานสำคัญในการพัฒนาเศรษฐกิจและสังคมของประเทศ ดังนั้น ประเทศใดที่ประชากรมีระดับพื้นฐานความรู้อยู่ในระดับสูงก็อนุมานได้ว่าประเทศนั้นมีความได้เปรียบทางด้านเศรษฐกิจและสังคม ดังนั้นจึงส่งผลให้ประเทศต่าง ๆ ได้มีการปฏิรูปการศึกษาให้เข้ากับการเปลี่ยนแปลงและการแข่งขันนี้ ในส่วนของประเทศไทยเองได้มีการปฏิรูปการศึกษาขึ้น เพื่อให้ทันกับการแข่งขันและเปลี่ยนแปลงในสังคมเศรษฐกิจโลก (สุนีย์. 2547) ผลของการปฏิรูปการศึกษาทำให้เกิดมีพระราชบัญญัติการศึกษาแห่งชาติฉบับปี พ.ศ. 2542 และฉบับแก้ไขเพิ่มเติม (ฉบับที่ 2) พ.ศ. 2545

พระราชบัญญัติการศึกษาแห่งชาติฉบับปี พ.ศ. 2542 และฉบับแก้ไขเพิ่มเติม (ฉบับที่ 2) พ.ศ. 2545 ได้ระบุให้มีการส่งเสริมให้ผู้เรียนมีโอกาสได้รับการศึกษาอย่างทั่วถึง ทั้งการศึกษาในระบบ นอกระบบ และตามอัธยาศัย โดยเน้นความจริงและผู้เรียนเป็นตัวหลักและวิชาการเป็นส่วนประกอบ ผู้เรียนสามารถเรียนรู้ได้ทุกเวลาและทุกสถานที่ ความสำคัญนี้ได้ถูกบัญญัติไว้ในหมวดที่ ๔ มาตรา ๒๕ (สำนักงานปลัดกระทรวง. 2545)

" รัฐต้องส่งเสริมการดำเนินงานและการจัดตั้งแหล่งการเรียนรู้ตลอดชีวิตทุกรูปแบบ ได้แก่ ห้องสมุดประชาชน พิพิธภัณฑ์ หอศิลป์ สวนสัตว์ สวนสาธารณะ สวนพฤกษศาสตร์ อุทยานวิทยาศาสตร์และเทคโนโลยี ศูนย์การกีฬาและนันทนาการ แหล่งข้อมูล และแหล่งการเรียนรู้อื่นอย่างพอเพียงและมีประสิทธิภาพ"

ในส่วนของการเรียนการสอนวิทยาศาสตร์นั้น เพื่อให้สอดคล้องกับการเปลี่ยนแปลงในการปฏิรูปการศึกษา สถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยี(สสวท) ได้ตระหนักว่า วิทยาศาสตร์ทำให้คนได้พัฒนาวิธีคิดทั้งความคิดเป็นเหตุเป็นผล คิดสร้างสรรค์ คิดวิเคราะห์ วิจารณ์ มีทักษะสำคัญในการค้นคว้าหาความรู้ มีความสามารถในการแก้ปัญหาอย่างเป็นระบบ สามารถตัดสินใจได้โดยใช้ข้อมูลที่หลากหลายและประจักษ์พยานที่ตรวจสอบได้ วิทยาศาสตร์เป็นวัฒนธรรม

ของโลกสมัยใหม่ ซึ่งเป็นสังคมแห่งความรู้ (knowledge based society) ทุกคนจึงจำเป็นต้องได้รับการพัฒนาให้รู้วิทยาศาสตร์ (scientific literacy for all) เพื่อที่จะให้มีความรู้ความเข้าใจโลกธรรมชาติและเทคโนโลยี และนำองค์ความรู้ไปใช้อย่างมีเหตุผล สร้างสรรค์ มีคุณธรรม ตลอดจนการพัฒนาสิ่งแวดล้อมและทรัพยากรธรรมชาติอย่างสมดุลและยั่งยืน สถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยีได้กำหนดวิสัยทัศน์การเรียนรู้วิทยาศาสตร์เพื่อให้สอดคล้องกับพระราชบัญญัติการศึกษาแห่งชาติ ฉบับปี พ.ศ. 2542 ไว้ดังนี้ (สสวท. 2546)

- การเรียนรู้วิทยาศาสตร์เป็นการพัฒนาผู้เรียนให้ได้รับทั้งความรู้ กระบวนการและเจตคติ ผู้เรียนทุกคนควรได้รับการกระตุ้นส่งเสริมให้สนใจและกระตือรือร้นที่จะเรียนรู้วิทยาศาสตร์ มีความสงสัยเกิดคำถามในสิ่งต่าง ๆ ที่เกี่ยวกับโลกธรรมชาติรอบตัว มีความมุ่งมั่นและมีความสุขที่จะศึกษาค้นคว้า สืบเสาะหาความรู้เพื่อรวบรวมข้อมูล วิเคราะห์ผล นำไปสู่คำตอบของคำถาม สามารถตัดสินใจด้วยการใช้ข้อมูลอย่างมีเหตุผล สามารถสื่อสารคำถาม คำตอบ ข้อมูลและสิ่งที่ค้นพบจากการเรียนรู้ให้ผู้อื่นเข้าใจได้
- การเรียนรู้วิทยาศาสตร์เป็นการเรียนรู้ตลอดชีวิต เนื่องจากความรู้วิทยาศาสตร์เป็นเรื่องราวเกี่ยวกับโลกธรรมชาติ (natural world) ซึ่งมีการเปลี่ยนแปลงตลอดเวลา ทุกคนจึงต้องเรียนรู้เพื่อนำผลการเรียนรู้ไปใช้ในชีวิตและการประกอบอาชีพ เมื่อผู้เรียนได้เรียนวิทยาศาสตร์โดยได้รับการกระตุ้นให้เกิดความตื่นเต้น ท้าทายกับการเผชิญสถานการณ์หรือปัญหา มีการร่วมกันคิด ลงมือปฏิบัติจริง ก็จะเข้าใจและเห็นความเชื่อมโยงของวิทยศาสตร์กับวิชาอื่นและชีวิต ทำให้สามารถอธิบาย ทำนายคาดการณ์สิ่งต่างๆ ได้อย่างมีเหตุผล การประสบความสำเร็จในการเรียนวิทยาศาสตร์จะเป็นแรงกระตุ้นให้ผู้เรียนมีความสนใจมุ่งมั่นที่จะสังเกต สำรวจตรวจสอบ สืบค้นความรู้ที่มีคุณค่าเพิ่มขึ้นอย่างไม่หยุดยั้ง การจัดกิจกรรมการเรียนการสอนจึงต้องให้สอดคล้องกับสภาพชีวิต โดยใช้แหล่งเรียนรู้ที่หลากหลายในท้องถิ่น และคำนึงถึงผู้เรียนที่มีวิธีการเรียนรู้ ความสนใจและความถนัดแตกต่างกัน
- การเรียนรู้วิทยาศาสตร์พื้นฐาน เป็นการเรียนรู้เพื่อความเข้าใจ ซาบซึ้งและเห็นความสำคัญของธรรมชาติและสิ่งแวดล้อม ซึ่งจะส่งผลให้ผู้เรียนสามารถเชื่อมโยงองค์ความรู้ หลาย ๆ ด้าน เป็นความรู้แบบองค์รวม อันจะนำไปสู่การสร้างสรรค์สิ่งต่างๆ และพัฒนาคุณภาพชีวิต มีความสามารถในการจัดการและร่วมกันดูแลรักษาโลกธรรมชาติอย่างยั่งยืน

จากการศึกษาพระราชบัญญัติการศึกษาแห่งชาติ ฉบับปี พ.ศ. 2542 และฉบับแก้ไขเพิ่มเติม (ฉบับที่ 2) พ.ศ. 2545 และวิสัยทัศน์ของวิทยาศาสตร์ศึกษา จะเห็นได้ว่าปรัชญาด้านการศึกษาได้เปลี่ยนแปลงไปจากการเรียนการสอนที่เน้นการจดจำองค์ความรู้มาเป็นการเรียนการสอนที่เน้นการสร้างองค์ความรู้ด้วยตนเอง (constructivism) และส่งเสริมให้เกิดการเรียนรู้อย่างต่อเนื่องตลอดชีวิต

(Life long learning) จากผลการศึกษานี้เองนำมาสู่การพัฒนาโปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่

การพัฒนาโปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่นี้ใช้แนวปรัชญาสรรคนิยม (constructivism) ที่เน้นการเรียนรู้ภายนอกห้องเรียน (informal setting) คือสวนสัตว์เชียงใหม่ เพื่อส่งเสริมให้เกิดโอกาสในการเรียนรู้วิทยาศาสตร์แก่ทุกคน ไม่ว่าจะเป็นกลุ่มการศึกษาในระบบ (formal education) ที่จะสามารถนำโปรแกรมการเรียนรู้วิทยาศาสตร์นี้เข้าเชื่อมโยงเนื้อหาการเรียนรู้วิทยาศาสตร์ตามเกณฑ์มาตรฐานการเรียนรู้สาระวิทยาศาสตร์ในช่วงชั้นที่ 3 หรือกลุ่มการศึกษาตามอัธยาศัย(non-formal education) และกลุ่มการศึกษานอกระบบ (informal education) ซึ่งจะสามารถนำโปรแกรมการเรียนรู้วิทยาศาสตร์นี้มาใช้เรียนรู้ได้เมื่อเข้าเยี่ยมชมสวนสัตว์เชียงใหม่ โดยแต่ละหน่วยการเรียนรู้จะประกอบไปด้วยกิจกรรมที่หลากหลาย และเน้นให้นักเรียนสร้างองค์ความรู้ด้วยตนเอง รวมทั้งการทำงานเป็นกลุ่ม ซึ่งจะใช้เวลาในการศึกษาโดยประมาณ 2 ชั่วโมงต่อหนึ่งหน่วยการเรียนรู้ เพื่อจุดมุ่งหวังให้ผู้เรียนได้เกิดการพัฒนาทักษะทางวิทยาศาสตร์ เจตคติต่อวิชาวิทยาศาสตร์ เจตคติทางวิทยาศาสตร์ และเจตคติต่อสิ่งแวดล้อม

จุดมุ่งหมายของโปรแกรม

1. เพื่อส่งเสริมให้นำโปรแกรมการเรียนรู้วิทยาศาสตร์ภายนอกห้องเรียนนี้ (informal science education) ไปใช้เชื่อมโยง เข้ากับการเรียนรู้วิทยาศาสตร์ในระบบ (formal education) ตามมาตรฐานการเรียนรู้วิทยาศาสตร์สำหรับนักเรียนในช่วงชั้นที่ 3
2. เพื่อส่งเสริมให้ผู้เรียนเพิ่มพูนทักษะทางวิทยาศาสตร์ เจตคติต่อวิทยาศาสตร์ เจตคติเชิงวิทยาศาสตร์ และเจตคติต่อสิ่งแวดล้อม หลังจากได้เรียนรู้ตามโปรแกรมวิทยาศาสตร์นี้
3. เพื่อเป็นโปรแกรมต้นแบบให้ครูวิทยาศาสตร์นำไปปรับปรุงหรือพัฒนาโปรแกรมการเรียนรู้นอกห้องเรียนในโรงเรียนตนเอง หรือแหล่งเรียนรู้ที่อยู่ใกล้บริเวณโรงเรียน

วิธีจัดประสบการณ์การเรียนรู้

โปรแกรมการเรียนรู้วิทยาศาสตร์ในแหล่งเรียนรู้สวนสัตว์เชียงใหม่ เป็นโปรแกรมที่เน้นให้นักเรียนสร้างองค์ความรู้ด้วยตนเอง ในสภาพแวดล้อมจริงตามธรรมชาติและการมีปฏิสัมพันธ์ระหว่างเพื่อนร่วมเรียน ซึ่งเป็นพื้นฐานของทฤษฎีสรรคนิยม (constructivism) แนวคิดนี้มีที่มาจากแนวคิดทางการศึกษาของของนักการศึกษาหลายท่านดังเช่น

- จอห์น ดิวอี้ (John Dewey) ซึ่งเป็นต้นคิดในเรื่องของ “การเรียนรู้โดยการกระทำ” หรือ “Learning by Doing” (Dewey ,1938) อันเป็นแนวคิดที่แพร่หลายและได้รับการยอมรับทั่วโลกมานาน

แล้ว การจัดการเรียนการสอนโดยให้ผู้เรียนเป็นผู้ลงมือปฏิบัติจัดกระทำนี้ นับว่าเป็นการเปลี่ยนบทบาทในการเรียนรู้ของผู้เรียนจากการเป็น “ผู้รับ” มาเป็น “ผู้เรียน” และเปลี่ยนบทบาทของครูจาก “ผู้สอน” หรือ “ผู้ถ่ายทอดข้อมูลความรู้” มาเป็น “ผู้จัดประสบการณ์การเรียนรู้” ให้ผู้เรียน ซึ่งการเปลี่ยนแปลงบทบาทนี้ เท่ากับเป็นการเปลี่ยนจุดเน้นของการเรียนรู้ว่าอยู่ที่ผู้เรียนมากกว่าอยู่ที่ผู้สอนดังนั้นผู้เรียนจึง กลายเป็นศูนย์กลางของการเรียนการสอน เพราะบทบาทในการเรียนรู้ส่วนใหญ่จะอยู่ที่ตัวผู้เรียนเป็นสำคัญ

- ปิอาเจต์ (Piaget) นักจิตวิทยาชาวสวิสได้วิจัยเกี่ยวกับพัฒนาการของมนุษย์และได้ค้นพบว่า พัฒนาการทางสติปัญญาของมนุษย์จะเกิดขึ้นต่อมื่อมีการปรับตัวเข้ากับสิ่งแวดล้อม โดยประสบการณ์การเรียนรู้ที่ได้มาจะมาจากการผสมผสานหรือการซึมซับ (assimilation) และอยู่ในรูปแบบของโครงสร้างของสติปัญญา (cognitive Structure) ของเด็ก ซึ่งเด็กในแต่ละวัยจะมีโครงสร้างทางสติปัญญาแตกต่างกัน โดยผู้เรียนเป็นผู้สร้าง (construct) ความรู้จากความสัมพันธ์ระหว่างสิ่งที่พบเห็นกับความรู้ความเข้าใจเดิมที่มีมาก่อน โดยพยายามนำความเข้าใจเกี่ยวกับเหตุการณ์และปรากฏการณ์ที่ตนพบเห็นมาสร้างเป็นโครงสร้างทางปัญญา (schema) โดยโครงสร้างทางปัญญาจะมีการพัฒนาโดยผ่านกระบวนการดูดซึม (assimilation) ซึ่งเป็นการนำความความรู้ใหม่หรือสิ่งแวดล้อมภายนอกเข้ามาไว้ในโครงสร้างทางปัญญา จากนั้นจะเกิดการปรับโครงสร้างของสติปัญญาให้เข้ากับสิ่งแวดล้อม หรือประสบการณ์ใหม่ โดยเชื่อมโยงกับประสบการณ์เดิมของตน (Accommodation) เพื่อสร้างภาวะที่สมดุลย์ให้ความรู้ (equilibration) ทางสติปัญญาจากขั้นต่ำไปหาขั้นที่สูงกว่าตามลำดับขั้น ซึ่งจะเห็นได้ว่าเป็นกระบวนการที่เด็กเป็นผู้สร้างความรู้ให้แก่ตนเอง ให้เหมาะสมกับระดับพัฒนาการของเขา ดังนั้นครูนอกจากจะเป็นผู้สอน แล้ว ครูจะต้องมีบทบาทที่จะจัดประสบการณ์การเรียนรู้ให้แก่ผู้เรียนด้วย เพื่อให้ผู้เรียนมีปฏิสัมพันธ์กับสิ่งแวดล้อม และเกิดการซึมซับหรือผสมผสาน ประสบการณ์ ใหม่ให้เข้ากับโครงสร้างทางสติปัญญา

- วิกอทสกี้ (Vygotsky) ซึ่งเป็นชาวรัสเซีย เชื่อว่าบริบททางสังคม และวัฒนธรรมมีอิทธิพลต่อการเรียนรู้ และสนับสนุนให้ใช้การค้นคว้าความรู้ในการเรียน หลักการเรียนรู้ของวิกอทสกี้จะสร้างเสริมการสร้างการเรียนรู้โดยชุมชนมีบทบาทสำคัญในการเรียนรู้ บุคคลที่อยู่แวดล้อมผู้เรียน มีอิทธิพลต่อการมองโลกของผู้เรียน วิกอทสกี้ได้เสนอเรื่องเขตของการพัฒนาได้ (zone of proximal development) ของผู้เรียน หมายถึง อาณาเขตของศักยภาพของบุคคล ซึ่งสามารถได้รับการพัฒนาได้จากการมีปฏิสัมพันธ์ทางสังคมกับผู้ที่มีความสามารถมากกว่า ทำให้ได้มาซึ่งความคิดรวบยอดและการร่วมมือ แนวคิดนี้ชี้ให้เห็นวิธีการสำคัญในการพัฒนาผู้เรียน คือ การให้นั่งร้าน (scaffolding) เพื่อสนับสนุนทั้งด้านข้อมูลและความร่วมมือ ทำให้ปัญหาการเรียนรู้ที่ผู้เรียนต้องเผชิญมีความซับซ้อนน้อยลง จนทำให้ผู้เรียนสามารถแก้ปัญหาด้วยตนเองได้ในที่สุด (Vygotsky. 1978)

โปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบทตามแนวทฤษฎีสรรคนิยมนี้ ได้พัฒนาขึ้นจากแนวคิดตามแนวปรัชญาสรรคนิยมดังกล่าว ซึ่งขั้นตอนในการเรียนรู้จะประกอบไปด้วยหกขั้นตอนตามรูปแบบการเรียนรู้ที่Gagnon และ Collay ได้พัฒนาขึ้นดังนี้ (Gagnon;& Collay. 2001)

1. สร้างสถานการณ์การเรียนรู้ (situation) ขั้นนี้จัดเป็นขั้นการเตรียมความพร้อมของผู้เรียนและแจ้งให้ผู้เรียนทราบถึงเรื่องที่จะเรียนรู้และผลการเรียนรู้ที่คาดหวัง

2. จัดกลุ่มการเรียนรู้ (grouping) เพื่อจัดกลุ่มการเรียนรู้ของผู้เรียนให้เหมาะสมกับสถานการณ์การเรียนรู้ อุปกรณ์ และส่งเสริมการทำงาน การเรียนรู้ร่วมกับผู้อื่นตามแนวทฤษฎีสรรคนิยม

3. เชื่อมโยงควมรู้ (bridge) เป็นขั้นการสำรวจความรู้พื้นฐานเดิมของผู้เรียน เพื่อแก้ไขข้อเข้าใจที่ผิดพลาด (miss conception) เพื่อเตรียมความพร้อมของนักเรียนเพื่อสร้างองค์ความรู้ใหม่

4. คำถามเพื่อการเรียนรู้ (question) เป็นการใช้คำถามเพื่อให้ผู้เรียนเกิดการสร้างองค์ความรู้ใหม่

5. แสดงออกของความรู้ (exhibition) เป็นขั้นที่ให้ผู้เรียนแสดงออกถึงองค์ความรู้ที่ได้สร้างเพิ่มขึ้น ปรับเปลี่ยนหรือเพิ่มเติมองค์ความรู้ที่ถูกต้องให้กับนักเรียน

6. สะท้อนความรู้ (refection) เป็นขั้นที่นักเรียนนำองค์ความรู้ที่สร้างขึ้นมาสะท้อนความคิดเชื่อมโยงกับสถานการณ์ต่างๆ เพื่อการพัฒนาความรู้ขั้นสูง

การวัดและประเมินผล

การวัดผลประเมินผลการเรียนรู้ในโปรแกรมโปรแกรมวิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่ จะยึดตามแนวคิดของการประเมินตามสภาพจริง (authentic assessment) โดยมีวิธีการประเมินที่หลากหลาย ทั้งจากการสังเกตของผู้นำกิจกรรมในแต่ละหน่วยการเรียนรู้ ประเมินจากผลงานของนักเรียนในแต่ละหน่วยการเรียนรู้ การประเมินจากกลุ่มผู้เรียน และการประเมินด้วยตัวผู้สอนและผู้เรียนเอง

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โปรแกรมการเรียนรู้วิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฏีสรรคนิยม ณ สวนสัตว์เชียงใหม่

กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
หลากหลายสายพันธุ์ชีวิต	**มาตรฐานการเรียนรู้สาระที่ 1 สิ่งมีชีวิตกับกระบวนการดำรงชีวิต** **มาตราฐาน ว 1.2** เข้าใจกระบวนการและความคัญของการถ่ายทอดลักษณะทางพันธุกรรม วิวัฒนาการของสิ่งมีชีวิต ความหลากหลายทางชีวภาพ การใช้เทคโนโลยีที่มีผลต่อมนุษย์และสิ่งแวดล้อม มีกระบวนการสืบเสาะหาความรู้ และจิตวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้ และนำความรู้ไปใช้ประโยชน์	สำรวจ สืบค้นข้อมูล และอธิบายความหลากหลายทางชีวภาพในท้องถิ่น ที่ทำให้สิ่งมีชีวิตดำรงชีวิตอยู่ได้อย่างสมดุลย์ และผลต่อการดำรงชีวิตของมนุษย์ ทั้งในด้านที่เป็นประโยชน์และโทษ โดยเฉพาะโรคที่มีผลต่อสังคม	1. สำรวจ สืบค้นข้อมูล และอธิบายความหลากหลายทางชีวภาพในท้องถิ่น 2. สืบค้นข้อมูลและอธิบายผลดีและผลเสียของความหลากหลายททางชีวภาพที่มีต่อมนุษย์	1. การสำรวจความหลากหลายทางชีวภาพในท้องถิ่น 2.การสืบค้นข้อมูล การอภิปรายผลของความหลากหลายทางชีวภาพที่มีต่อมนุษย์	3

กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
อยู่ร่วมกันสายสัมพันธ์ชีวิต	**มาตรฐานการเรียนรู้สาระที่ 2 ชีวิตกับสิ่งแวดล้อม** **มาตราฐาน ว 2.1** เข้าใจสิ่งแวดล้อมในท้องถิ่น ความสัมพันธ์ระหว่างสิ่งแวดล้อมกับสิ่งมีชีวิต ความสัมพันธ์ระหว่างสิ่งมีชีวิตต่างๆ ในระบบนิเวศน์ มีกระบวนการสืบเสาะหาความรู้และเจตคติทางวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้ และนำความรู้ไปใช้ประโยชน์	1. สำรวจตรวจสอบระบบนิเวศน์ต่างๆ ในท้องถิ่น อธิบายความสัมพันธ์ขององค์ประกอบภายในระบบนิเวศน์ การถ่ายทอดพลังงาน วัฏจักรของสารและการเปลี่ยนแปลงขนาดของประชากร	1. สำรวจ อธิบายและเขียนภาพแสดงความสัมพันธ์ขององค์ประกอบระบบนิเวศน์ในท้องถิ่นและการถ่ายทอดพลังงาน	1. ระบบนิเวศ 2. ห่วงโซ่อาหาร 3. สายใยอาหาร 4. ความสัมพันธ์ระหว่างสิ่งมีชีวิต	3

กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
นกน้อยคล้อยบิน	**มาตรฐานการเรียนรู้สาระที่ 4 : แรงและการเคลื่อนที่** **มาตรฐาน ว 4.2** : เข้าใจลักษณะการเคลื่อนที่แบบต่าง ๆ ของวัตถุในธรรมชาติ มีกระบวนการสืบเสาะหาความรู้และจิตวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้ นำความรู้ไปใช้ประโยชน์	1. สังเกตการเคลื่อนที่แบบต่าง ๆ ในชีวิตประจำวัน และอธิบายผลของแรงที่กระทำต่อวัตถุและลักษณะการเคลื่อนที่ รวมทั้งการนำไปใช้ประโยชน์	1. สำรวจ สังเกต และระบุการเคลื่อนที่ของนก 2. ทดลอง และอธิบายผลของแรงที่ทำให้นิกบินได้	1. การสังเกต การทดลอง และการอภิปรายเกี่ยวกับการเคลื่อนที่โดยการบินของนก และการนำไปใช้ประโยชน์ 2. การสืบค้นข้อมูล การอภิปรายเกี่ยวกับการใช้ประโยชน์จากความรู้เรื่องการบินของนก	3

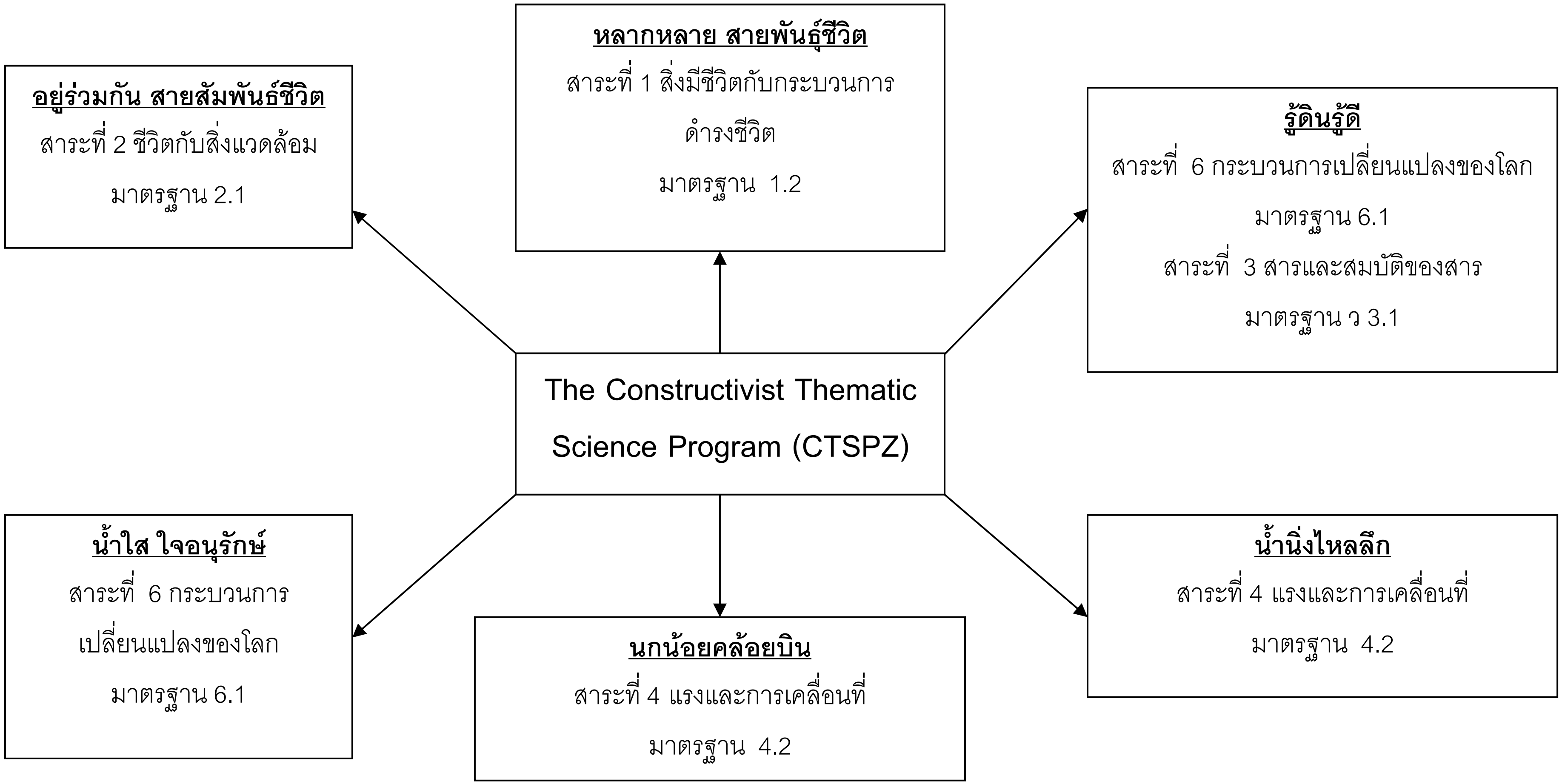
กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
รู้ดิน รู้ดี	**สาระที่ 6 กระบวนการเปลี่ยนแปลงของโลก** **มาตรฐาน ว 6.1** เข้าใจกระบวนการต่าง ๆ ที่เกิดขึ้นบนผิวโลกและภายในโลก ความสัมพันธ์ของกระบวนการต่าง ๆ ที่มีผลต่อการเปลี่ยนแปลงภูมิอากาศ ภูมิประเทศ และสัณฐานของโลก มีกระบวนการสืบเสาะหาความรู้และจิตวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้และนำความรู้ไปใช้ประโยชน์	1.สำรวจตรวจสอบ อภิปรายและอธิบายเกี่ยวกับชั้นหน้าตัดของดิน สมบัติของดิน การปรับปรุงคุณภาพของดิน และการนำไปใช้ประโยชน์ 2. สำรวจตรวจสอบ สังเกต และอธิบายกระบวนการเกิด ลักษณะขององค์ประกอบ สมบัติของหินและแร่ รวมทั้งการใช้ประโยชน์	1.ทดสอบและอธิบายสมบัติบางประการของดิน 2. สืบค้นข้อมูล อธิบายและเขียนแผนภาพชั้นหน้าตัดของดิน การกำเนิดดิน 3. อภิปรายและเสนอะแนะการปรับปรุงคุณภาพของดินให้เมาะกับการใช้ประโยชน์ 4. สืบค้นข้อมูล นำเสนอและจำแนกประเภทของหินในท้องถิ่น การใช้ประโยชน์จากหิน	1. องค์ประกอบของดิน 2. ชั้นหน้าตัดของดิน 3. การอนุรักษ์และปรับปรุงคุณภาพของดิน 4. ชนิดของหิน	3

กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
น้ำใส ใจอนุรักษ์	**มาตรฐานการเรียนรู้สาระที่ 6 : กระบวนการเปลี่ยนแปลงของโลก** **มาตรฐาน ว 6.1** : เข้าใจกระบวนการต่างๆ ที่เกิดขึ้นบนผิวโลกและภายในโลก ความสัมพันธ์ของกระบวนการต่าง ๆ ที่มีผลต่อการเปลี่ยนแปลงภูมิอากาศ ภูมิประเทศ และสัณฐานของโลก มีกระบวนการสืบเสาะหาความรู้และจิตวิทยาศาสตร์	สื่อสารสิ่งที่เรียนรู้ นำความรู้ไปใช้ประโยชน์ สำรวจตรวจสอบ อภิปราย และอธิบายเกี่ยวกับแหล่งน้ำบนพื้นโลก แหล่งน้ำใต้ดิน และการนำมาใช้ประโยชน์	1. ทดลองและอธิบายลักษณะ สมบัติ และคุณภาพของแหล่งน้ำบนพื้นโลก 2. สำรวจ อธิบาย และยกตัวอย่างการใช้ประโยชน์จากแหล่งน้ำในท้องถิ่น	1. การสาธิต การทดลอง และการอภิปรายเกี่ยวกับแหล่งน้ำบนพื้นโลกและการใช้ประโยชน์ 2. การสำรวจการใช้ประโยชน์แหล่งน้ำในท้องถิ่น 3. การสืบค้นข้อมูลเกี่ยวกับการใช้ประโยชน์ทรัพยากรในแหล่งน้ำบนพื้นโลก	3

กิจกรรม	มาตรฐานการเรียนรู้	มาตรฐานการเรียนรู้ช่วงชั้นที่ 3	ผลการเรียนรู้ที่คาดหวัง	สาระการเรียนรู้	เวลา (ชั่วโมง)
น้ำนิ่งไหลลึก	**สาระที่ 4 แรงและการเคลื่อนที่** **มาตรฐาน ว 4.2** เข้าใจลักษณะการเคลื่อนที่แบบต่าง ๆ ของวัตถุในธรรมชาติ มีกระบวนการสืบเสาะหาความรู้และจิตวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้และนำความรู้ไปใช้ประโยชน์	1. สังเกตการเคลื่อนที่แบบต่าง ๆ ในชีวิตประจำวัน และอธิบายผลของแรงที่กระทำต่อวัตถุและลักษณะการเคลื่อนที่ รวมทั้งการนำไปใช้ประโยชน์	1. สำรวจ สังเกต และระบุการเคลื่อนที่แบบต่างๆ ในชีวิตประจำวัน	1. การสังเกต การทดลอง และอภิปรายเกี่ยวกับการเคลื่อนที่แบบต่างๆ ในชีวิตประจำวัน และการนำไปใช้ประโยชน์ 2. การสืบค้นข้อมูล การอภิปรายเกี่ยวกับการใช้ประโยชน์จากความรู้เรื่องการเคลื่อนที่แบบต่าง ๆ	3

โปรแกรมวิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม ณ สวนสัตว์เชียงใหม่

(A Constructivist Thematic Science Program at Chiangmai Zoo)



Appendix 4

Sample of unit of learning

หน่วยการเรียนรู้เรื่อง อยู่ร่วมกัน สายสัมพันธ์ชีวิต

ระดับชั้น ช่วงชั้นที่ 3 (ม.1- ม. 3)

เวลา 3 ชั่วโมง **สถานที่** สวนชมนกนครพิงค์ และกรงสัตว์ต่างๆ

มาตรฐานการเรียนรู้สาระที่ 2 ชีวิตกับสิ่งแวดล้อม

มาตรฐาน ว 2.1

เข้าใจสิ่งแวดล้อมในท้องถิ่น ความสัมพันธ์ระหว่างสิ่งแวดล้อมกับสิ่งมีชีวิต ความสัมพันธ์ระหว่างสิ่งมีชีวิตต่างๆ ในระบบนิเวศ มีกระบวนการสืบเสาะหาความรู้ และเจตคติทางวิทยาศาสตร์ สื่อสารสิ่งที่เรียนรู้ และนำความรู้ไปใช้ประโยชน์

มาตรฐานช่วงชั้นที่ 3

สำรวจตรวจสอบระบบนิเวศต่างๆ ในท้องถิ่น อธิบายความสัมพันธ์ขององค์ประกอบภายในระบบนิเวศ การถ่ายทอดพลังงาน วัฏจักรของสารและการเปลี่ยนแปลงขนาดของประชากร

ผลการเรียนรู้ที่คาดหวัง

สำรวจ อธิบายและเขียนภาพแสดงความสัมพันธ์ขององค์ประกอบระบบนิเวศในท้องถิ่นและการถ่ายทอดพลังงาน

ทักษะการเรียนรู้

1. ทักษะการสังเกต (observation)
2. ทักษะการพยากรณ์ (prediction)
3. ทักษะการลงความเห็นจากข้อมูล (inferring)
4. ทักษะการสื่อสาร (communication)

สื่อ อุปกรณ์

1. ถุงพลาสติกเก็บตัวอย่าง พืช สัตว์ เล็ก ๆ
2. กระดาษขนาดใหญ่สำหรับเขียนแสดงห่วงโซ่อาหาร
3. ปากกาสีเมจิก

เอกสารประกอบการเรียนรู้

1. ใบความรู้ที่ 1 และ 2
2. ใบกิจกรรมที่ 1-6

แนวความคิดหลัก

โซ่อาหาร (food chain) คือ การกินเป็นทอด ๆ หรือการถ่ายทอดพลังงานจาก ผู้ผลิต (producer) ไปยังผู้บริโภค (consumer) ลำดับต่าง ๆ และท้ายสุดไปสู่ผู้ย่อยสารอินทรีย์ (decomposer)

สายใยอาหาร (food web) คือความสัมพันธ์ระหว่างห่วงโซ่อาหารหลาย ๆ ห่วงโซ่ ซึ่ง ในระบบนิเวศนั้นมีห่วงโซ่อาหารมากมาย สิ่งมีชีวิตที่เป็นส่วนหนึ่งของโซ่อาหารหนึ่ง อาจเป็นส่วนของโซ่อาหารอีกหลาย ๆโซ่อาหาร

กระบวนการเรียนรู้

1. ขั้นสร้างสถานการณ์การเรียนรู้ (situations) (15 **นาที**)

1.1 ผู้นำกิจกรรมและนักเรียน ไปยังจุดการเรียนรู้ สวนนกนครพิงค์ จากนั้นทำกิจกรรมสันทนาการเพื่อเข้าสู่สถานการณ์การเรียนรู้ โดยให้นักเรียนร้องเพลง ประกอบท่าทาง ในเพลง เจ้านกน้อย

" เจ้านกน้อยคล้อยบินสู่เวหา เจ้าถลา ๆ เล่นลม สมฤดี บินถลาๆ เล่นลม บินล่องบินลอย บินถลา ๆ เล่นลม บินล่องบินลอย"

1.2 ผู้นำกิจกรรมให้นักเรียนแข่งขันกันตอบชื่อนกที่นักเรียนรู้จัก และอาหารที่นกกิน เช่น

นกกระจิบ กิน ข้าวโพด

เหยี่ยว กิน หนู

1. **ขั้นจัดกลุ่มการเรียนรู้** (grouping) (15 **นาที**)

1.1 นักเรียนจับฉลาก จับกลุ่ม โดยนักเรียนแต่ละคนจะได้ชื่อนก และเสียงร้องของนก

1. นกฮูก ร้อง ฮูก ๆ
2. นกกา ร้อง กา ๆ
3. นกกระจิบ ร้อง จิ๊บ ๆ
4. นกแก้ว ร้อง แก้ว ๆ
5. นกเขา ร้อง จูกกรู้ ๆ

1.2 นักเรียน ร้องเสียงนกตามฉลากที่ตัวเองจับได้ เพื่อรวมกลุ่มกับเพื่อน ๆคนอื่นที่ส่งเสียงนกเช่นเดียวกับตนเอง กลุ่มไหนที่จำนวนคนครบก่อน ให้นั่งลง

2. **ขั้นเชื่อมโยงความรู้** (bridge) (30 **นาที**)

2.1 เมื่อนักเรียนจับกลุ่มกันเรียบร้อยแล้ว ผู้นำกิจกรรมแบ่งนักเรียนให้ทำกิจกรรมตามจุดเรียนรู้ที่แตกต่างกัน โดยให้นักเรียนทำกิจกรรมตามใบกิจกรรมที่ 1 โดยผู้นำกิจกรรมให้ความรู้เกี่ยวกับการสังเกตสัตว์ อย่างถูกต้อง

2.2 นักเรียนมารวมกันหลังจากเสร็จสิ้นการศึกษาจากจุดศึกษาของตนเอง เพื่อนำเสนอผลการสำรวจของตนเองตามกิจกรรมที่ 1

2.3 ผู้นำกิจกรรมสรุป และให้ความรู้กับนักเรียน ตามใบความรู้ที่ 1

2.4 นักเรียนแต่ละกลุ่มอภิปรายถึงความสัมพันธ์ของห่วงโซ่อาหารของแต่ละกลุ่ม

3. **ขั้นคำถามเพื่อนการเรียนรู้** (question) (40 **นาที**)

3.1 นักเรียนแต่ละกลุ่มแยกย้ายไปทำกิจกรรมตามใบกิจกรรมที่ 2 ในแต่ละจุดการเรียนรู้ ดังเช่น

-. กรงนก	- กรงสัตว์หากินกลางคืน
- กรงเสือ	- กรงหมี
- กรงสัตว์เลื้อยคลาน	- กรงลิง

4.2 ผู้นำกิจกรรมเดินสำรวจการทำงานของนักเรียนแต่ละกลุ่มพร้อมใช้คำถามเพื่อให้นักเรียนเกิดการเรียนรู้ ดังเช่น

- อาหารของสัตว์ที่นักเรียนสำรวจคืออะไร ?

- อาหารชนิดนี้ยังเป็นอาหารของสัตว์ชนิดอื่นๆ ได้อีกหรือไม่

- หากสัตว์ชนิดนี้ไม่กินอาหารดังที่นักเรียนสังเกต มันจะสามารถกินอย่างอื่นทดแทนได้หรือไม่ ?

4.3. ผู้นำกิจกรรมแนะวิธีเก็บตัวอย่างสิ่งมีชีวิตที่ถูกต้องให้กับนักเรียน พร้อมสอดแทรกการอนุรักษ์สิ่งแวดล้อม เช่น เรื่องการเก็บตัวอย่างที่ถูกต้องโดยไม่ทำลายสิ่งแวดล้อม

5. ขั้นแสดงออกของความรู้ (exhibit) (40 **นาที**)

5.1 นักเรียนแต่ละกลุ่มนำเสนอห่วงโซ่อาหาร ณ จุดที่นักเรียนไปศึกษา พร้อมแสดงตัวอย่างผู้ผลิต ผู้บริโภค หรือผู้ย่อยสลายสารอินทรีย์ที่นักเรียนได้เก็บมา และนักเรียนซักถามข้อสงสัย โดยผู้นำกิจกรรมใช้คำถามกระตุ้นให้นักเรียนคิด เช่น

- ห่วงโซ่อาหารของกลุ่มใดมีความใกล้เคียงกันบ้าง อย่างไร

- นักเรียนคิดว่าห่วงโซ่อาหารของแต่ละกลุ่มมีความสัมพันธ์กันหรือไม่

5.2 นักเรียนแต่ละคน นำข้อมูล สายใยอาหารของแต่ละกลุ่ม มาเขียนให้มีความสัมพันธ์กันเกิดเป็นสายใยอาหาร (food web) ตามใบกิจกรรมที่ 3

5.3 ผู้นำกิจกรรมและนักเรียนสรุปแนวคิดเรื่องสายใยอาหารและความสัมพันธ์ระหว่างสิ่งมีชีวิตตามใบความรู้ที่ 2

5.4 นักเรียนทำการสำรวจ ความสัมพันธ์ระหว่างสิงมีชีวิตตามใบกิจกรรมที่ 4

6. ขั้นสะท้อนความรู้ (reflection) (40 **นาที**)

6.1 นักเรียนทำกิจกรรมตามใบกิจกรรมที่ 5

6.2 ผู้นำกิจกรรมสรุปกิจกรรมที่ 5 โดยใช้คำถามดังนี้

- ในขณะที่นักเรียนนั่งกันเป็นวงกลมอย่างเป็นระเบียบ และทุกคนอยู่ในวงกลมครบนักเรียนรู้สึกอย่างไร?

- เมื่อเพื่อนคนใด คนหนึ่ง หลุดออกไปจากวงกลม เกิดอะไรขึ้น

- การขาดเพื่อนคนใดคนหนึ่งไป ทำให้เกิดผลเสียอย่างไรบ้างในวงกลม

6.3 นักเรียนทำกิจกรรมในใบกิจกรรมที่ 6 และครูใช้คำถามกระตุ้นให้นักเรียนคิดดังนี้

- หากส่วนใดส่วนหนึ่งในระบบนิเวศถูกทำลาย มันจะกระทบกับส่วนอื่นๆ อย่างไรบ้าง
- นักเรียนจะป้องกันไม่ให้เกิดการทำลายส่วนใดส่วนหนึ่งในระบบนิเวศนั้นอย่างไร
- นักเรียนจะมีวิธีแก้ไขอย่างไร หากส่วนหนึ่งในระบบนิเวศถูกทำลาย

การประเมินผล

1. แบบประเมินผลภาระงาน การนำเสนอ
2. แบบประเมินทักษะการทำงานเป็นกลุ่มของนักเรียน

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบความรู้ที่ 1: ระบบนิเวศและห่วงโซ่อาหาร

ระบบนิเวศ (ecosystem)

ระบบนิเวศ หมายถึง หน่วยพื้นที่หนึ่งที่ประกอบด้วยสังคมของสิ่งมีชีวิตกับ สิ่งแวดล้อมที่มีปฏิสัมพันธ์กันหน้าที่ร่วมกัน

โครงสร้างของระบบนิเวศ (ecosystem structure)

โครงสร้างของระบบนิเวศทุกแห่ง จะมีองค์ประกอบพื้นฐานที่คล้ายคลึงกัน ซึ่งพอจะแบ่งออกได้เป็น 2 ส่วนใหญ่ ๆ คือ

1. **องค์ประกอบที่ไม่มีชีวิต** (abiotic component) ได้แก่

1.1 สารอินทรีย์ (organic) ได้แก่ ซากพืช ซากสัตว์ ฮิวมัส คาร์โบไฮเดรต ไขมัน โปรตีน

1.2 สารอนินทรีย์ (inorganic) ได้แก่ เกลือแร่ น้ำ คาร์บอน ไนโตรเจน โปตัสเซียม เป็นต้น

1.3 สภาพแวดล้อมทางกายภาพ (physical) ได้แก่ อุณหภูมิ แสง ความชื้น ความเป็นกรด เป็นด่าง แสง ความเค็ม เป็นต้น

2. **องค์ประกอบที่มีชีวิต** (biotic component) แบ่งได้เป็น 4 ส่วน ได้แก่

2.1 **ผู้ผลิต** (producer) หมายถึง พวกที่สามารถนำเอาอนินทรีย์สารมาสร้างเป็นอินทรีย์สารโดยผ่านกระบวนการสังเคราะห์แสง และอาศัยแสงจากดวงอาทิตย์ ผู้ผลิตเหล่านี้ได้แก่ พืชที่มีสีเขียวหรือมีคลอโรฟิลล์นั่นเอง

2.2 **ผู้บริโภค** (consumer) หมายถึง พวกที่ไม่สามารถนำเอาอนินทรีย์สารมาสร้างเป็นอินทรีย์สารได้ ต้องพึ่งพาอาศัยสิ่งอื่นในการสังเคราะห์อาหาร แบ่งออกเป็น 4 พวก ได้แก่

1) ผู้บริโภคขั้นปฐมภูมิ (primary consumers) หมายถึง สัตว์ที่กินพืชเป็นอาหาร (herbivores) ได้แก่ กระต่าย เต่า กวาง เป็นต้น

2) ผู้บริโภคขั้นทุติยภูมิ (secondary consumers) หมายถึง สัตว์ที่กินสัตว์เป็นอาหาร (carnivores) ได้แก่ สิงโต เสือ เป็นต้น

3) ผู้บริโภคขั้นตติยภูมิ (tertiary consumers) หมายถึง สัตว์ที่กินทั้งพืชและสัตว์เป็นอาหาร (omnivores) ได้แก่ ไก่ สุนัข นก มนุษย์ เป็นต้น

2.3 ผู้ย่อยสลาย (decomposer) หมายถึง จุลินทรีย์ทั้งหลายที่ช่วยในการย่อยสลายซากพืชซากสัตว์ต่าง ๆ ให้เน่าเปื่อยกลายเป็นสารอินทรีย์ต่อไป

ความสัมพันธ์เชิงอาหารของสิ่งมีชีวิต

ห่วงโซ่อาหาร (food chain) พลังงานที่ผู้ผลิตหรือพืชรับจากดวงอาทิตย์ จะถูกเปลี่ยนไปอยู่ในรูปของสารอาหารและจะมีการถ่ายทอดพลังงานไปตามลำดับขั้นของการกินอาหารภายในระบบนิเวศ กล่าวคือ ผู้บริโภคได้รับพลังงานจากผู้ผลิต โดยการกินต่อกันเป็นทอด ๆ ในแต่ละลำดับขั้นของการถ่ายทอดพลังงาน พลังงานที่ได้รับจะค่อย ๆ ลดลงไปในแต่ละลำดับ เนื่องจากสูญเสียไปในรูปของพลังงานความร้อน กระบวนการเคลื่อนย้ายหรือถ่ายทอดพลังงานในรูปสารอาหาร จากผู้ผลิตไปสู่ผู้บริโภค โดยการกินต่อกันเป็นทอด ๆ เรียกว่า “ห่วงโซ่อาหาร” (food chain) หรือบางครั้งอาจเรียกห่วงโซ่อาหารนี้ว่า “ห่วงโซ่พลังงาน” (energy chain) จำนวนของระดับ (trophic level) การถ่ายทอดพลังงานขึ้นกับลักษณะหรือชนิดของระบบนิเวศ

ระดับที่ 1 พืชหรือผู้ผลิต ใช้พลังงานแสงอาทิตย์และธาตุอาหารมาผลิตส่วนต่าง ๆ ของพืช
ระดับที่ 2 ผู้บริโภคขั้นต้น ได้แก่ แมลง หนอน สัตว์กินพืช
ระดับที่ 3 ผู้บริโภคขั้นที่สอง ได้แก่ สัตว์กินแมลง หนอน
ระดับที่ 4 ผู้บริโภคขั้นที่สาม ได้แก่ สัตว์กินสัตว์ด้วยกันเป็นอาหาร
ระดับที่ 5 ผู้ย่อยสลาย ย่อยสลายผู้ผลิต และผู้บริโภคทุกระดับ

หลักเกณฑ์ในการเขียนแสดงห่วงโซ่อาหาร

การถ่ายทอดพลังงานในรูปอาหารจากสิ่งมีชีวิตหนึ่งส่งต่อไปสิ่งมีชีวิตอื่น ให้เขียนแทนด้วยลูกศร หัวลูกศรมักจะมีทิศทางชี้ไปยังสิ่งมีชีวิตที่เป็นผู้บริโภค หรือผู้ได้รับการถ่ายทอดพลังงานมาจากตัวอย่างห่วงโซ่อาหาร หญ้า → ตั๊กแตน → นก หมายความว่าพลังงานเคมีในรูปอาหารจากหญ้าจะถ่ายทอดไปยังตั๊กแตน (ตั๊กแตนกินหญ้า) และพลังงานเคมีจากตั๊กแตนจะถ่ายทอดต่อไปยังนก (นกกินตั๊กแตน)

เอกสารอ้างอิง

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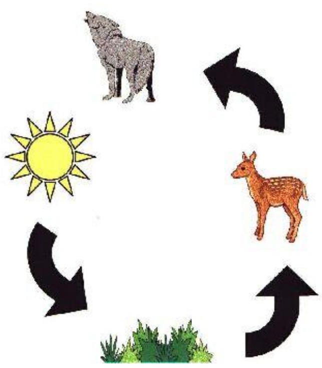
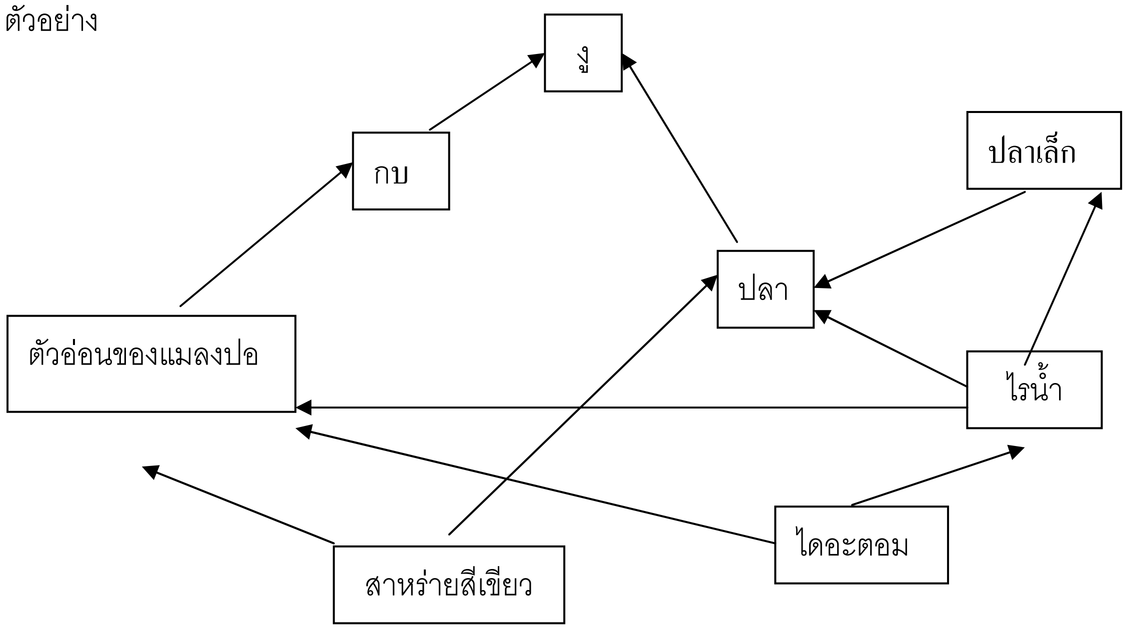


กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบความรู้ที่ 2: ความสัมพันธ์ระหว่างสิ่งมีชีวิตในระบบนิเวศและสายใยอาหาร

สายใยอาหาร (food web) หมายถึง ห่วงโซ่อาหารที่ซับซ้อนหลายๆ ชุด (complex food chain) ซึ่งต่อเนื่องกัน ทำให้เกิดการถ่ายทอดพลังงานในรูปของอาหารระหว่างสิ่งมีชีวิตที่มีความ เกี่ยวข้องสัมพันธ์กันอย่างซับซ้อน จึงมีโอกาสถ่ายทอดพลังงานได้หลายทิศทาง

ความสัมพันธ์เชิงอาหารระหว่างสิ่งมีชีวิต ในลักษณะสายใยอาหารจะเกิดในธรรมชาติจริงๆ มากกว่าในลักษณะห่วงโซ่อาหาร เพราะสิ่งมีชีวิตแต่ละชนิดกินอาหารได้หลายชนิด และ สิ่งมีชีวิตบางชนิดเป็นอาหารของสัตว์ได้หลายชนิด จึงเกิดห่วงโซ่อาหารเชื่อมโยงกันคล้ายใยแมงมุม ดังตัวอย่าง



ความสัมพันธ์ระหว่างสิ่งมีชีวิตในระบบนิเวศ

ถ้าพิจารณาความสัมพันธ์ระหว่างสภาพแวดล้อมที่มีชีวิตกับสิ่งมีชีวิตในห่วงโซ่อาหารต่างๆ ก็จะพบความสัมพันธ์หลายรูปแบบ ดังนี้

1. **การล่าเหยื่อ** (predation) เป็นความสัมพันธ์ที่ฝ่ายหนึ่งเป็นผู้ล่า (predator) ส่วนอีกฝ่ายเป็นผู้ถูกล่าหรือเหยื่อ (prey) เช่น นกคอยจ้องจับแมลงกิน นกฮูกคอยจับงูกินในเวลากลางคืน

2. **ภาวะอิงอาศัย หรือภาวะมีการเกื้อกูล** (commensalism) เหาฉลามเป็นปลาชนิดหนึ่งที่มีอวัยวะสำหรับดูดเกาะติดปลาฉลาม อาศัยกินเศษอาหารจากปลาฉลาม โดยไม่ได้ดูดเลือดหรือทำอันตรายใดๆ แก่ปลาฉลาม ความสัมพันธ์แบบนี้เป็นความสัมพันธ์ที่ได้ประโยชน์เพียงฝ่ายเดียว ส่วนอีกฝ่ายหนึ่งก็ไม่เสียประโยชน์แต่อย่างใด

3. **การได้ประโยชน์ร่วมกัน** (protocooperation) ในธรรมชาติเราอาจเห็นเถาวัลย์ พลูด่าง กล้วยไม้ หรือเฟิร์นบางชนิด เจริญอยู่บนลำต้นและ กิ่งไม้ของต้นไม้ใหญ่ ลักษณะการเกาะของพืชพวกนี้จะอยู่บริเวณผิวของเปลือกต้นไม้ ไม่ได้มีการเบียดเบียนอาหารจากต้นไม้ใหญ่แต่อย่างใด แต่อาจจะได้ความชื้นหรือแร่ธาตุบางอย่างจากเปลือกต้นไม้เหล่านั้น

นกเอี้ยงบนหลังควาย กินแมลงบนผิวหนังควายเป็นอาหาร ควายได้ประโยชน์จากการที่นกเอี้ยงช่วยลดจำนวนแมลงที่เป็นปรสิตของควาย เป็นการได้ประโยชน์ร่วมกันของควายกับนกเอี้ยง

4. **ภาวะที่พึ่งพากัน** (mutualism) ไลเคนส์ (lichens) เป็นสิ่งมีชีวิตสองชนิดอาศัยอยู่ด้วยกัน คือรากับสาหร่าย พบตามเปลือกต้นไม้ขนาดใหญ่ ทั้งสาหร่ายและราต่างได้รับประโยชน์ กล่าวคือสาหร่ายสร้างอาหารได้เอง แต่ต้องอาศัยความชื้นจากรา ส่วนราก็ได้อาศัยดูดอาหารที่สาหร่ายสร้างขึ้น

5. **ภาวะปรสิต** (paratism) ร่างกายของสิ่งมีชีวิตก็เป็นแหล่งที่อยู่ของสิ่งมีชีวิตบางชนิดที่ดำรงชีพแบบปรสิต ผู้ถูกอาศัยจะเป็นฝ่ายเสียประโยชน์ ส่วนผู้ที่ไปอาศัยคือ ปรสิตจะเป็นฝ่ายได้รับประโยชน์เนื่องจากปรสิตจะคอยแย่งอาหารหรือกินส่วนของร่างกายผู้ถูกอาศัย

6. **ภาวะมีการย่อยสลาย** (saprophytism) ความสัมพันธ์อีกแบบหนึ่งที่ท่านคงเคยเห็นคือ ราขึ้นบนผลไม้ที่สุกงอม ตามตอไม้ผุมีเห็ดขึ้น กองขยะถูกย่อยสลายเน่าเปื่อยผุพัง ภาวะเช่นนี้เกิดจากการดำรงชีพแบบหนึ่ง ของกลุ่มสิ่งมีชีวิตที่เป็นผู้ย่อยสลายอินทรีย์สาร ได้แก่ จุลินทรีย์พวกเห็ดรา แบคทีเรีย

7. **ภาวะการแข่งขัน** (competition) สิ่งมีชีวิตที่อาศัยอยู่ร่วมกันในบริเวณหนึ่งๆ ไม่ว่าจะเป็นชนิดเดียวกัน หรือต่างชนิดก็ตามจะพบว่ามีการแก่งแย่งแข่งขันกัน เพื่อให้ได้รับปัจจัยต่างๆ ในการดำรงชีพ ตัวอย่างต้นไม้ที่ปลูกในเนื้อที่จำกัด แต่ละต้นจะพยายามเจริญขึ้นไปเพื่อรับแสงแดด ฝูงปลาแย่งกันตะครุบเหยื่อ

8. **ภาวะเป็นกลาง** (neutralism) เป็นความสัมพันธ์ที่ต่างฝ่ายต่างไม่ได้ประโยชน์และไม่เสียประโยชน์ เช่น ต้นไม้ใหญ่กับไส้เดือนดิน

9. **ภาวะอะเมนลิซึม** (amenlism) เป็นภาวะที่ฝ่ายหนึ่งเสียประโยชน์ แต่อีกฝ่ายหนึ่งไม่ได้รับประโยชน์หรือเสียประโยชน์ เช่น ต้นไม้เล็กใต้ต้นไม้ใหญ่

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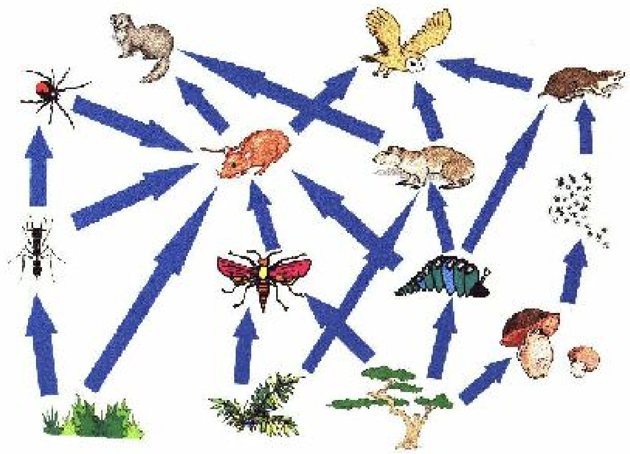

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 1: เรื่องของนก

ชื่อ-สกุล..จุดศึกษา…………………………………..

คำชี้แจง

ให้นักเรียนสำรวจบริเวณจุดศึกษาที่ได้รับมอบหมายแล้วตอบคำถามต่อไปนี้

จุดประสงค์

1. ใช้ทักษะการสังเกต และการสำรวจ เพื่อบันทึกข้อมูลต่างๆ ของนก
2. ระบุที่มาของแหล่งอาหารนกได้ว่ามาจากที่ใด
3. จำแนกกลุ่มของผู้บริโภคโดยใช้ที่มาของอาหารที่กินเป็นเกณฑ์

กิจกรรม

1. **เกี่ยวกับนก**

1.1 นกที่นักเรียนพบในบริเวณนี้คือนกอะไร..

1.2 จงบรรยายลักษณะของนกที่นักเรียนพบ

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1.3 ให้นักเรียนวาดภาพของนกที่นักเรียนพบ

2. อาหารนก

2.1 อาหารของนกชนิดนี้ คือ..

2.2 อาหารของนกชนิดนี้ มาจาก...

2.2 สิ่งมีชีวิตประเภทใดบริโภคอาหารชนิดนี้อีก...

3. ศัตรูของนก

3.1 ศัตรูของนกชนิดนี้ได้แก่อะไรบ้าง..

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4. ให้นักเรียนเขียนการกินต่อเป็นทอด ๆ บริเวณจุดศึกษาของนักเรียน

อาหารของนก นกที่พบ ศัตรูของนก

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 2: ห่วงโซ่อาหาร

ชื่อ-สกุล...จุดศึกษา…………………………………..

คำชี้แจง ให้นักเรียนทำการศึกษาบริเวณจุดศึกษา เก็บตัวอย่างและตอบคำถามดังต่อไปนี้

จุดประสงค์

1. สังเกต สำรวจตรวจสอบ ข้อมูลสัตว์แต่ละชนิด
2. เข้าใจ และสามารถเขียนห่วงโซ่อาหารของสัตว์แต่ละชนิดได้ถูกต้อง

กิจกรรม

1. **ผู้ผลิต** (Producer)

ผู้ผลิตบริเวณจุดศึกษาได้แก่...

2. **ผู้บริโภค** (Consumer)

1) ผู้บริโภคขั้นปฐมภูมิ (primary consumers) บริเวณจุดศึกษาได้แก่....................................
อาหารที่ถูกบริโภคคือ..

2) ผู้บริโภคขั้นทุติยภูมิ (secondary consumers) บริเวณจุดศึกษาได้แก่ ....
อาหารที่ถูกบริโภคคือ..

3) ผู้บริโภคขั้นตติยภูมิ (tertiary consumers) บริเวณจุดศึกษาได้แก่.....................................
อาหารที่ถูกบริโภคคือ..

3. **ผู้ย่อยสลาย** (decomposer) ได้แก่..

4. จากข้อมูลในข้อ 1-3 ให้นักเรียนเขียนห่วงโซ่อาหารบริเวณจุดศึกษา

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 3: สายใยอาหาร

ชื่อ-สกุล..จุดศึกษา…………………………………….

คำชี้แจง ให้นักเรียนเขียนสายใยอาหาร (food web) ซึ่งแสดงความสัมพันธ์ระหว่างห่วงโซ่อาหาร (food chain) จากที่แต่ละกลุ่มได้นำเสนอมาตามกิจกรรมที่ 2 พร้อมทั้งระบุความสัมพันธ์ของสิ่งมีชีวิตในห่วงโซ่อาหาร

จุดประสงค์

เข้าใจ และวิเคราะห์หาความสัมพันธ์ของสิ่งมีชีวิตชนิดต่างๆ แล้วนำมาเขียนเป็นสายใยอาหารได้อย่างถูกต้อง

กิจกรรม

1. ให้นักเรียนเขียนห่วงโซ่อาหารที่แต่ละกลุ่มได้ทำการศึกษาตามจุดศึกษาต่าง ๆ

2. ให้นักเรียนเขียนสายใยอาหาร (food web) จากความสัมพันธ์ของห่วงโซ่อาหาร (food chain) ในแต่ละจุดศึกษา

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 4 : ความสัมพันธ์ของสิ่งมีชีวิต

ชื่อ-สกุล...จุดศึกษา…………………………………..

คำชี้แจง ให้นักเรียนสำรวจความสัมพันธ์ของสิ่งมีชีวิตต่างๆ ในบริเวณสวนสัตว์แล้วระบุชนิดของความสัมพันธ์นั้น ๆ

จุดประสงค์

1. ทำกิจกรรมภาคสนามเพื่อสำรวจสภาพทั่วไปของสิ่งแวดล้อมในบริเวณที่ศึกษา
2. สังเกต บันทึก สภาพทั่วไป และองค์ประกอบที่มีชีวิตและไม่มีชีวิตในบริเวณที่ศึกษา
3. ใช้ข้อมูลที่ได้ อธิบาย และวิเคราะห์ความสัมพันธ์ระหว่างสิ่งมีชีวิต

กิจกรรม

ความสัมพันธ์ระหว่างสิ่งมีชีวิต

1 **ความสัมพันธ์แบบ การล่าเหยื่อ** (predation) ได้แก่จุดศึกษาใด..

ผู้ล่า (predator)ได้แก่ ....**เหยื่อ** (prey) ได้แก่...

จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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2 **ภาวะอิงอาศัย หรือภาวะมีการเกื้อกูล** (commensalisms) ได้แก่จุดศึกษาใด.....................

จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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3 **การได้ประโยชน์ร่วมกัน** (protocooperation) ได้แก่จุดศึกษาใด..

จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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4 **ภาวะที่พึ่งพากัน** (mutualism) ได้แก่จุดศึกษาใด..
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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5 **ภาวะปรสิต** (paratism) ได้แก่จุดศึกษาใด..
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain) นี้

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6 **ภาวะมีการย่อยสลาย** (saprophytism) ได้แก่จุดศึกษาใด...
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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7 **ภาวะการแข่งขัน** (competition) ได้แก่จุดศึกษาใด...
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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8 **ภาวะเป็นกลาง** (neutralism) ได้แก่จุดศึกษาใด...
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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9 **ภาวะอะเมนลิซึม** (amenlism) ได้แก่จุดศึกษาใด..
จงอธิบายความสัมพันธ์ระหว่างสิ่งมีชีวิตในห่วงโซ่อาหาร (food chain)นี้

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กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 5: สัมพันธ์ สำคัญ

ชื่อ-สกุล..จุดศึกษา…………………………………..

คำชี้แจง ให้นักเรียนทำกิจกรรมดังต่อไปนี้

จุดประสงค์

ตระหนักถึงความสำคัญ และความสัมพันธ์ระหว่างองค์ประกอบต่าง ๆ ในระบบนิเวศ

กิจกรรม

1. นักเรียนทุกคนยืนล้อมกันเป็นวงกลมให้ชิดกันมากที่สุด โดยให้หัวไหล่ ชน หัวไหล่
2. เมื่อทุกคนอยู่ในวงกลมแล้วให้แต่ละคนหันขวาพร้อม ๆ กัน
3. นักเรียนแต่ละคนเลือกที่จะเป็นหน่วยใดหน่วยหนึ่งในห่วงโซ่อาหาร ไว้ในใจ โดยไม่บอกเพื่อน ดังนี้
    - ผู้ผลิต (producer)
    - ผู้บริโภค หมายเลข 1 (primary consumers)
    - ผู้บริโภค หมายเลข 2 (secondary consumers)
    - ผู้บริโภค หมายเลข 3 (tertiary consumers)
    - ผู้ย่อยสลาย (decomposers)
4. เมื่อนักเรียนเลือกได้แล้วว่าจะเป็นหน่วยใด ให้นักเรียนย่อตัวนั่งลงบนตักเพื่อนให้ได้ในวงกลม
5. จากนั้นให้นักเรียนรอฟังคำสั่งจากผู้นำกิจกรรม โดยเมื่อผู้นำกิจกรรมเอ่ยชื่อหน่วยใดในห่วงโซ่อาหารแล้วตรงกับหน่วยที่นักเรียนเลือกไว้ในใจนั้น ให้นักเรียนกระโดดออกมาจากวงกลม
6. ทำซ้ำกิจกรรมในข้อ 1-5 ประมาณ 3 ครั้ง
7. สรุปกิจกรรมโดยตอบคำถามต่อไปนี้
    - เมื่อทุกคนนั่งลงในวงกลมพร้อมๆ กันวงกลมมั่นคงหรือไม่

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    - เกิดอะไรขึ้นเมื่อมีคนใดคนหนึ่งกระโดดออกจากวงกลม

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    - นักเรียนได้ข้อคิดอะไรจากกิจกรรมนี้เมื่อเปรียบเทียบกับความสัมพันธ์ของ

สิ่งมีชีวิตในสายใยอาหาร (food web)...

กิจกรรม อยู่ร่วมกันสายสัมพันธ์ชีวิต

ใบกิจกรรมที่ 6 :อยู่ร่วมกันสายสัมพันธ์ชีวิต

ชื่อ-สกุล...จุดศึกษา…………………………………..

คำชี้แจง ให้นักเรียนพิจารณาสายใยอาหารในกิจกรรมที่ 3 แล้วตอบคำถามดังต่อไปนี้

จุดประสงค์

นักเรียนนำความรู้เรื่องความสัมพันธ์ของสิ่งมีชีวิตในระบบนิเวศมาวิเคราะห์ อธิบาย และเสนอแนะแนวคิดในการอนุรักษ์สิ่งแวดล้อม

กิจกรรม

1. ให้นักเรียนเลือกดึงสิ่งมีชีวิต 1 ชนิดออกจากสายใยอาหาร
   สิ่งมีชีวิตที่นักเรียนดึงออกมาคือ..
   สิ่งมีชีวิตนี้มีความสำคัญอย่างไรในสายใยอาหาร

....

.... ………..

ในธรรมชาติอะไรเป็นสาเหตุให้หน่วยนั้นถูกกำจัดออกจากสายใยอาหาร ....

....

....

3. เมื่อสูญเสียสิ่งมีชีวิตนั้นออกจากสายใยอาหาร เกิดผลกระทบกับสิ่งมีชีวิตอื่น ๆ ในสายใยอาหารหรือไม่ อย่างไร

....

....

....

4. นักเรียนจะป้องกันไม่ได้เกิดการสูญเสียสิ่งมีชีวิตชนิดนี้ได้อย่างไร ....

....

....

5. หากเกิดการสูญเสียสิ่งมีชีวิตนี้ในสายใยอาหารนักเรียนคิดว่ามีสิ่งมีชีวิตชนิดไหนจะทดแทนได้และจะแก้ไขได้อย่างไร

....

....

....

Appendix 5

Picture of learning activities

Bernoulli force

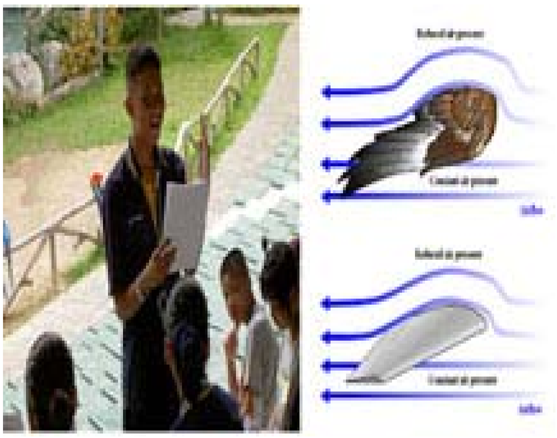
Situation

Grouping

Bridge

Questions

Evaluation



Reflection

Food Web

Situation

Grouping

Bridge

Questions

Evaluation

Reflection

Velocity

Situation

Grouping

Bridge

Questions

Evaluation

Reflection

Biodiversity

Situation

Grouping

Bridge

Questions

Evaluation

Reflection

Water conservation

Situation

Grouping

Bridge

Questions

Evaluation

Reflection

Soil horizontal

Situation

Grouping

Bridge

Questions

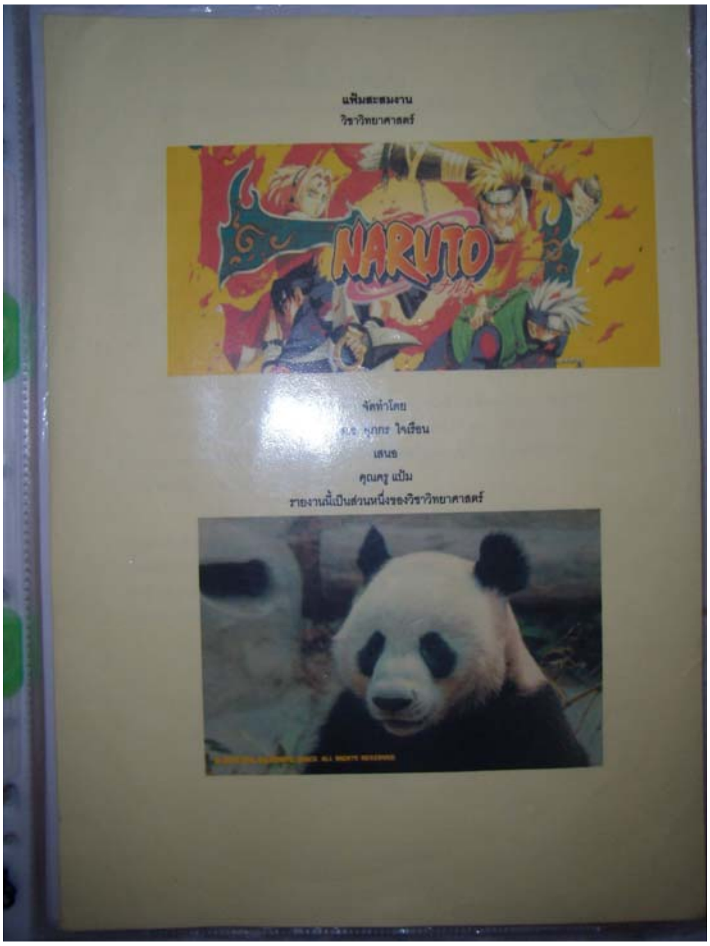
Evaluation

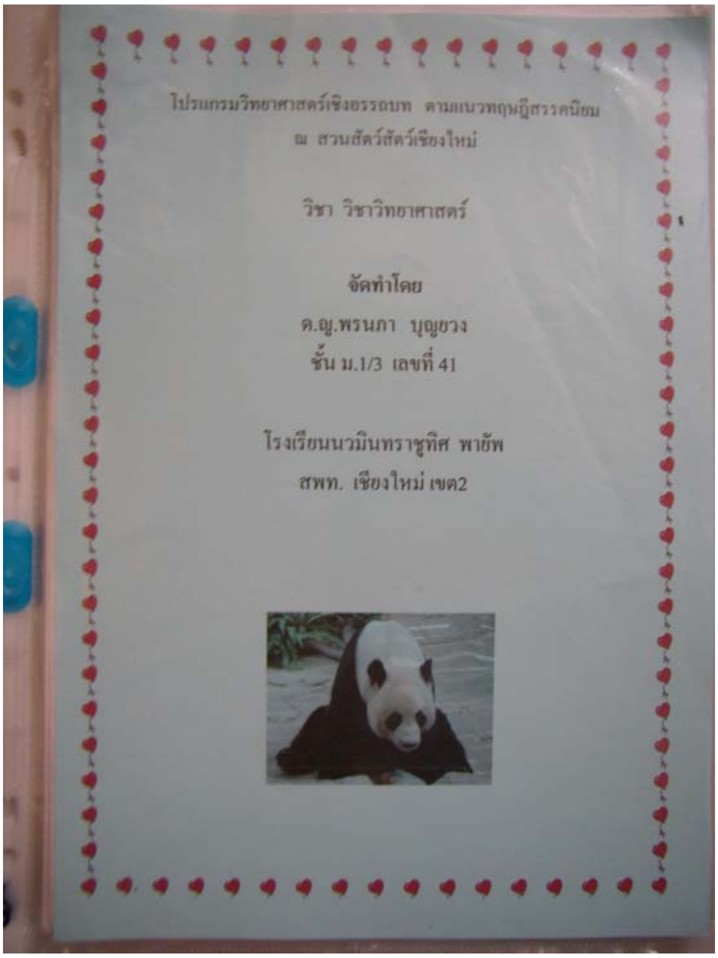
Reflection

Appendix 6

Sample of students' works

Portfolio


แฟ้มสะสมงาน
วิชาวิทยาศาสตร์
NARUTO
จัดทำโดย
เสนอ
คุณครู แป้ม
รายงานนี้เป็นส่วนหนึ่งของวิชาวิทยาศาสตร์


โปรแกรมวิทยาศาสตร์เชิงอรรถบท ตามแนวทฤษฎีสรรคนิยม
ณ สวนสัตว์สัตว์เชียงใหม่
วิชา วิชาวิทยาศาสตร์
จัดทำโดย
ด.ญ.พรนภา บุญยวง
ชั้น ม.1/3 เลขที่ 41
โรงเรียนนวมินทราชูทิศ พายัพ
สพท. เชียงใหม่ เขต2

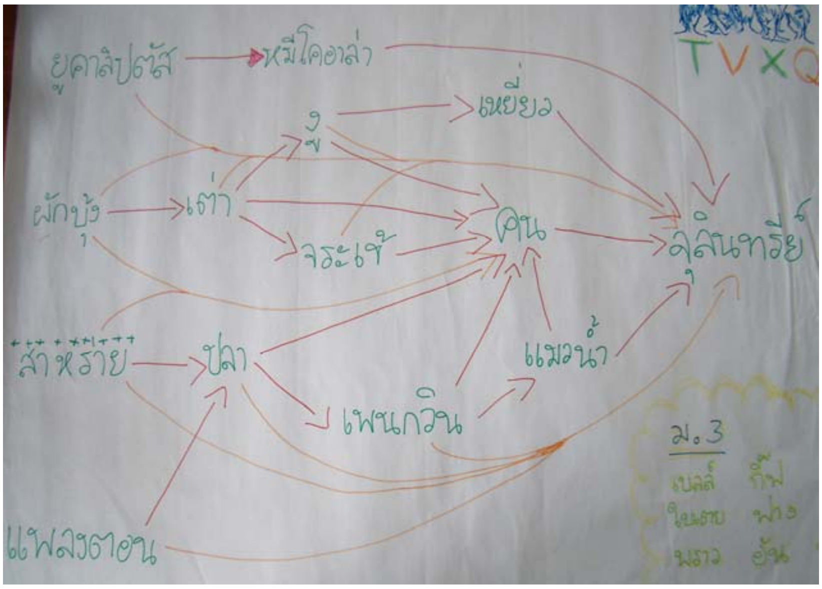

ห่วงโซ่อาหาร
หมีโคอาล่า
ใบและต้นยูคาลิปตัส
แบคทีเรีย
จุลินทรีย์
Demon 40
<หญิง>


"ห่วงโซ่อาหาร"
ผักบุ้ง
จอกแหน
เต่า
กบ
snake
เหยี่ยว
"จุลินทรีย์"


SCIENCE
ห่วงโซ่ อาหาร
จุลินทรีย์
D'38


สายใยอาหาร
สาหร่าย
เต่า
ปลาใหญ่
เหยี่ยว
เพนกวิน
สิงโตทะเล
จระเข้
หมีโคอาล่า
แมวน้ำ
ใบและต้นยูคาลิปตัส
Demon 40


สายใยอาหาร
แพลงตอน
ยูคาลิปตัส
หมีโคอาล่า
CO-R-LA
ผัก
กุ้ง
เต่า
ปลา
จระเข้
นกเพนกวิน
สิงโตทะเล
คน
จุลินทรีย์


ยูคาลิปตัส
หมีโคอาล่า
TVXQ
งู
เหยี่ยว
ผักบุ้ง
เต่า
จระเข้
คน
จุลินทรีย์
สาหร่าย
ปลา
แมวน้ำ
เพนกวิน
แพลงตอน
ม.3

VITAE

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