REINFORCEMENT OF SCIENCE LEARNING THROUGH LOCAL CULTURE

A DISSERTATION

BY

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Prasart Nuangchalerm

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CHAPTER 1

INTRODUCTION

Background

In 1999, Thailand initiated sweeping curriculum reform in an effort to improve students' achievement and make education better serve the needs of society. In particular, it was believed that the existing curriculum failed to maximize student learning in the crucial subjects of mathematics, science, and technology. Students' scores on the Third International Mathematics and Science Study (TIMSS) seem to bear this out (Beaton; et al. 1996). In addition, the existing curriculum seems unable to provide students with skills needed to tackle fast changes in social and economic areas (Ministry of Education. 2002: 1).

The Thai Ministry of Education reported that: (1) the formulation of curricula by central authorities does not respond to the real needs of school and society; (2) curricula and learning development in mathematics, science and technologies have failed to develop and to encourage the full potential of students; and (3) the application of curricula has failed to foster foundations for the management of life skills, and has not succeeded to enable the students to effectively react with the rapid changes in social and economic areas (Ministry of Education. 2002: 1). Based on this report, Thailand needs the appropriate ways to promote and manage learning.

The current Thai National Education Act was launched in 1999. An important part of this Act recommends that all schools should incorporate indigenous knowledge into the school curriculum. Children should learn science in their communities based on the cultural beliefs, values, practices, and experiences of Thai citizens.

The importance of indigenous knowledge related to science would be helpful in the classroom. Indigenous knowledge has science embedded and inherited in it such as the Yupiaqs know how to develop a fishing gear to catch a particular species of fish in a particular type of water. Fisherman has to have significant scientific knowledge of behaviors for each species of fish, tidal patterns, and the patterns of flowing water, as well as knowledge of migration patterns, mating habits, and feeding behaviors of a wide range of wildlife (Kawagley; et al. 1998: 133-144). Teaching and learning science should include the interaction and communication among students, indigenous knowledge, and scientific knowledge in various places where they live (Ogawa. 1995: 583).

Recently, indigenous knowledge has played a role in the context of Thai science education from various research reports. Ketku (1998: abstract) conducted the presentation ability in science and values on Thai wisdom in science by using the instructional science package on Thai wisdom. Kongbangpra (1999: abstract) studied learning achievement and ability in thinking of sustainable development by studying package with the value analysis of Thai wisdom. Saeng-Xuto (2001: abstract) analyzed indigenous knowledge and technology as related to science in the upper northern part of Thailand.

Not only science plays a major role in our society, but also culture is a diverse wisdom, which is developed and served all people on the same footing as science. Indigenous people know how to survive in their local communities based on learning by doing or practical science (Ganjanapan. 2000: 197-198). Culture likes integrated things and produces important knowledge (Ogawa. 1995: 583).

Bausor and Poole (2003: 117) pointed out that science learning requires consideration of how science is affected by the contexts in which it is practiced, including spirit, moral, society, history, and culture. Attention also needs to be paid to the scope and the limits of science. Cultural aspects can reinforce learning about science, that is, it contains scientific conceptions that students should learn.

The World Conference on Cultural Policies (Mexico City) in 1982 recognized that culture is the whole complex of distinctive spiritual, material, intellectual and emotional features that characterize a society or social group. It includes not only the arts and letters, but also mode of life, the fundamental rights of the human being, value system, traditions and beliefs (UNESCO. 1995: 22; Eawsriwongse. 2004: 431).

Culture and science are produced by the relationship between man and nature, and the interaction between man and society. To indigenous people, nature and culture cannot be easily separated. Cultural expressions are deeply extended to nature and the environment (Posey. 1998: 43). The learning of indigenous knowledge is about the way of knowing science which is culturally based, and would allow for a process of science. In other words, indigenous knowledge and information passing through a cultural sieve would enable students to be able to interpret and categorize scientific knowledge based on cultural beliefs, values, practices and experiences.

The cultural traditions include a set of knowledge acquired collectively in various systems. It enables natural resources to be conserved and regenerated in community development. In every culture, every society has built up a body of technical and practical expertise, which is still being enriched. Some of these cultural traditions attempt to comprehend and interpreted of the world. Some traditions meet the need to organize knowledge and know-how somewhat along the lines of the various scientific disciplines. The fairly widespread dissemination of such knowledge and the existence of reserved pools of know-how in both traditional and modern society result in cultural divisions, which are very often in social divisions as well (UNESCO. 1995: 108).

The holistic view of science learning should be integrated and linked to science, technology, and society (Bernstein. 1983: 29; Apple. 1996: 22; Latour. 1999: 22). Hence, the new era of science education in Thailand has its compass. Then, the Thai National Education Act is shaping its development and forming its contours.

In the context of community, school is locally centered and directed towards the scientific knowledge. The science curriculum is seen as a means to improve living conditions. Moreover, it helps students think more intelligently about how national and world affairs are affecting their lives (McNeil. 1995; Forrest. 2000).

Science curriculum should play a role to serve both indigenous knowledge and science. The local context should be paralleled with globalization, grassroot learning, local appreciation and self-responsibility to society. The implications for teaching consist of curricular objectives and lesson plans. It should focus on fundamental principles of scientific knowledge. Teaching activities should encourage the development of principle understanding and students' work should be considered or assessed in terms of authentic view (Duschl; & Hamilton. 1992: 5).

Several works about incorporating culturally-based knowledge into school science have been reported e.g. Yakubu (1994: 343-360), Costa (1995: 313-333), Jegede (1995: 97-137), Ogawa (1995: 583-593), Jegede (1997: 1-20), Kawagley et al (1998: 133-144), Aikenhead and Jegede (1999: 269-287), Walker (1999: 203-219), Forrest (2000), Omoifo and Ogawa (2001), Ogawa (2001), Ogawa and Omoifo (2001).

The importance of learning should have a balance between local knowledge and modern scientific knowledge. Students can learn and understand the important things to serve their real needs. They can preserve environment and live together with nature through their local culture respectively (Na Thalang. 1991: 81).

Based on the cultural capital and the way of learning in Thai culture, reinforcement of science learning through local culture can promote ways of learning science. In addition, the Thai National Education Act of 1999 states that all schools should incorporate indigenous knowledge into their school curriculum. Students should have learning activities locally and gain understanding globally. This study aims to reinforce science learning through local culture by designing the science curriculum, implement the proposed science curriculum, and examine the learning outcomes. The significance of this study occurs in school-based science curriculum and ways to reinforce science learning through local culture.

Objective of the study

This study aims to reinforce science learning through local culture by designing the science curriculum. It also aims to implement the proposed science curriculum, and to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior.

Significance of the study

The benefits of this study will be instantiated in the ways to promote the reinforcement of science learning through local culture.

Scope of the study

1. Population

The population of this study can be divided into two groups;

1.1 Population for designing the reinforcement of science learning through local culture consist of science curriculum developers, educational technologists or evaluators, ecologists or environmentalists, national science teachers or master science teachers, and indigenous specialists.

1.2 Population for studying the impacts of reinforcement of science learning through local culture are Mathayomsuksa 3 students of Khon Kaen Educational Region 3.

2. Samples

The samples of this study are selected by purposive sampling. They can be divided into two groups;

2.1 Samples for designing the science curriculum for reinforcement of science learning through local culture consist of five science curriculum developers, five educational technologists or evaluators, five ecologists or environmentalist, four national science teachers or master science teachers, and five indigenous specialists.

2.2 Samples for studying the impacts of reinforcement of science learning through local culture by the use of science curriculum designed are Mathayomsuksa 3 students at Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school of Khon Kaen Educational Region 3.

3. Variables

3.1 Independent variable:

The reinforcement of science learning through local culture

3.2 Dependent variable:

The learning outcomes of proposed science curriculum are science learning achievement, values of science-culture in accord, and environmental conservation behavior

Definition of terms

The definitions of each terminology concerning this study can be defined as follow;

1. **Local culture** is the knowledge, thoughts, feelings, and behavior of indigenous people. It is a way of life, collective knowledge, creative thinking, transferable knowledge, and dynamical change, which is related to local environment. This study employed *PAH POOH TAH* (a small village's woodland in the northeastern part of Thailand) as a model of local culture, which is related to conservation biology.

2. **Reinforcement of science learning** is a situation to provide stimuli for gaining students' knowledge and understanding in science.

3. **Reinforcement of science learning through local culture** is a situation to provide positive stimuli for gaining students' knowledge and understanding in science. The positive stimulus of this study is a proposed science curriculum which employed *PAH POOH TAH* to be a model of local culture and learning resource. It also uses local language to reinforce science learning through local culture. The curriculum allows students to have scientific activities in both indoor and outdoor learning experiences, which are scientifically and culturally accorded. The reinforcement of science learning through local culture can be monitored by science learning achievement, values of science-culture in accord, and environmental conservation behavior.

4. **Science learning achievement** is an ability of students in knowing and understanding science. It can be evaluated by achievement tests. The science learning achievement tests will evaluate students' ability in knowledge, comprehension, application, and scientific process skills.

5. **Values of science-culture in accord** is the principle about what is important on knowledge-based in local context, culturally-based knowledge, and collectively-based knowledge in three criteria; moral and ethics, art and way of life, and self-sustainability. The values of science-culture in accord can be measured by the values of test for science-culture in accord.

6. **Environmental conservation behavior** is individual action to conserve environment through feeling, thinking, and acting of individual to conserve environment. It can be measured by environmental conservation behavior questionnaire.

Theoretical framework

This study aims to reinforce science learning through local culture by designing the science curriculum for Mathayomsuksa 3 students. It also aims to implement the proposed science curriculum and to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior. The positive stimuli of this study was by the use of science curriculum, which employed *PAH POOH TAH* and local language to reinforce science learning through local culture. The theoretical framework of this study is presented in Figure 1.

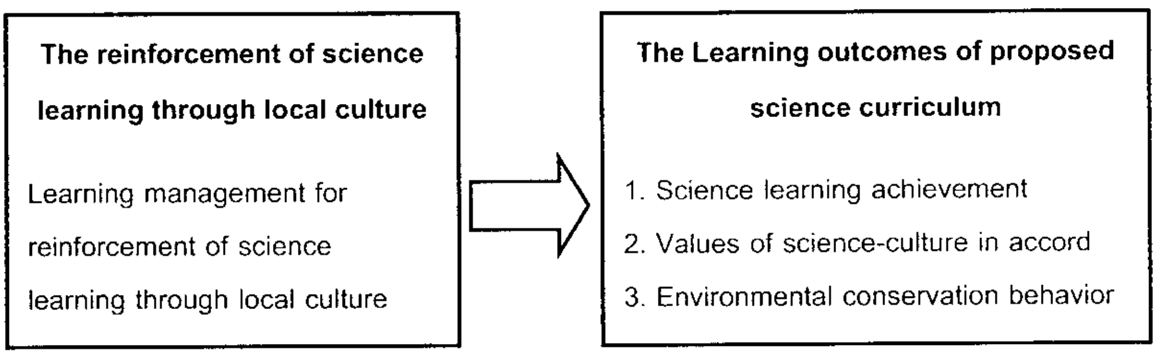

Figure 1 Theoretical framework for the study.

Hypotheses

The reinforcement of science learning through local culture is examined as follows:

1. The posttest scores of the science learning achievement is higher than the pretest scores.
2. The posttest scores of the values of science-culture in accord is higher than the pretest scores.
3. The posttest scores of the environmental conservation behavior is higher than the pretest scores.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter presents the literatures related to reinforcement of science learning through local culture. Four main topics are explored and reviewed.

1. Science learning management
    - 1.1 Scientific knowledge
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    - 1.3 Science education in Thailand
    - 1.4 Learning management in science
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        - 1.6.2 Selecting Curriculum Content
        - 1.6.3 Constructing curriculum
        - 1.6.4 Implementing curriculum
        - 1.6.5 Evaluating curriculum
2. Local culture
    - 2.1 Indigenous knowledge
    - 2.2 Indigenous knowledge and science education
    - 2.3 *PAH POOH TAH* : a model of local culture
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3. Science learning achievement
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4. Values of science-culture in accord
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    - 4.2 Studies of scientific value

1. Science learning management

This topic presents about science learning management. It includes what scientific knowledge is, how scientific knowledge is important for science education, how science education and learning management works, what reinforcement of science learning says, and how science curriculum develops.

1.1 Scientific knowledge

The term 'science' is defined in many different ways depending on dimension of thinking and doing, but most definition focus on the way of knowing and understanding natural world. It also covers the activity of scientists, the knowledge held, and the institutions that practice science. The example of such definition of science can be described as follows;

Science concerns on extension of everyday observations about nature, systematic experimentation and reasoning, induction and deduction, and forming the core scientific method leads us to understand the world. The heart of science is observation, experimentation, and mathematical reasoning. Scientific method and research methodology employ observation as a base of knowing and understanding nature (Saiyot. 1980: 6; Saiyot; & Saiyot. 1995: 14). The attitudes or predispositions tend to characterize their work (Chaille′; & Britain. 1991: 179; Carin. 1993: 16; Harlen. 2000: 1). Science can be defined in the sense of a body of knowledge as a way to think and to investigate (Collete; & Chiappetta. 1994: 30; Ross; et al. 2000: 1).

Brady (1989) characterized science into 6 meanings: (a) a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws; (b) systematic knowledge of the physical or material world; (c) systematized knowledge in general; (d) knowledge as of facts or principles, knowledge gained by systematic study; (e) a particular branch of knowledge; and (f) skill and proficiency. This means that science can be defined in different ways depending upon the idea and perspective of each individual.

Science tries to establish certain predictability about life and nature with sufficient evidence that serve our inquiring minds (Bhavilai. 1993). Science is not only a body of knowledge, but it is also the process to inquire knowledge about natural world and beyond, and creates new knowledge by using scientific method as a base of findings.

Science also wants to claim for itself the status of knowledge that is provable. It is possible to observe a sufficient number of particular cases and it can be generalized into some simple statements. Science as an activity is more important than the process of induction. We cannot prove scientific knowledge unless we give the word 'prove' much weaker sense than customary. Scientific knowledge cannot be proven, it can be made more 'probable' (Donnelly. 1986). As a pinpoint of rationality, science was introduced and employed in our society. We are facing not only scientific knowledge, but also indigenous knowledge is raising its role in the changing world.

Science is a rational perceiving of reality where perceiving means both the action of constructing reality and construct of reality. Science can be defined in three types: (1) a culture-dependent collective rational perceiving of reality, (2) a rational perceiving of reality which is unique to each individual, and (3) a collective rational perceiving of reality. It is shared and authorized by the scientific community (Ogawa. 1995: 583).

Science provides a powerful way of investigating and understanding the world. It is related to problems of everyday living and stresses practical skills, decision-making, and problem-solving. Science is not merely the conventional school subjects, but it includes the vital applications in everyday life activities i.e. health, agriculture, and industry.

In summary, science can be defined as knowledge that is based on testing and proving facts, or the study that produces knowledge. Science is also a particular area of knowledge. It is a useful knowledge for survival. It employs scientific method as a key element to meet new challenges and produce new knowledge.

1.2 Scientific knowledge and science education

Science studies have produced an extensive body of knowledge by looking for the scientific theory, process of development, negotiation and acceptance of new scientific knowledge (Savathanaphaibul. 1983a: 110-111). The importance of scientific knowledge and its role in education can be concluded that science is a tool to help us learn the reality of the world.

Science education deals with the processes of passing on knowledge, understanding of science, and its practices to new students. It concerns the training of the next generation of scientists into scientific ways of thinking and working in terms of wider dissemination of public understanding of science.

Scientific knowledge and its processes are important for the students in that they can be applied outside strictly scientific activities. In the context of education it is noted that science helps us gain an understanding of fundamental human traits. Understanding science also leads us to scientific literacy, a prerequisite for functioning in modern society, and prepares students for their futures (Lee. 2002: 1).

The new challenge of science teaching and learning processes should emphasize on the inquiring knowledge from various ways. We can bring scientific skills to learn more about physical and biological worlds.

In the present, there is much knowledge that we cannot teach our students in school. The key point to teach our children is not to teach specific content knowledge, but we should try to lead them by helping them construct an inquiring mind. They could have scientific process skills, which are the base of learning. Teaching and learning processes encourage them to the freedom of learning in a modern society.

The failure of modern science course in school in fully achieving the declared goals in relationship with students' understanding nature of science is that there is a degree of confusion in providing teachers with an adequate understanding of basic issues in the philosophy of science.

Moreover, the importance in the design of learning experiences needs to be improved. Many science curricula pay too much emphasis on inductive methods. It is ready to accept instrumentalist view of scientific theory, a serious underestimation of the complexity relation between observation and theory. Science curricula neglect the activities of the scientific community in validating and disseminating scientific knowledge (Hodson. 1991).

Science is a part of our culture and heritage, and scientific knowledge ought to be a common property (Shortland; & Gregory. 1991: 7). Today, we are facing with science and technology as parts of universal human culture, and at the same time also have many local characteristics. Thai society has a potential to develop its own science and technology. Both imported and indigenous science and technology can be incorporated into important tools, which can provide development options for people at all levels in the society (Yuthavong. 1997: 138).

Modern science has concerned itself with the understanding of the universe which influences human social/cultural issues. Teachers should provide effective instruction to students in a variety of cultures (Benson. 2001). Science in different culture needs to change conceptions in the specific social and environmental conditions. It needs to understand the systems of students' daily life and cultural beliefs to promote science learning. Socio-cultural factors are the key element of conceptual development and conceptual change (Walker. 1999: 203-219).

Aikenhead (2001: 180-188) summarized the cultural science classroom into 3 classes; First, the difference between a student's cultural identity and the culture of science or school science. Second, the effectiveness with which students are able to access the cultural border between their life-world and the world of science or school science, and third, the assistance students receive as they negotiate those cultural borders.

Science learning in the modern world is not only modern science as the major knowledge in the school science, but also culturally-based knowledge as is a complex science education for achievement of the students' conception about natural world. The various kinds of knowledge should be incorporated to encourage epistemological science classroom. Given diversity of scientific practices and inherent limitations of school science, culturally based knowledge should be considered (Rudolph. 2003: 64-79). Although science achievement has affected everyday live, learning science based on culturally science context or indigenous knowledge is a key point to promote science.

1.3 Science education in Thailand

The Thai Ministry of Education reported the limitations in the past curriculum and teaching-learning activities in three main criteria: (1) the formulation of curriculum by central authorities does not respond to the real needs of Thai society, (2) The former curriculum and teaching-learning activities in mathematics, science and technologies areas failed. It needs to be improved based on the development of problem-solving skills, creativity, and attitude towards mathematics, science and technologies, and (3) The application of the past curriculum does not respond and help children to foster the foundations of critical thinking, life skills, and thus it is unable to assist students to effectively tackle the fast changes in social and economic areas (Ministry of Education. 2002: 1).

The limitations of the past curriculum and learning patterns will be changed by the educational reform in 1999. The basic reasons of the reform consist of the failures in various kinds of problem. For example, in 1997 Thailand faced an unprecedented huge economic crisis. In addition, The Third International Mathematics and Science Study (TIMSS) indicated that Thailand's scientific and technological knowledge has a poor preparation. According to these results, Thai people have worried about the potential of their children's problem-solving skills and life skills. They need to prepare smart children to face the changing world.

Recent education reforms in Thailand, as propagated by the National Education Act of B.E. 2542, have responded to Thais' need in terms of education for the future. The expectation is that the schools in Thailand should develop their own curricula based on the relationship between national education standards and local contexts. The expectation from this Act emphasizes the principle express to both students and teachers.

Students are the most important part to construct knowledge and understanding for individual and community development. Teachers should change their behavior in teaching process in order to be a facilitator and help students to meet knowledge to their full potential. This Act also aims at the full potential and development of Thai people in physical and mental health, wisdom, knowledge, morality, integrity, connection, and so on in order to be able to live with other people by appropriation and peace.

The curriculum development of an educational institution is emphasized by indigenous knowledge, inter-disciplinary sciences, and manipulation of diversity of research methodology. Information and findings are valuable in the problem solving pedagogy. Research and development in the educational institution curriculum should have integral characteristics between qualitative and quantitative research. The way to determine what research methodology should be applied depends on the appropriation of inter-disciplinary sciences and its test from the field study or community feedback (Ministry of Education. 2002: 3).

Some reasons above become a prior problem of Thai education and society. A major principle of the reform is that the students are incapable of learning but lacking of self-development, which are regarded as most important. The teaching-learning process shall aim to enabling the students to develop themselves at their own pace and to the best of their potentials. In addition, emphasizing on the educational system through formal, non-formal, and informal approaches shall give emphasis to knowledge, morality, learning process, and integration, depending on the appropriateness of each level of education. Furthermore, science learning should result in gaining knowledge, understanding, and attitude towards science (Office of the National Education Commission. 1999).

1.4 Learning management in science

The National Education Act of B.E. 2542 (A.D. 1999) proposes how to manage science learning. In the section 23, this Act states that formal, informal, and non-informal education should emphasize knowledge, moral, and integrated learning process. Learners can gain more knowledge and understanding from science and technology. Also, indigenous knowledge, culture, religion, and society should be taken into account. Section 27 mentions that the Basic Education Commission will prescribe core curricula for basic education for the purposes of preserving Thai identity, good citizenship, desirable way of life, livelihood, as well as for further education.

Educational institutions have the duty and responsibility to develop the educational institution curricula inline with the core curricula. Educational institutions can develop and manage the learning process by considering the aims and curriculum structure of primary and secondary levels (B.E. 2533). It emphasizes the community needs to be inline with local problems, and learners can learn their real life from local areas.

The educational institutions can develop the educational institution curriculum by considering the principles, aims, structures, and standards of basic education. The education institutions will be responsible for prescribing curricular substance relating to the needs of community and society.

The responsibility of science education should concern the individual and social potentials of all people. It should view education as a process continuing throughout each person's lifetime. A balanced curriculum should adequately cover all aspects of life, unified way, helping to lay moral foundations, and preparing each child for the requirements of everyday life (Burrows et al. 1991: 260).

The Basic Education Curriculum 2001 is composed of knowledge, understanding, learning processes, values, moral, and attitudes which are divided into eight broad subjects that Thai students should learn: Thai language, Mathematics, Science, Social studies, religion and culture, Health and physical education, Art, Career and technology, and Foreign languages (Ministry of Education. 2002: 5).

According to the Basic Education Curriculum 2001, the subjects of Science and Social studies, religion and culture are considered to promote the quality of students. The reinforcement of science learning through local culture, especially environmental conservation on *PAH POOH TAH* is introduced to this study (Table 1).

Table 1 *Science* and *Social studies, religion and culture* are the subjects for promoting the quality of students in this study.

Categories	Subcategories	Standards
Science	Subcategory 2: Life and environment	Standard Sc 2.1 : Understanding the local environment, relationship between environments and living things, relationship between living things and its ecosystem are inquired based on attitude towards science. Students can communicate science as to what they learn and how they use it.
		Standard Sc 2.2 : Understanding the importance of natural resources in local community, and also having awareness in its practices in local, nation, and global levels, which are inquired based on attitude towards science. Students can communicate science as to what they learn and how they can sustain natural resources and environment.
	Subcategory 8: The nature of science and technology	Standards Sc 8.1 : Employing the process of science to solve problems should be reminded. Understanding the natural phenomena that it has regularity. It can be explained and improved by tools. Science, technology, society, and environment are harmonistic disciplines.
Social studies, Religion, and Culture	Subcategory 5: Geography	Standard SRC 5.2 : Understanding the relationship between human beings and physical environment, cultural creation, and awareness in natural resources and environments.

The subject of science is divided into 8 subcategories; (1) organism and its organism and its existence processes, (2) life and environment, (3) matter and its properties, (4) force and mobility, (5) energy, (6) earth evolution, (7) astronomy and space, and (8) the nature of science and technology (Ministry of Education. 2002: 14-16). Each subcategory is defined in different topics providing the content framework of what students should know.

1.5 Reinforcement of science learning

Reinforcement is the situation that someone receives the reinforcer from the stimuli then he/she will change his/her behaviors (Malott; & Suarez. 2004: 35). Behavior is caused by external events to a person. It can be understood in terms of simple laws applying to both human beings and animals. Behavior is determined by its consequences. Responses become more probable as the result of some consequences and are less probable as the result of others (Stipek. 1993: 25).

1.5.1 Fundamental of reinforcement

The reinforcement refers to consequences that increase the probability of a behavior by taking something away or increasing its intensity. It can be categorized into two ways; positive and negative. Kahn (1999) defined the positive and negative reinforcements for implication as follow:

Positive reinforcement will occur when an action, object, or event is presented to a person for performing an operant behavior. So the person who chooses to do that operant behavior again will receive a consequence. The positive reinforcement can be explained by a few important assumptions. First, when the person chooses to repeat the operant, the consequence must meet the requirement to that person. Second, the presentation of the desirable consequence must be contingent on performance of the operant behavior. And third, according to some randoms or fixed schedules of reinforcement, the satisfaction of the person who receives the reinforcement must be presented in responsibility to the operant behavior.

Dickson et al (1993: 27-30) categorized the positive reinforcer into five categories; primary reinforcer, conditioned reinforcer, social reinforcer, sensory reinforcer, and activity reinforcer. The details of five reinforcers are provided below.

Primary reinforcer is a stimuli, positive value and reinforcing potential of which do not reply upon a process of prior learning. We depend upon something for survival, which is due to our biological make-up. The primary reinforcers include food, drink, sex, etc. The limitations of these are the direct goals influencing the complexities of interpersonal behavior in modern society. The primary reinforcers are said to be the rewards as they are basic needs of people.

Conditioned reinforcer or secondary reinforcer, it is in sharp contrast to the previous. It includes that events have no intrinsic worth, but it is derived from an earlier association with primary reinforcers. The conditioned reinforcers include token, stickers, vouchers, stamps, badges, stars, etc.

Social reinforcer includes the rewards that govern and shape. These rewards can be thought of either process or content. The process is an inherent part of interpersonal contact. According to Skinner, positive social reactions can be used to shape interpersonal behavior because they serve as generalized reinforcers. 'A common generalized reinforcer is approval.... It may be little more than a nod of the head or a smile on the part of someone who characteristically supplies a variety of reinforcers. Sometime... it has a verbal form "Right! or Good!"' (Dickson; et al. 1993: 29; citing Skinner. 1957).

Sensory reinforcer is one type of the attractions, for example, listening to beautiful music, looking at a striking painting, attending the theater, and so on. It will often sustain to do so, to appreciate the certain quantities and qualities of sensory stimulation.

Activity reinforcer can be a powerful means of organizing a routine work and maximizing commitment in a diversity of professional settings. Students who prefer the practical classes with didactic instruction will freely choose their own questions or hypotheses on what they should find out or prove.

Reinforcers and punishments are defined strictly in terms of their effects on behavior. It cannot be identified independently of reinforcement or punishment effects. As opportunity to perform in front of the class may be a real treat for an outgoing, self-assured child, and would serve as a positive reinforcer. The same opportunity may be punishing for a shy child or a child who lacks self-confidence.

The reinforcement is used to examine science learning. If students have positive reinforcement, they will gain more knowledge and understanding about natural world. Students can establish scientific knowledge and useful knowledge to learn in the everyday life (Amos; & Boohan. 2002: 38). There are four positive reinforcers to help students learn science, society, material, activity, and token (Kahn. 1999: 36-39).

Social reinforcers are affirmative stimuli received from other people. It is typically verbal in nature and packaged in the forms of praise, compliments, acknowledgements, answers in the affirmative, and other verbal messages that we want to hear.

Material reinforcers are tangible reinforcers because of their physical nature. Material reinforcers are objects, things, and possessions. Unlike token reinforcers, material reinforcers derive their value from what they can be traded. Material reinforcers can be represented by clothing, automobiles, houses, stereo, computers, and more conspicuous materials.

Activity reinforcers are the participation in a pleasure, relaxing, or positively stimulating activity. This participation can be passive and observational. There are numerous experiences such as joy, excitement, and stimulation. Some behaviors relate to the activity of human being. Scientists have suggested that man is innately programmed to seek natural highs and altered states of consciousness. These experiences are tantamount to primary reinforcers. It is a significant part of society as well as culture throughout the world.

Token reinforcers pose a very little value that cannot be eaten, worn, driven, or used. Token is the most flexible and uniformly pervasive of all secondary reinforcers. Most students value grades, stars, merits, trophies, and ribbons. It can explain why token reinforcers are so useful in establishing contingencies for purposeful behavior change.

Negative reinforcement will occur when there is performing a particular operant behavior to avoid or escape from some forms of punishment. If this operant is successful, students will quickly learn to perform the same behavior again in the next time to avoid that punishment.

Negative reinforcement also concerns science learning. We should learn how students respond to certain circumstances in various ways. Students may show escaping or avoiding behaviors. We might have learned to escape by apologizing, creative rationalizing, shutting our mouth, begging, making amends, outright lying, or just bolting out the door. The relationship between escaping behavior and avoiding behavior is typically more successful, adaptive, and also much less anxiety provoking (Kahn. 1999: 40-43).

It is widely accepted that reinforcement can modify the future probability of the behavior. We have to know how reinforcement works for science learning. It will be briefly mentioned below according to Dickson et al (1993: 34-39).

1. Automatic effect includes Thorndike and Skinner theories claiming that reinforcement functions largely automatic to bring about behavioral change. Two important implications stem from this view. The first is that the individual's awareness of what is taking place. It is not a prerequisite of reinforcement. The second concerns the nature of the relationship between the targeted response and the reinforcing event.

- Awareness is a conscious deliberation, which is a necessary prerequisite for operant conditioning to be manifested. It is the present consensus of opinion as far as social performance is concerned. It is probably little instrumental conditioning taking place without at least some minimal level of conscious involvement.

- Relationship between response and reinforcers depends on the behavior in question bringing about a positive outcome. A belief in contingency is necessary and sufficient conditions for reinforcement to take place as a common in association with unconscious operation. It can be concluded that rewards work best when the individuals involved the awareness of casual relationship between doing and outcome.

2. Motivation is a factor in interpersonally skilled performance. The motivation is a base of reinforcement. It is not only the attainment of the goal, which is rewarding but also the evidence of the progress is forwarding and will be positively valued.

3. Information can serve rewards to motivate. Rewards also serve to influence through acting as incentives by pursuing one action rather than another.

Life has plenty of stimuli, events, and conditions that help us survive. We have involved many of those biologically helpful conditions. Malott and Suarez (2004: 17-18) pointed out that the fundamental concept in the analysis of behavior concerns the reinforcement principle. A response will occur more frequently if a reinforcer or an increase in a reinforcer has intermediately followed it in the past.

The principle of stimulus control is applied to human beings and animals. For example, a teacher standing in front of the classroom may cause children to pay their attention. Children are rewarded for paying attention or punished for not doing that while teacher standing in front of the class. This situation is a stimulus by reinforcement. A change in the stimulus such as a student standing in front of the class instead of a teacher, it may not cause children to pay attention because a person other than a teacher is not previously associated with positive reinforcers or punishments.

However, Reinforcement theory is considered as 'mechanistic' because no reference is made to unobservable variables such as choice, beliefs, expectations, or emotions (Stipek. 1993: 27). The emphasis is exclusively the environment and observable behaviors. The person's behavior at any given time is fully determined by his or her reinforcement history and the contingencies in the present environment. Thoughts and feelings, according to reinforcement theory, are irrelevant (Stipek. 1993: 28; citing Skinner. 1974).

The studies of reinforcement of science learning have been reported. For example, Jubjitt (1991: abstract) studied the effects of pre-class concentration upon achievement in science, scientific attitudes, science process skills, and learning retention of Mathayomsuksa 2 students. The findings revealed that learning retention of achievement in science on the knowledge, comprehension, and the scientific process skills on the defining operationally of experimental and control groups were significantly different. Tungchitprasonk (1989: abstract) studied the Prathomsuksa 6 students' achievement, retention, and scientific attitudes by using supplementary reading textbooks with emphasis and non-emphasis on content presentation based on scientific method sequences. The results of this study showed that learning achievement and retention was significantly different between experimental and control groups, but there was not significantly different between experimental and control groups in scientific attitudes.

Kirdbantakien (2003: abstract) studied the learning achievement in science process skills, attitudes, and learning retention of level 3 students with different learning abilities by using types of multimedia program and teacher's manual. Different types of learning, and learning abilities affected the learning retention, but different types of learning and different learning abilities did not affect learning retention.

Reinforcement affects a particular behavior only if it is contingent on that behavior. Teacher must reinforce only desirable behavior and ignore or punish undesirable behavior. If maximum learning is the goal, behaviors that enhance learning need to be rewarded. Students should be reinforced for paying attention to the teacher or the task at hand, persisting on tasks, selecting challenging tasks, completing tasks, and other behaviors that enhance learning (Stipek. 1993: 29).

The value of reinforcement can be seriously regarded. Several facets of the concept should be noted. When reinforcement plays its role in science learning, the teaching and learning process should be considered. Science educators can seek for ways to promote reinforcement of science learning by various kinds of method.

1.5.2 Implication of reinforcement

Students are intensely engaged in intellectual tasks. Teachers need their students to ask more questions in the class. The teacher can directly reinforce students for looking in their direction, but it is difficult to reinforce students for listening or thinking about the information which the teachers are presenting. So the teachers can carefully observe the response from students and provide more works to the students. If students cheat or guess on the tests, teachers will inadvertently reward that cheating or guessing behaviors by giving more assignments to the students (Stipek. 1993: 36).

Piaget (1952) provided an explanation for children's repetitive and occasionally annoying behaviors. Their behavior will appear to serve no purpose. For example, when children begin to learn to take off their shoes, they will repeatedly remove them. Children also turn the door knobs without any apparent desire to open the door. They will open and shut the cupboards with little interest in the contents in the cupboards.

Students can control their own behavior to improve themselves in selecting and administering reinforcement. Self-reinforcement increases performance mainly through its motivational function. They can make self-reward condition by attaining a certain level of performance; individuals create self-inducements to persist in their efforts until their performance matches.

The competency of motivation is a biological base drives individuals to engage in their activities. It results in increased competency to deal with environment. While there is merits to view it, it is important to recognize the role of the social environment. The students must learn both skills and cultures in the same time. Cultural and social environments are the bodies of knowledge which are developed and passed from generation to generation.

Teachers are also sometimes unaware of inconsistencies between the behavior, students' desire, and the contingencies in their classroom. It is useful for teachers and parents to reflect upon the kinds of rewards and punishments, the behavior upon which these consequences are contingent, and the degree to which they are available to all children.

The reinforcement techniques are used virtually in all classroom settings. While teachers praise students, give grades or gold stars, put students' papers on public display, or require students to stay after school for disruptive behavior thus this means that teachers are applying principles of reinforcement theory. There are costs for over-reliance on reinforcement as a means of motivating behavior.

1.6 Curriculum development

A major question in education is how to provide children not only meet individual needs but also social realities, culture, and human values to the students (Kindred; et al. 1976: 1). Curriculum is the key for the aspects mentioned.

The terminology of curriculum should be clearly defined, even though it has been defined in a broad and a narrow sense. The term 'curriculum' has been in the literature for a long time. A number of publications have appeared since 1950, resulting from the 1947 conference at the University of Chicago (Herrick; & Tyler. 1950).

Many workers gave the definitions of curriculum and they are as follows:

- Which is taught in school (Buswell. 1942: 446; Krug. 1957: 3; Faunce; & Bossing. 1958: 115; Wagner. 1958: 328; Ragan. 1960: 3; Saylor; & Alexander. 1966: 57; Doll. 1982: 4; Oliva. 1997: 4).
- A set of subject (Smith; et al. 1957: 3; Oliva. 1997: 4).
- Content (Longstreet; & Shane. 1993: 47; Posner. 1995: 5-7; Oliva. 1997: 4).
- A program of study (Miel. 1955: 21; Beauchamp. 1956: 41; Doll. 1982: 4; Posner. 1995: 5-7; Oliva. 1997: 4).
- A set of materials (Thompson; & Gregg. 1997: 28; citing Foshay. 1969; Posner. 1995: 5-7; Oliva. 1997: 4).
- A sequence of courses (Posner. 1995: 5-7; Oliva. 1997: 4).
- A set of performance objectives (Oliva. 1997: 4).
- A course of study (Thompson; & Gregg. 1997: 28; citing Foshay. 1969; Posner. 1995: 5-7; Oliva. 1997: 4).
- Everything that goes on within the school, including extra-class activities, guidance, and interpersonal relationships (Whitfield. 1971: 2; Doll. 1982: 4; Longstreet; & Shane. 1993: 47; Oliva. 1997: 4; Thompson; & Gregg. 1997: 28).
- Which is taught both inside and outside the school and directed by school (Doll. 1982: 4; Oliva. 1997: 4).

- Everything that is planned by school personel (Saylor; & Alexander. 1966: 57; Oliva. 1997: 4).
- A series of experiences undergoes by students in the school (Whitfield. 1971: 2; Doll. 1982: 4; Longstreet; & Shane. 1993: 47; Thomson; & Gregg. 1997: 28; Posner. 1995: 5-7; Oliva. 1997: 4).
- Which an individual student experiences as a result of schooling (Longstreet; & Shane. 1993: 47; Oliva. 1997: 4).
- Ends, or outcomes of being educated (Doll. 1982: 4).
- Systems for achieving educational production (Doll. 1982: 4).

Curriculum definition can be concluded by the researcher as it is all of experiences set for students, learning activities, content or program study, and plans for learning. Curriculum is important for educational system in order to gain developments, skills, and competency to people. In addition a way to the best develop curriculum should be considered to prepare our children to face future challenges.

Snively and Corsiglia (2001: 6-34) developed science curriculum relating to indigenous knowledge by using the term, Traditional Ecological Knowledge (TEK). Five steps of curriculum development were proposed. Its unit in cross-cultural science teaching was outlined. The model of this approach provides a general framework for exploring both indigenous knowledge and modern scientific knowledge. The process of curriculum development for this study includes five steps; (1) choosing a science concept or topic of interest, (2) identifying personal knowledge, (3) searching various perspectives, (4) reflecting, and (5) evaluating the process.

Fensham (2000: 149) illustrated that curriculum designers should know science in order to include science in a curriculum by proposing three phases;

Phase 1: societal experts systematically determine features of society endemic to an informed public. These judgements are based on problems. These experts have had communication with the public.

Phase 2: academic scientists specify science content associated with the features of society identified in phase 1.

Phase 3: based on phase 1 and 2, science educators develop a science curriculum. The phases address the content to be included in a curriculum, not the implementation of the curriculum.

There are researches on curriculum development, which are related to this study. These are some following examples.

Arevbu (1980: abstract) studied the relationship between curriculum innovation in integrated science and curriculum differentiation, and how curriculum innovation is filtered through teachers and students in the classroom. The result showed that the integrated science had been fed into Nigerian educational system from the top (national level) and processed through various channels to the grass roots at the bottom level.

Buasonte (1992: abstract) developed curriculum for transmitting local wisdom into school community in the lower central part of Thailand. There are four steps for developing curriculum - research, development, research, and evaluation - by employing the participatory action research. The findings revealed that community has indigenous knowledge to conserve and utilize plants from forestry village. Indigenous people also supported the curriculum and instruction for transmitting the indigenous knowledge to the students in school.

Hassanein (1997: abstract) studied how knowledge-related activities can be a basis for collective action at local level. The findings showed that different lived experiences in each person produce multiple and partial perspectives from which local knowledge is generated and exchanged. Also, Pranee (2002: abstract) developed the curriculum for local community conditions and local needs by employing the technique of participatory action research. In this case, indigenous knowledge is brought into classroom.

Maneekosol (1996: abstract) developed action research curriculum for the primary teachers. Five steps of curriculum development are; content analysis, draft-curriculum development, draft-curriculum evaluation, implementation, and curriculum evaluation. Bunsai (1998: abstract) developed a high school biology curriculum on basic biotechnology by utilizing waste-based laboratories. Students can learn biotechnology in the positive changes on cognitive, affective, and psychomotor domains.

Jansawang (2005) developed and implemented an elective science curriculum, chemicals in everyday life, for the lower secondary school students with local wisdom. The findings revealed that students have the post-test scores significantly higher than the pre-test scores. The awareness of value of local wisdom and benefit of local resources are gained. Moreover, students enjoyed learning science based on the learning cycle because they developed both investigation skills and team-working skills.

Pupaka (2005) developed a high school chemistry curriculum incorporating into real-life situations by using inquiry cycle approaches to evaluate the learning outcomes. The teachers' and students' opinions on the implementation were examined. The results showed that the scores of students' learning achievement and manipulative skills after studying learning units are higher than the scores before. Moreover, studying learning units and students' scientific mind component after the study has a high score. In addition, Thanaprayothsak (2005) studied and developed a high school curriculum on natural resources and environmental pollution related to real life issues based on inquiry cycle approach. The result of the study revealed that developed science curriculum related to real life situations was effective and could be used in the classroom.

The fundamental changes taking place in culture and society must be accompanied by a reexamination and reconstruction of its institutions. The rapidity of today's societal changes calls for equally rapid changes in the organization and administration of the entire educational structure. Applicable knowledge and new techniques must be applied to curriculum content and organization and to the methods and materials of instruction (Kindred; et al. 1976: 12).

1.6.1 Setting curriculum purposes and objectives

The objectives of curriculum have been derived from the society services expected by schools and from the needs of school pupils as they live in their culture (Beauchamp. 1961: 36). It means attempting to focus upon both social demands for school and the individual demands for derivation of school objectives or society-centered position, child-centered position and the interactive position respectively.

Purposes and objectives are expected outcomes, which we have set. Kindred et al (1976: 54-56) stated that the purpose of curriculum should be composed of 7 issues;

1. To serve young people,
2. To facilitate self-development and self-actualization,
3. To provide general education, including opportunities for the development of a sense of inquiry, curiosity, and commitment for learning,
4. To provide opportunities for exploration,
5. To provide the individualization of instruction,
6. To improve articulation with school program, and
7. To provide opportunities for racial integration.

These issues point to the direction for school program to facilitate children to develop both physical and psychological states.

Curriculum objectives expressed in behavioral terms specify the desired changes in the students. These means that they should think, feel, and act after exposure to the educational experiences. All concepts of science directly relate to the natural phenomena and changes occurring in the environment. Madrazo and Rhoton (1999: 26-28) proposed that the middle school science curriculum and life activities can help students learn science by increasing self-awareness. Middle school science curriculum needs to have high expectations of all students and provide them with opportunities to actively engage in science learning.

Additionally, curriculum needs to include approaches, techniques, and activities that improve students' knowledge and awareness of cultural perspectives. Then, teachers should incorporate a variety of teaching styles that are in consistent with cultural groups into science classrooms. All activities in classroom need to provide students with the opportunity to emphasize with the actions and emotions of various peoples in different places. Science curriculum should allow students to meet experience and to understand the rich diversity of scientific endeavors (Rudolph. 2000: 403-419).

The consideration for needs in educational objective involves the use of important sources from everyday knowledge environment to be a part of the educational development of the students (Tyler. 1949: 8). They can perceive new knowledge between the life situations in relation with learning situations involving the interaction to their environment.

1.6.2 Selecting Curriculum Content

School purposes and curricular objectives determine curricular contents. It may be stated in behavioral terms and with high degree of precision. Local curriculum is based on the core/national curriculum. Educational experts from the upper level set the goals and pattern of the curriculum. The processes of curriculum development are clarified, systematic, without much complexity. The village-level workers are educators. It is extremely important that they participate in using their knowledge from both body of theory and practice into the local students (Shield. 1967: 60).

The learning cycle is a model for designing science lessons that ensures a successful, positive experience for students. The learning cycle consists of 4 phases (Bently; et al. 2000: 181-183). They are as follows:

1. Introduction, the purpose of introduction is to motivate students. At this time teacher captures the students' interest through the use of discrepant events, demonstrations, interesting materials or challenging questions and problem to solve.

2. Exploration is a very active phase for the students. Students can manipulate and investigate the concept to be learned. The scientific process skills are important and obvious during this phase. The teacher's role at this time is one of guidance. The purpose of exploration is to provide children with an experience-based opportunity to construct their own understanding of the concept.

3. Concept development, this phase provides an opportunity for students to report their findings and share what they discovered with other students. They elicit information and ideas generated during exploration. The teacher directs the discussion and provides appropriate terminology. If there is information in a written format, it might help in the verbalization or clarification of the concept from a textbook or other source.

4. Application, this phase provides that opportunity. It may take the form of another activity, or it may be a problem solving or a question-answering discussion. The application of the concept may also serve as a means of evaluation. The purpose of this phase of the learning cycle is to assess student understanding of the concept.

Science = Content + Process + Attitude. This formula is just the opposite of what scientists really do. The scientist starts with curiosity. Question needs to be answered or a problem needs to be solved. The science process skills are primary important for the students gaining an information. Content or knowledge is a typical starting point in designing curriculum. Knowledge is the product of scientific investigation. A more appropriate representation of the three aspects of science would be rewritten as Science = Attitude + Process ⟶ Knowledge (Bently; et al. 2000: 177-178).

The science content which should be taught in school can be considered into two factors: (1) the body of knowledge that it is currently accepted as official science and (2) the ability to learn of child (Henriques. 1990). Lock and Tilling (2002: 79-87) found that students enjoy fieldwork which made them understand scientific knowledge and gained their experiences. The accessible habitats such as grasslands, woodlands, and freshwater areas are real and similar to local field. Moreover, students are being assessed when they have not had the opportunity to develop their skills and knowledge to the maximum.

Szybek (2002) studied the science knowledge as to be developed and learned separately from its possible use. He found that it includes the act of "application". The connection between science knowledge and everyday issues to which this knowledge is to be applied is not visible until after the application is performed.

Knowledge from community studies provides valuable opportunities for students to involve in public life and develop citizenship participation skills. Hendrikson (1985) indicated that experimental community-based learning raises student motivation. Dimensional model of community study - community as a source of content, community as a source of learning experiences, community serves as a dimension of community study - uses the community to enhance skill development.

1.6.3 Constructing curriculum

The construction of the curriculum for this study employed Delphi technique. Its details is given as follow:

1.6.3.1 Definitions

Delphi is a forecasting technique based on subjective information. It can be defined as a stepwise procedure that allows the researcher to obtain a consensus opinion by separately collecting the opinion of several experts on one specific topic avoiding face-to-face discussion (Quaile; & Fowles. 1975: 179-192; Ford. 1975: 139-164; Kendall. 1977: 75-85; Dajani; et al. 1979: 83-90; Riggs. 1983: 89-94; Rowe; et al. 1991: 235-251). It is generally used for future events such as technological developments which is used the estimations and feedback summaries from the experts until reasonable consensus occurs. It has been used in various software cost-estimating activities including estimation of factors influencing software costs (HyperDictionary. 2003).

Sriparsart (1980: 52) and Vittayaanumas (1987: 25) defined Delphi technique as a process to seek the possibility of experts' opinion by interviewing. According to Jamornmarn (1997: 131), a definition of Delphi is a technique to collect and classify experts' opinion based on the reasonable consensus. The main features of the technique are anonymity, numeric response and feedback. For anonymity, each expert is unaware of the opinions and individual responses of the rest of the group thereby avoiding biased answers.

The primary purpose of the Delphi process is to obtain input from "expert" individuals concerning problems or future directions or needs. Specific objectives might include: (1) identifying emerging social, economic and demographic trends and their implications for the future, (2) obtaining input from "expert" residents concerning key issues affecting the community, and (3) developing ideas for dealing with priority concerns (Duttweiler. 2002).

The Delphi process is an under-used research methodology that combines quantitative and qualitative methods to explore the future (Ludwig. 1997). Not only does it recognizes human judgement as legitimate and useful inputs in generating forecasts, but also acknowledges the issues that arise from conventional meetings. Single experts sometimes suffer biases, and group meetings often suffer from follow-the-leader tendencies and reluctance to abandon previously stated views. The Delphi method is designed to overcome these disadvantages by allowing a group of experts to reach consensus through anonymous discussion. It is useful in answering one single-dimension question.

It can be concluded that Delphi technique is the process to justify free experts' opinion by interviewing and response to reasonable consensus in each criteria. It aggregates the judgements of a number of individuals in order to improve the quality of decision-making.

1.6.3.2 Characteristics of Delphi Technique

The Delphi technique has a research methodology, which is conducted from experts' opinion. These experts share a common interest (the subject of the Delphi) but usually represent different points of view. The original Delphi process consists of three key elements: a structured information flow, feedback to the participants, and anonymity for the participants.

The Delphi technique has a number of following advantages (Duttweiler. 2002).

1. Opportunity to involve experts, clientele, program sponsors, or administrators who cannot come together physically.
2. Expert involvement may increase validity of information gathered.
3. Individuals can remain anonymous.
4. Domination by individuals is limited.
5. The process can be used to aggregate judgements even when participants hostile towards one another or when personality styles would be distracting in a face-to-face setting.
6. Key community leaders, "experts," and individuals who are not currently affiliated with project may become involved.

Experts in various fields of study are key informants. They have to give reasonable feedback and take a responsibility to participate in the criteria. Delphi technique needs at least 17 experts to contribute ideas (Table 2).

Table 2 The relationship between decreasing deviation and number of experts

Number of experts	Decreasing deviation	Decreased deviation
1-5	1.20-0.70	0.50
5-9	0.70-0.58	0.12
9-13	0.58-0.54	0.04
13-17	0.54-0.50	0.04
17-21	0.50-0.48	0.02
21-25	0.48-0.46	0.02
25-29	0.46-0.44	0.02

(Source: Vittayaanumas. 1987: 28-29)

The Delphi technique is very useful to collect experts' opinion but it still has some limitations. The general complaints against the Delphi technique were summarized by Makridakis and Wheelright (Duttweiler. 2002; citing Makridakis; & Wheelright. 1978) in terms of (a) a low level of reliability in the collective opinion which leads to a dependency on experts selected, (b) ambiguity in the questionnaires can taint the results, and (c) it is difficult to assess the degree of expertise incorporated into the forecast. The following limitations of Delphi were pointed out by another scholar.

1. Time needed to implement (minimum is about 45 days).
2. Participants must have reading and writing skills. Some of the experts may be poor forecasters.

3. High participant motivation is especially needed since other people are not present to stimulate and maintain motivation and they are expected to participate at least two times.
4. Skill is required in developing questionnaires and summarizing findings between iterations of questionnaires
5. Experts tend to judge the future of events in isolation from other developments.

1.6.3.3 Methodology

The first stage of the process is defining the number of experts and selecting the experts. Then, the questionnaire is designed and sent to the selected experts. The third stage is collecting the experts' responses for statistical analysis. In the next stage, the results of the third stage as well as the new questionnaire are sent back to some experts. A key element is that the experts are aware of the results of the previous stage in order to reconsider those answers, which have fallen in the interquartile range. The Delphi analysis is complete when consensus is reached and this usually occurs after the third or fourth round of questions.

Participant selection for a Delphi forecasting study is critical. Experts should be carefully identified and a nominated. Random selection is not acceptable. The researcher needs to locate and target individuals who have the knowledge and experiences, and are self-motivated. These participants remain anonymous to each other to facilitate the free expression of ideas without bias. The following steps are involved in the Delphi technique.

1. Formation of a team to undertake and monitor a Delphi on a given subject.
2. Selection of one or more panels to participate in the exercise.
3. Development of the first round Delphi questionnaire.
4. Testing the questionnaire for proper wording, ambiguities, and vagueness.
5. Transmission of the first questionnaires to the panelists.
6. Analysis of the first round responses.
7. Preparation of the second round questionnaires (and possible testing).
8. Transmission of the second round questionnaires to the panelists.
9. Analysis of the second round responses (steps 7 to 9 are reiterated as long as desired or necessary to achieve stability in the results).
10. Preparation of a report to present the conclusions of the exercise.

Each round poses a series of Likert questions, the answers are tabulated, and the results are used to form the basis for the next round of questions. Through several iterations, usually three, this process synthesizes the experts' responses, resulting in a consensus that reflects the group's intuition, savvy, and expert knowledge. Although the outcome of a Delphi sequence is nothing but opinion, they are the opinions of the experts who made up the panel and the panel viewpoint is summarized statistically rather than in terms of a majority vote.

In a Delphi study, developing and processing questionnaires are interconnected. Participants agree to receive and respond to a series of questionnaires, usually three sets. The first questionnaire can be composed of several forms, but among these, there is one or two open-ended questions related to the subject. The second questionnaire is a culmination of information collected from the first questionnaire and it consists of a series of structured questions developed by the researcher. Participants rank items into an order or use a Likert-type rating scale to prioritize items and are asked to comment on their rationale and to add some more items. The third questionnaire asks participants to re-rate each item, but this time, they are provided with: (a) statistical feedback regarding their own ratings, (b) feedback on how the group rated the same item and (c) a summary of comments made by participants (Ludwig. 1997).

There are a few cases in Thailand that Delphi technique has been used to develop science curriculum. Klinpongsa (1995: abstract) employed Delphi method to develop the curriculum of physics. The result showed that Delphi method provided a high proficiency to develop this curriculum. Khantatui (2001: abstract) studied model-enhancing students' emotional intelligence through Delphi technique. Vadcharavivad (2001: abstract) developed a curriculum to enhance the research competencies for nursing students by the use of Delphi technique to survey experts' opinions.

Based on the advantage of Delphi technique and its high proficiency to survey experts' opinions with reasonable consensus. This study employed Delphi technique to design and construct science curriculum.

1.6.4 Implementing curriculum

Science is a body of knowledge that is grouped around a fruitful method of exploring the secrets of nature. Vaidya (1971: 134-162) classified the method of teaching into three aspects; oral, observation and practical. He provided the detailed methods of teaching science from his classification. They are as follows.

1. Oral methods consist of talk, narration, lecture, and work at book.
2. Observation methods consist of demonstration of natural objects, demonstration of charts and models, demonstration of slides and films, and chalk drawing.
3. Practical methods consist of conducting observations, conducting experiments,and conducting relevant laboratory work.

Krajcik et al (1999: 22) proposed that science teaching has five major elements. First, the teacher serves as a guide in the classroom and he/she should encourage student to do exploration and learning, rather than as an authoritative presenter of knowledge. Second, the content of science should be taught as a process, involving investigation and answering questions. Third, science instruction needs to be integrated with other disciplines. Fourth, science instruction should encourage student to challenge conceptions and debate ideas. Fifth, science instruction should build upon children's prior experiences and knowledge.

According to The National Academy of Sciences (2000: 116), after learning science, students should:

1. Understand that science is more than knowing fact. Students need to develop abilities to inquire knowledge similar to those in the standards and need to learn strategies for scientific thinking.
2. Build new knowledge and understanding on what they have already known and believed.
3. Have conceptions about natural phenomena and conceptions that influence their learning.
4. Formulate new knowledge by modifying and refining their current concepts and by adding new concepts to what they have already known.
5. Change their ideas when they find those ideas to be unsatisfied, especially when their present ideas do not sufficiently describe or explain event or observation. Moreover, they change ideas when they discover alternatives that seem plausible and appear to be more useful.

6. Understand the social environment in which students interact. Students benefit from opportunities to articulate their ideas to others, challenge the idea for each other, and construct their ideas.

Whether or not teaching science will reach the aims of how students understand science is depending upon teaching style. Teaching style is identified as "the way in which we use all experiences to consciously conduct a teaching-learning exchange" (Heimlich; & Norland. 1994: 40). Other workers in educational field suggest that teaching style is "the attitude teachers hold toward various instructional programs, methods, and resources as well as the students prefers working with" (Heimlich; & Norland. 1994: 41; citing Dunn; & Dunn. 1979). Gauld (Heimlich; & Norland. 1994: 41; citing Gauld. 1982) has defined the teaching style as "the consistent way which a teacher organizes and delivers a body of knowledge". Huelsman (Heimlich; & Norland. 1994: 41; citing Huelsman. 1983) defined it as a complex of personal attitudes, traits, and behaviors as well as the media used to transmit or receive the data from students.

Axelrod (1970: 38-55) identified five teaching styles based on the study at the University of California: 1) drillmaster or recitation class, 2) content centered, 3) instructor centered, 4) intellect centered, and 5) person centered. These five teaching styles can be a combination of instructions for subject-centered, teacher-centered, and student-centered approaches.

Heimlich and Norland (1994: 43-47) classified teaching style into three types: style based on the teacher's characteristics, style based on student characteristics, and no single definition. A teacher directly helps the students gain an introspective growth process. Teaching-learning exchange consists of content, environment, teacher, organization, learning community, individual student, and culture.

Fensham (2000: 148) argued that there are three important domains involving in effectively teaching science. First, science needs to be taught from children's everyday life experiences. Children can learn science from a variety of sources. Second, science is a school subject that should inform and enrich individual lives. Teaching science is about things in term of individual experiences and the ability to function as a citizen in society. Finally, teaching science is important for health and well-being, survival strategies, and the human race. The role of science in school should emphasize on both individual views and social activities that integrate between thinking and doing.

Inquiry is currently raised in terms of science teaching. Inquiry is the process of finding out by searching for knowledge and understanding (Collete; & Chiappetta. 1994: 86). It involves identifying problems, posing questions, and seeking answer. It can be conducted in a variety of ways such as observing nature, predicting outcomes, manipulating variables, analyzing situations, and evaluating assertions.

Inquiry can be viewed in two ways, teaching science as inquiry and teaching science through inquiry. Teaching science as inquiry requires science teacher to understand the nature of science and how knowledge is acquired. Scientific inquiry often begins with the desire of understanding the nature by thinking about it and forming ideas and explanations. Teaching science through inquiry refers to the skills and strategies, purportedly used by scientists, which have been considered by science educators (Collete; & Chiappetta. 1994: 86).

The learning cycle is a model for conducting science lessons that ensure a success and positive experience for students. It was incorporated with the Science Curriculum Improvement Study (1974) created during the 1960s. The learning cycle consisted of 4 phases;

1. Introduction: the purpose of introduction is to motivate students. At this time teacher captures the students' interest through the use of discrepant event demonstrations, interesting materials or challenging questions and problem to solve.

2. Exploration: it is a very active phase for the students. Students work with manipulative investigating the concept to be learned. This phase allows students to experience objects and events in order to stimulate their thinking about a concept or principle and to permit them to discover patterns and relationships. The science process skills are important and obvious during this phase. Teacher's role at this time is the guidance. The purpose of exploration is to provide children with an experience-based opportunity to construct their own understanding of the concept.

3. Concept development or invention: it is the phase that provides an opportunity for students to report their findings and share what they discovered with other students. This phase allows students to express the relationships between objects and events that they have experienced. The teacher directs the discussion and provides appropriate terminology. Teachers also serve as a guide to channel thinking, encourage students to construct

appropriate labels for the relationships for their discoveries. If there is information in a written format, that might help in the verbalization or clarification of the concept from a textbook or other source.

4. Application: it is the phase provides opportunity. It may take the form of another activity, or it may be a problem solving or a question-answering discussion. This phase allows students to apply their knowledge for a given concept to other situations. The teacher encourages the student to find examples to illustrate the concept. It permits students to generalize their learning, thus reinforcing newly acquired knowledge and attaining concepts. The application of the concept may also serve as a means of evaluation.

Additionally, Biological Science Curriculum Study developed 5E instructional model (Biological Science Curriculum Study. 1990). This approach of the teaching science through inquiry is an elaboration of the learning cycle. The 5E model has five phases, which are described below.

1. Engagement is the phase to capture students' attention and to engage them in the study of a concept, principle, issue, or problem. These activities can be in forms of question, discrepant event, problem, puzzle, or any other strategy used to focus thinking. The engagement phase introduces students to the investigation that they will undertake and the manner about inquiry. During this phase teacher guides students to make connection between what they know and what they are about to study.

2. Exploration is the phase, which students carry out investigations. Students gather information, test out ideas, record observations, do experiments, etc. This phase can provide concrete, hands-on experiences that bring students into contact with phenomena or situations. Teacher serves as a facilitator of learning, helping students to find out and discover ideas.

3. Explanation is the phase, which permits students to make sense from their explorations. They are encouraged to find patterns, relationships, and answer to questions. Students are urged to explain their findings and to demonstrate their understanding. The teacher uses questions to guide thinking and reasoning for the students.

4. Elaboration is the phase, which gives an opportunity for the students to apply for different situations and concepts as well as skills that they have acquired. The application of newly acquired information and skills is reinforced in new contexts and it makes learning more meaningful.

5. Evaluation is the phase, which calls students to demonstrate their knowledge and understanding the ideas under study. These activities also serve to reinforce important learning outcomes. This assessment can be based upon the measurement of many types of cognitive and psychomotor behaviors such as producing written works, demonstrating laboratory skills and procedures, and completing projects.

To the study, the researcher develops learning process by conducting activity plans based on LADDA instructional model (Figure 2). This instructional model can be given more details in terms of Learning, Analyzing, Deciding, Doing, and Application.

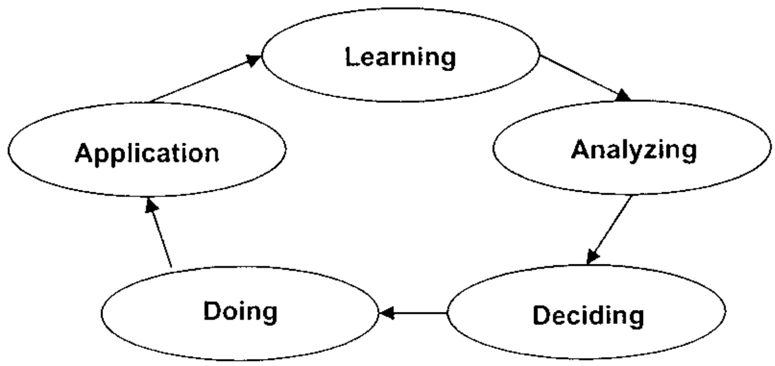


Figure 2 LADDA instructional model.

Learning is the process that aims to facilitate students to construct their knowledge. The learning activities will occur both inside and outside classrooms. Savathanaphaibul (1983b: 105-110) proposed the steps of inquiry in terms of 'exploration' by encouraging students to seek information to build scientific concept. The source of concept is derived from hands-on experiences, experimentation, and secondary data. Thiammuang (1986: abstract) studied the effect of inquiry method with the emphasis on integrated science process skills towards students' logical reasoning and achievement in science studies. The logical reasoning skills were significantly different between experimental and control groups. Phothibundit (2000: abstract) studied the development of teaching/learning activities for science subject for 7th grade students based on cooperative learning model and development of the learning achievement in science. The results showed that students developed social skills and a feeling of self-esteem. They also made a higher learning achievement score in their study of the "ecosystem" topic. Chatwirakom (2003: abstract) developed a science instructional model by focusing on students' construction of knowledge for Mathayomsuksa 1 on ecosystem. The result revealed that students had a higher score of science learning achievement and attitude towards the science after they had learned that model.

Analyzing is the process that aims to analyze some situations which relate to their problems or situations in school community. Bruner (1960) considered acquisition the grasping of new information. It may also replace previously acquired information or it may merely refine or further qualify previous information. Savathanaphaibul (1983b: 105-110) proposed the steps of inquiry in terms of 'invention' by allowing students to think beyond what important knowledge and understanding. Teachers can reinforce science learning by questionings, situations, experimentations, etc. Thiammuang (1986: abstract) studied the effect of inquiry method with the emphasis on integrated science process skills towards students' logical reasoning and achievement in science studies. The logical reasoning skills were significantly different between experimental and control groups. In addition, Singkeawsub (1995: abstract) studied the science learning achievement and attitude towards environment social studies of Mathayomsuksa 1 students through the environmental survey method and the method in the teacher's manual. The findings showed that students had the development on analyzing when they learned.

Deciding is the process that aims to decide and select what is the best way to solve problems or situations in school community. Bruner (1960) considered transformation is the individual's capacity to process a new information so as to transcend or go beyond it. Promsiri (1996: abstract) studied on Mathayomsuksa 1 students' achievement and environment – based values through field trips in social studies; and Ludeerat (2003: abstract) studied learning achievement and attitude towards environment of level III student's by using field site study for environmental conservation camp. Their findings revealed that learning achievement and attitude towards the environment between experimental and control groups were significantly different. These studies revealed that students had the development on deciding based on the values of science.

Doing is the process that aims to do or react with something after student analyzed and decided based on the problems or situations in school community. Savathanaphaibul (1983b: 105-110) proposed the steps of inquiry in terms of 'invention' by allowing students to think beyond what important knowledge and understanding. Teachers can reinforce science learning by questionings, settings situations, doing experimentations, etc. Wannachawee (1985) studied the scientific process skills, achievement, and retention of students taught through the inquiry method. The result showed that science learning achievement and scientific process skills were significantly different between experimental and control groups. Phuengpreda (1989: abstract) assessed the achievement in scientific and science process skill and learning retention in physical and biological sciences by using inquiry method with videotape instruction and the method in teacher's manual. The study revealed that science learning achievement and scientific process skills were significantly different between experimental and control groups, but the learning retention was not different.

Students can learn science through inquiry method by using hands-on experiences or experimentation to lead them to have knowledge and understanding in science. At that time, affective domain would be promoted. Chatwirakom (2003: abstract) developed a science instructional model by focusing on students' construction of knowledge for Mathayomsuksa 1 on ecosystem. The result revealed that students had a higher score of science learning achievement and attitude towards the science after they had learned. Suriyapom (2003: abstract) found that learning achievement and attitudes on conservation of community forest of Prathomsuksa 6 students can be enhanced. The attitudes and learning achievement on community forest after experiment was significantly higher than before.

Application is the process that aims to help student make conception and apply knowledge into practice relating to their real life situation. Savathanaphaibul (1983b: 105-110) proposed the steps of inquiry in terms of 'discovery' by allowing students to recall what they had learned and what important knowledge is useful for their life. Jansawang (2005) developed and implemented an elective science curriculum, "chemicals in everyday life" for the lower secondary school students with local wisdom. The result of the study revealed that students could gain their knowledge, aware of value of local wisdom, and benefit of local resources. Thanaprayothsak (2005) studied a high school curriculum on natural resources and environmental pollution related to real life issues based on inquiry cycle approach and also studied the implementation of this curriculum. The curriculum was effective and could be used in classrooms. Students can learn science based on real life situation.

The five steps of LADDA instructional model related to the taxonomy of educational objectives (Bloom; et al.1964) are used for science teaching. This model is developed based on the educational objectives: cognitive, affective, and psychomotor. The inquiry method is also considered and adapted for appropriate learning management (Science Curriculum Improvement Study. 1974; Savathanaphaibul. 1983b; Biological Science Curriculum Study. 1990; Collete; & Chiappetta. 1994; Savathanaphaibul. 2003). Student will learn science with inquiring mind. The values of science will also be promoted for conserving their local environment through local culture. The scientific knowledge and indigenous knowledge will change them to have positive behavior, beliefs, and interest about local environment management (McPherson; & DeStefano. 2003: 141).

1.6.5 Evaluating curriculum

Evaluation is the act of considering and judging curriculum after it is done. This study will evaluate how science curriculum plays its role in school science.

Evaluation is the procedure used in determining the effectiveness of teaching and/or the value of learning experience in assisting students to achieve the goal. Additionally, we can consider evaluation as the process of delineating, obtaining and providing information which is useful for making decisions and judgements (Davis. 1980: 13). Evaluation may be regarded as a process of finding out how well stated objectives have been met. The process of evaluation will involve identifying the strengths and weaknesses of the plans (Tyler. 1981). Assessment has to be done with the direct measurement of something in order to determine the rate, level, or amount. It concerns the making of judgement as quality, status, or effectiveness, and incorporates the results of assessment. Kindred et al (1976: 186) gave brief reasons for assessment and they are as follows:

1. To find out how much achievement that students have made in a given field.
2. To find out what sort of achievement that students have made in a given field.
3. To supply students with information that enables them to understand their own progress towards established goals.
4. To create a learning situation that is appropriate for each student since each one has his/her unique learning style.
5. To stimulate students to be in a positive way so that they may progress towards their ability level.
6. To help students identify their learning problems and to find solutions for them.
7. To bring about in a state of readiness for teacher aid based on an understanding of students needs and weaknesses.

8. To report to the parents how well their children are doing in achievement in school.
9. To determine how well the instructional program meets the needs of students and society.

However, the purposes of curriculum evaluation should attempt to answer two questions: (1) do planned learning opportunities, programs, courses, and activities which are developed and organized actually produce desired results?, and (2) how can the curriculum offering best be improved? (McNeil. 1981).

Solano-Flores and Nelson-Barber (1999) proposed a model for developing culturally responsive science assessments as an alternative to the more popular approach of adapting assessments originally developed for a mainstream student population. This model was built on knowledge, which gained from both developing science assessments for linguistic minorities and constructing tools for effective science assessment.

The relationship between evaluation theory and curriculum practice can take three forms (Hamilton. 1976: 72-73):

1. The relationship might be casual. Changes in evaluation are attributed to change in curriculum practice.
2. The relationship might be fortuitous. Its connection is admitted but it is simply attributed to a chance or an impact from outside factors.
3. The relationship might be non-existent. The curriculum development and evaluation are treated as mutually independent disciplines.

The choice for the method of evaluation depends on the purpose by considering both high reliability and high validity. Reliability and validity are important concepts for describing the outcomes of assessment which should be taken into account for deciding the way that evidence is gathered and interpreted. These are choices of method to evaluate:

- Judging the evidence in relation with the goals of learning. It is important to recognize the different bases for judgements in assessment in order to apply them appropriately. Child-referenced assessment is appropriate for formative assessment and for providing encouraging feedback to children.

- Interpreting the judgements. Assessment results must be interpreted cautiously as the guides to what children can do but they are not as indicating any kind of certainty about it. No assessment can be used with predictive certainty. It is good to treat a student by using a hypothesis. Then the teacher can simply assign an appropriated work for a particular student. The teacher should not prejudice against that student until getting the result from him/her.

- Taking action. The taking action in assessment must be influential.

- Feedback into teaching, adjusting the challenge or support given to individual children to help them develop their scientific ideas, skills and attitudes.

- Feedback to the children, given in a form that enables them to see how to improve their work and encourages them to take the necessary steps.

- Reporting progress made in learning over a particular time to parents, other teachers and the children themselves (Bently; et al. 2000: 133-138).

The teachers as facilitators should encourage the students to learn scientific knowledge in classroom. Students must also learn science content in the ways that make sense to them. Also, they have understanding of science which must be consistent with current models of how the physical and biological world work. Students also should have their knowledge which is flexible across multiple contexts because science has larger sets of concepts, which require practice for students to relate the concepts to the new and varied situations (Mestre; & Cocking. 2002: 19-21).

The Ministry of Education (2003: abstract) reported the monitoring and evaluating on institutional curriculum of Mathayomsuksa schools. This study revealed that the institutional curriculum has a number of problems i.e. teachers lack the knowledge and understanding in curriculum development; science and mathematics subjects need more teachers to prepare learning experiences for school science; teachers misunderstand how to use subjects in various areas; evaluation and activity plans are limited; and learning experiences do not allow students to meet their real needs.

From the results above, the Thai National Education Act of 1999 stated that all schools should develop their own school curriculum. School community can participate in teaching-learning process, making a decision, and accepting what important knowledge for their children. Students should have knowledge and understanding of their own culture and modern culture of the world by using principles of science as a base of science learning.

2. Local culture

This topic presents about local culture in terms of indigenous knowledge. The definitions and importance of indigenous knowledge will be given. The relationship between indigenous knowledge and science learning will be explained. The study proposed *PAH POOH TAH* (a small village's woodland in northeastern Thailand) as a model of local culture and the information of environmental conservation related to *PAH POOH TAH* will be presented.

2.1 Indigenous knowledge

Indigenous knowledge has motivated science education in the field of school science. Based on the respect to rational thinking, western science should not be taught alone in school, but indigenous knowledge which have been familiar with everyday lives, could be connected and integrated by science education system (Ogawa. 1995: 584).

Indigenous knowledge is characterized by various definitions, fragmented theoretical conceptions, and marginalized positions in the current mainstream knowledge system. The definition relevant to science education has been raised in terms of the important issues of the recognition on indigenous knowledge as a knowledge system and its nature of that knowledge. Different science educators give different meanings of indigenous knowledge. It can be comprehend as traditional knowledge and experiences of local people to transfer their knowledge and understanding of the world from person to person and to expand from individual into family, religion, society, politics, economics, and so on.

McClure (Surasin. 1996: 25; citing McClure. 1989) expanded that indigenous knowledge is a knowledge system which has been accumulated and evolved for a long time through experiences and trial-and-error problem solving.

Williams and Muchena (1991: 53) defined indigenous knowledge as a unique knowledge that is generated in response to the natural and human conditions of a particular environment and context. It is dynamic and creative in that experimentation and evaluation are continually stimulated by both adaptation requirements and external influences. Sillitoe (2002: 9) defined indigenous knowledge as the heritage of practical everyday life, with its functional demands. It is fluid, constantly changing, being dynamic and subject to ongoing local, regional and global negotiation between people and their environments.

Indigenous knowledge is the type of knowing, creating and innovating in various societies. Moreover, local communities have survived against all odds in various parts of the world through a constant process of experimentation, innovation and natural learning (Gupta. 2001; Nuangchalerm. 2003: 66). It is the pattern of valuable life in terms of long time process, which indicates the wisdom between individuals and community by accumulating and practicing from generation to generation. This knowledge may be in the form of human resource or knowledge resource and it maybe specific or general suit for technology and natural resources. Vital information on natural resource and the learning way of local people is often encoded in unique forms such as proverbs, myths, rituals, and ceremonies. Indigenous knowledge needs to be expanded to science education program because it is a significant source of learning form grassroot level.

Swift (1992: 26) covered the definition of indigenous knowledge that is not just a collection of isolated facts and skills. It is rather the end result of the way in which these have been put together since birth. Snively and Corsiglia (2001) argued that indigenous knowledge relates to scientific knowledge of long-resident, usually oral culture peoples, as well as the scientific knowledge of all people.

Ogawa (1995: 588) defined indigenous knowledge in terms of science as a culture–dependent collective rational perceiving of reality where collective means held in sufficiently similar form by many persons to allow effective communication, but independent of any particular mind or set of minds.

The terminology of indigenous knowledge can be considered into two types; first, the intangible type that is used in explaining of worldviews to guide in the life cycle, and providing values and meanings to everyday life. Second, the tangible type that is used in people's daily activities e.g. agricultural practices, environmental protection and management, and others. It is clearly expressed in the relationship between humans and environment, humans and community, and humans and the supernatural or spiritual sphere.

Indigenous knowledge is concerned in every society and culture. It is held by a specific group of culture, not by a specific individual. It might be tacitly transferred from generation to generation through daily social and cultural events. An individual cannot express indigenous science as a kind of specific theoretical system. The formation and transferring knowledge of human are expressed in forms of culture and way of life (Nuangchalerm. 2005: 23-24).

Indigenous knowledge is one type of science, which relates to culture and science in society. This knowledge has been developed through times based on the dimensions of culture and nature roles by its process of human adaptation.

2.2 Indigenous knowledge and science education

Indigenous knowledge has been subjected to western theories and research methodologies. A new kind of abstract knowledge has been created. Indigenous knowledge is secondary form of knowledge not the original indigenous itself. It is amenable to documentation and teaching in the classroom or on a field trip. It is important for students to recognize indigenous knowledge to be equal to other scientific knowledge. Both indigenous and scientific knowledge are treated under critical analysis in educational aspect.

Even though schools are specialized agencies of education, they may not be the most influential agents in supporting community development. Knowledge outside school may be more influential to the students' lives than school-based knowledge or school-based science. What a child learns from his parents through his out of school activities can be more meaningful to him (Kelly. 1980: 3). Indigenous knowledge is a significant learning process, which should be connected to scientific knowledge.

Based on belief, learning process takes place through the physical senses, seeing, hearing, touching, tasting, and smelling which our children learn, perceive, organize, and assign value. In each socio-cultural system, the way of perceiving, organizing, and valuing information gives a view of reality unlike any other (Brady. 1989).

UNESCO (1991: 4) wrote about local knowledge and skills that are necessary to utilize and apply to the solution of local problems. Science is concerned not only with the scientific community but also with society at large. Science should contribute to improve the quality of life, particularly of the most deprived. Science should promote the freedom to explore and express ideas. It has a role as a mode of inquiry leading to innovation. Moreover, scientific thinking as a mode of inquiry is not the only way of knowing and the domains of human experience, but it is very valuable to human being. Science needs to co-exist with other modes of knowing.

Kawagley et al (1998: 133-144) wrote on Yupiaq's indigenous worldview and learning culture in the parallel learning between western modern science and indigenous knowledge for science learning. Teaching and learning science should be aware of some foundations of changing in the way of students, teachers, and school community. They can learn their requirement based on respecting of beliefs and practice between indigenous knowledge and modern scientific knowledge.

Science learning should cover foundation of science in many other domains of knowledge. Based on an individual difference involved scientistic practice and application. Indigenous knowledge has an important role to respond to science in school community. It is collectively knowledge related to scientific conception which is needed to promote mainstream scientific knowledge. Students should be encouraged to understand the nature of science in culturally based science context (Cobern; & Loving. 2001: 50-67).

The role of indigenous knowledge should make students aware of: (a) their traditional culture; (b) the characteristics of science as a culture in itself, with a different view of man and nature, a different way of thinking, and its own history, philosophy and sociology; (c) examples of conflicts between scientific and traditional ways of thinking in everyday life; (d) scientific decision making with training in decision-making skills (Ogawa. 1986: 113-119). If important concepts are applied in private and professional life, things done at school will be seen by the student to link with everyday life.

Students should be taught in a cross-cultural approach. They would get access to learning the culture of science without necessarily replacing their indigenous beliefs about nature. Students will add new contexts to their cognitive schemata in which science concepts logically fit. Scientific beliefs can be compared and contrasted with indigenous beliefs in terms of ideologies, epistemologies, language conventions, norms, values, etc.

Hadzigeorgiou and Konsolas (2001: 39-49) criticized the traditional humanistic curriculum on the perspective of teaching and learning science. The notion of integration or holistic science curricula was concerned for the future of students' ability to solve problems, culture, society, politic and economies which are the bases of development. The socio-cultural infrastructure is a source of how science is useful for learning. From the rich diversity of culture in which students play their roles and interact with community, students also should be planted with the conceptions and theory of science, socio-cultural learning in science. They need to construct conceptual development in scientific conceptions (Hatano. 1990: 245-250).

The World Conference on Science recommended that scientific and traditional knowledge should be involved in the integrated projects linking between culture, environment and development in areas as the conservation of biological diversity, management of natural resources, understanding of natural hazards and mitigation of their impact (UNESCO. 1999).

Indigenous leaders and teachers should take equal responsibility in devising methodologies for curriculum development and teaching in shaping the partnership. Science teachers needed to pay particular attention. The best way of attending to socio-cultural aspects might be to make students feel comfortable in modern science classroom that uses familiar cultural ideas and materials. Culture links people into various modern science principles (Jegede. 1995: 113).

The cooperation between critical thinking and problem solving should be based on life situation or local knowledge. It has become more urgent as policies for Thai education reform. Science curriculum and instructional goal should progress beyond teaching basic content to serve disjointed facts that students require to learn.

The new paradigm of science learning we have been talking about involves the awareness of the interrelationship and interdependence of all phenomena. The source of knowledge and understanding about nature emerges from physical, biological, psychological, social, and cultural components. The formation of the way of new paradigm is already being shaped by many individuals, communities, and networks which viewed in terms of the relationships and integration (Capra. 1987).

Shifting paradigms in school science is stimulating for integration between indigenous and science knowledge. Science educators may have similar problems of shedding concepts culturally ingrained by the ideologies and conceptualization of their western sciences (Lewis; & Aikenhead. 2001: 3-5). Students learn science from both indigenous knowledge and scientific knowledge to conceptualize how science works in their everyday life. They learn and incorporate different worldviews into science lessons.

The educational paradigm emphasizes the problem-based or real life-based learning. Science content and pedagogical teaching should be integrated. Teachers integrate the subject content with many effective ways of teaching that content. That is to develop pedagogical content knowledge.

2.3 *PAH POOH TAH* : a model of local culture

Local knowledge can be produced and passed through local culture. The local culture is a base of learning in each local area. Some phenomena in terms of local culture can be explained by scientific conception. It has emerged from the relationship among human beings and human beings, human beings and society, and human beings and nature. It is creative thinking, collective knowledge, and transferable knowledge.

In this study, the *PAH POOH TAH* or sacred village forest is a model of local culture and scientific learning resources. *PAH POOH TAH* is the words of the dialect from northeastern part of Thailand. Those have the word-by-word meaning as: *PAH* = forest or woodland, *POOH* = paternal grandfather, *TAH* = maternal grandfather. Students can learn science from *PAH POOH TAH* in all seasons. Also, they can learn local culture as to how indigenous people preserve natural resources and conserve the environment.

The *PAH POOH TAH* is a kind of forestry village where indigenous people utilize. *PAH POOH TAH* in the area of this study can be described as deciduous forest. It is widely distributed in northeastern region and dominated by dipterocarp trees. It is located in the rising ground near a village. The boundary of land of *POOH TAH* is covered by various kinds of plants. It also preserves the biological diversity in community i.e. animals, plants, and microbes. Generally, the forest ecosystem has two components; biotic and abiotic components (Miller Jr. 2002: 76). The *PAH POOH TAH* is one type of forest ecosystem which located near community. It can be given more details as bellow:

1. Biotic component is categorized into three types.

1.1 Producer is a group of living things, which can make photosynthesis. The member of this group consists of bacteria, algae, and plants. There are many kinds of plant which local people can use for medicine, food, wood, etc. in daily life.

1.2 Consumer is a group of living things which uptake energy by grazing other living things because it cannot make photosynthesis. The members of this group consists of herbivore (grass shopper, beetle, dung beetle, etc.), carnivore (snakes, frog, etc.), and omnivore (birds, etc.). The animals in *PAH POOH TAH*, local people can use it for food.

1.3 Decomposer is a group of living things which uptake energy from detritus by releasing some enzymes to breakdown and to absorb some nutrients. The members of this group consist of bacteria, fungi, and mushrooms.

2. Abiotic component is categorized into two types.

2.1 Man-made such as the small house for *POOH TAH* and other things which local people use for showing their pledge.

2.2 Nature such as (1) inorganic substances e.g. carbon, nitrogen, carbon dioxide, oxygen, water, etc. (2) organic substances e.g. protein, carbohydrate, fat, etc. (3) physical factors e.g. light, temperature, acid-base, humidity, air, water, etc.

The forest soils in *PAH POOH TAH* need to be studied in the texture, base-rich nature, and level of fertility. Craul (Moffat; & Buckley. 1995. 79; citing Craul. 1985) described in details for the properties of soils between disturbed and undisturbed areas. They are discussed briefly below:

- Soil materials on disturbed land are either degraded or simply derived from minerals rocks or overburden. The soil fertility is commonplace, especially of nitrogen and phosphorus. Deficiencies in other nutrients can occur locally.

- The amount of rootable materials can be limited availability, and may be to small to sustain the growth of a tree crop, supplying nutrients, moisture and anchorage.

- Soil materials usually have large bulk densities because of having been compacted by movement or vehicle traffic. Compact soils prevent tree root extension and encourage drought and premature wind blow.

- Disturbed soils often have alkaline reaction and they are contaminated by lime-rich materials such as cement. Alkaline soils will reduce choice of suitable tree species.

- Soil aeration and drainage are often impaired on disturbed sites, in some cases due simply to the large soil bulk density occurring, but sometimes a consequence of shallow site gradient, adverse soil texture, or both.

- New materials used for tree planting, for example mineral spoils, may contain little or no organic matter. They are therefore comparatively sterilize and only small populations of soil fauna and microflora may be present. Soil nutrient cycling will therefore be inhibited and the long-term survival of trees compromised.

- Some materials on disturbed sites may be toxic. Depending on the severity of the toxicity, trees may not grow at all or may survive in stunted form.

Moreover, woodland is the richest habitat for terrestrial invertebrate and almost all of group invertebrates have large numbers of woodland species (Key. 1995: 149). Many species are extremely specialized in their habitat requirements. The adults and larvae of many species of insect frequently have very different habitat requirements. Sometimes they live in totally dissimilar habitats from each other that therefore they need to be within the dispersal range of each life stage.

Woodland has a great deal of offering invertebrate conservation e.g. insects, millipede, ants, etc. Putnam (Gill; et al. 1995: 214; citing Putnam. 1989) caught invertebrate by pitfall traps between disturbed and undisturbed areas. The undisturbed area had a higher invertebrate population than those of the disturbed area. Invertebrates can considerably augment the fauna of existing habitat especially woodland. In the long term, if woodland invertebrates are conserved, they will be benefited for each community in forms of food, natural predators and preys, insects for agriculture, and insects for plants breeding.

Additionally, vertebrate animals distributes in woodland depend on its habitat such as birds, reptiles, mammals, etc. They have an interaction with other plants and animals. For example, rodent densities and species composition may be influenced by a greater extent of successional changes in the ground vegetation. The *PAH POOH TAH* provides a greater diversity of habitat and hence animals than agricultural crops. Vertebrate communities will develop with the ecological succession in woodland.

Moreover, *PAH POOH TAH* is the bank of plants. It preserves many types of local plants which serves local people for food, materials, and herbal plants (Kestes. 1994: 48-60). The animals in *PAH POOH TAH* do not only give benefit for local people but also distribute their species in various habitats and as food sources. Local species, deciduous plants, and dipterocarps are most plants in *PAH POOH TAH*. Sometimes alien species are found because local people introduced them. The dominant trees species in *PAH POOH TAH* are for example, *Dipterocarpus* spp., *Xylia* spp., and other trees. These species are giant trees. Their characteristics are high stem, stretching upward of the sight, clean trunk because of their self-pruning habit. Another dominant plant is bamboo (*Bambusa* spp.). It is widely distributed in *PAH POOH TAH* and it serves local people for food, and sticks. Kestes (1994: 89-90) found that the values on *PAH POOH TAH* in terms of belief which can help the spirit of local people. The habit of conservation based on beliefs, practices, and way of life is inherited in environmental science.

Based on the rich natural resources and the belief in *POOH TAH*, this shows that how indigenous people pay their respect to nature. *PAH POOH TAH* is a keystone to indicate about local culture and indigenous knowledge for preserving, sustaining, accepting, and awaking natural resources. The *PAH POOH TAH* serves indigenous people in the following ways:

1. The sacred village forest for conducting ritualistic ceremony: indigenous people use and preserve *PAH POOH TAH* to show their belief on *POOH TAH*.

2. The forestry village for all: Indigenous people utilize *PAH POOH TAH* for economic and natural resources to survive in daily life.

PAH POOH TAH is an important source for all people in local area. It is sacred forestry places where members in local community have the responsibility to preserve. It can be said that *PAH POOH TAH* is a protected area for biological diversity. The *PAH POOH TAH* is a forest community as a source of wood products, flood and erosion control, rangelands, and wildlife habitats (Chiras; et al. 2002: 369). It is also as an important source for herbal plants and foods such as mushrooms, herbal trees, fruits, vegetables, trees, and insects.

2.4 Environmental conservation in *PAH POOH TAH*

In the era of globalization or global village, we have to think globally, and to act locally. The environmental conservation needs to encourage people to conserve natural resources and environment. It should not separate human being from society, culture, and environment. Culture and society can be developed in relation to the way of life and natural traits (Saminpanya. 1996: 153).

The environmental conservation can set the images of how students learn science through local culture. Each set of images is underpinned by values of science. It can appear to be in conflict with the traditional cultural values. This conflict is not new but the debate is no longer one-side in favor of science. It is possible for students to develop a coherent body of knowledge. Science seems to have many conflicts with cultural values but they can be resolved. Science can contribute to an integrated values system (UNESCO. 1991: 3).

The environmental conservation in science can be focused on three different levels. The first level is the 'facts'. The second level is the 'concepts', and the third level is the 'values' level. The factual approach may have sufficed in an earlier, less complex world (UNESCO. 1991: 17).

PAH POOH TAH is a case study of how local people in the northeastern part of Thailand can conserve their forest village and environment. Local people have developed the way of life through local culture, nature, and society. Forest village can be conserved successfully and described scientifically. Knowledge, process, and application in *PAH POOH TAH* will be analyzed and designed for science curriculum. The curriculum will have the contents of biological diversity, ecosystem, and conservation and it should encourage students to develop their values on local ecology and environmental conservation.

The *PAH POOH TAH* can be described in terms of science and its thematic science in Figure 2. Ecosystem, biological diversity, and conservation are themes for learning science through local culture. Not only science is presented in this study, but social studies, religion, and culture are also incorporated. Suriyapom (2003: abstract) found that learning achievement and attitudes on conservation of community forest of Prathomsuksa 6 students could be enhanced. The attitudes and learning achievement on community forest after experiment was significantly higher than before. It indicated that students could learn and understand community forest as a base of learning science.

Som-In (1992) pointed out that *POOH TAH* is a significant social institute for Isan (northeastern part of Thailand) communities. When indigenous people settle their community then *PAH POOH TAH* is established. It looks like a conserved area for preservation of natural resource based on the belief in their ancestors. According to Thamawatra (1990) and Kestes (1994), *PAH POOH TAH* is a sacred village forest where natural resources and environment in each community are preserved. It is not far from each community and it is a significant source for the villagers' survival. Indigenous people have ceremonies and ways to preserve *PAH POOH TAH* and other things in this area.

Surasin (1996: abstract) studied local practices relating to natural management of community members of two villages in Thailand. The findings can be concluded that (1) local residents possess a wealth of knowledge and skills and still employ them in use of natural resources for survival and well-being (2) much of the wisdom and skills have been lost and continued to disappear at a rapid rate due to both internal and external stresses (3) not all indigenous knowledge systems in use today are environmentally sustainable or in harmony with nature (4) indigenous knowledge systems are not equally generated, distributed and transferred among community members and between genders (5) indigenous knowledge within itself contains the potential for growth and transformation (6) local organization strategies and practices may offer possible solutions to conflicts and confrontation over resource distribution and utilization within the community and with the outsiders (7) indigenous knowledge and local practices have been largely ignored by the outsiders working in the community (8) the role of the indigenous knowledge in natural resource management in local context is difficult for development workers to gain an adequate understanding and evaluation of situations.

Steinmetz (1999) studied the local ecological knowledge of the Karen community in Thung Yai Naresuan wildlife sanctuary. He found that the Karen and their knowledge systems are under great pressure, resulting from rapid changes in their socio-economic situation. The threaten of state policy and scientific community also ignore or dismiss their folklore, which derived from cursory observations and myths. Karen members can use their local ecological knowledge to conserve Thung Yai Naresuan area. This local ecological knowledge is inseparable conservation biology to protect their local environment, participate legally in the management of their ancestral lands, and it can be used for sustainable development between grassroot level and state policy level. Finally, he proposed to pass the local ecological knowledge on to younger generations and to integrate this knowledge into educational system.

Yongyod (2001) studied *PAH POOH TAH* in Changwat Mahasarakham and found that *PAH POOH TAH* is a forest where local people use it in terms of basic needs for their daily life. The law for using natural resources in *PAH POOH TAH* is set by local people. They have responsibility to preserve and sustain *PAH POOH TAH* because it is crucial for their livelihood.

Santasombat (2001) published his work "Biodiversity and indigenous knowledge for sustainable" which is an attempt to understand and explain the indistinguishable relationship between biodiversity and indigenous knowledge in the upper northern part of Thailand. He found that the richness of local biological resources and the persistence of indigenous knowledge are two important bases for sustainable development. The cultural diversity and indigenous knowledge on medicinal and food plants, the conservation of traditional agro-ecosystems and resource management, and social and ecological justice are the basic conditions for the pursuit of sustainable development.

Chamarik and Santasombat (Putasen. 1996: 78-79; citing Chamarik; & Santasombat. 1992) outlined the eight conditions in order to conserve community forest. First, local people must have a strong sense of community within the kinship group. They involve some forms of mutual assistance amongst relatives and neighbors, and a sharing of common belief and traditional practices. Second, there should be mutual benefits for the common users of forest. This condition is a vital part of the input of the production process, and it requires the mutual conservation. Third, the natural resources in the forest area need to be well preserved through maintenance of the community forest. Fourth, the community requires a strong leader with wisdom and vision to adopt existing local practices to the changing nature of the socio-economic and political situation. Fifth, there must be already exists some forms of people's organization in the community. Sixth, there must have been a long tradition in recognizing some resources. Natural resources must be managed by the community to provide mutual benefits for, and fair distribution to all members. Seventh, the community must be in a state of permanent settlement with certain criteria of social composition and levels of resource use. Eight, the community must have a prevailing resource utilization network of its own.

Indigenous knowledge should be taught together within a western-based science and technology curriculum. The intellectual value of indigenous people's knowledge is credited. Teachers should convey to their students that indigenous knowledge is as important as science. Charron (1987: abstract) studied the youths' understanding of science in a rural community. The results showed that the youths' understandings of what science is worth of further investigation because (1) students reflect one aspect of shared local culture, and (2) there was an evidence in this study that students' science perceptions influenced their classroom performances. Additionally, it was concluded that comparison of students' science perceptions in a given community to science experts' views would provide a basis for improving local science programs.

Indigenous leaders and teachers should take equal responsibility in devising methodologies for curriculum development and teaching, and in shaping the partnership. The important roles of indigenous knowledge in our society are as follows.

1. It has made, and sustained a significant contribution to resolve local problems.
2. Indigenous knowledge and science are linked to educational system and developmental issues.
3. Indigenous knowledge contributes to science in many fields related to natural resource management.
4. Indigenous knowledge can help scientists to understand the issues of biodiversity and natural forest management.
5. Indigenous knowledge provides science with insight into developmental issues.

Indigenous people have developed a holistic traditional scientific knowledge of their lands, natural resources and environment for many generations. The people and their communities will enjoy the full measure of human rights and fundamental freedoms without hindrance or discrimination. Indigenous people have the right to conserve, restore and protect their environment and the productive capacity of their land, territories and resources, as well as to obtain the assistance for this purpose from states and through international cooperation. (United Nations Conference on Environment and Development. 1992: 227).

The environmental conservation means the consideration of how local people preserve the protected areas in local community. The other living things have adapted to and may continue to fit into the cultural landscape (Kirby. 1996: 141). Common species which can well adapt to human modified landscapes may need no special conservation but some development projects do change their habitat. Some species were reduced in number in local community because they cannot tolerate the changed environment. *PAH POOH TAH* is not only considered as a cultural forest, but also it should be considered as a protected area in local community for conserving biodiversity.

The biodiversity of *PAH POOH TAH* can provide potential use values such as new and useful products supplied by species, or potentially important resources that can be used in improving presently utilized species. It is important reason why local people need to save biodiversity.

The social dimensions of biodiversity are crucial. It is important to understand that human beings interact with the natural world and the way that is a result of a variety of ecological, historical, social, cultural economical and political factors. The knowledge about natural systems and species existence is valuable in itself. It is evidenced by the concern and support expressed for prevention of rainforest destruction or species loss in many places (Furze; et al. 1996: 20).

Habitat-based conservation is a way of structured conservation. The range of conditions across a landscape may be presented in a series of relatively small patches. It is commonly developed in local areas where much of the landscape has been modified (Kirby. 1996: 152). Spencer (1995: 3-4) proposed the long-term commitment to conserve ecological change into three circumstances: changes in personnel, new science and technology understanding, and project funding. It is important to learn and plan for our science students.

Above all, arbitrary decisions regarding *PAH POOH TAH* components should be avoided. The forestry village might be established to promote nature conservation, to enhance the future conservation prospects for a particular species, for recreation and for study (Spencer. 1995: 11) as well as for cultural heritage of that community (Kestes. 1994: 96). Local people might conserve the nature for landscape, recreation or scientific study, and cultural transmission. All are valid reasons for establishing woodland, and all options may be justifiably pursued somewhere in the country. Each objective gives different meaning to the woodland created. Not all objectives are as dependent on the passage of time and commitment to a particular management regime to fulfill their objectives as those concerned with nature conservation (Spencer. 1995: 11).

In various seminars on culture and rural development, held by several Thai non-governmental agencies, most issues are related to development. However, most participants are the outsiders who have more educated than indigenous people. Hence, the outsiders dominate the seminars. In fact, local people know better than the outsiders about indigenous knowledge, values, beliefs, knowledge transactions and communications, the way of life to survive in the suitable environment, and how to encourage local people to have principal roles to develop their community. The outsiders should play the supporting role (Boonyarattanasoontorn; & Chutima. 1995).

The notion that local practices play an important part on their natural resources and environments is currently very fashionable. The consideration of how indigenous knowledge can manage and conserve nature may be an enthusiasm for science educators (Figure 3). The biodiversity will be remained by providing the appropriate learning. The rationale for attempting to conserve and recreate biological meaningful and diverse ecosystem is that environmental conservation. Students should have the habit of environmental conservation that they make a continuous contribution to local, national, and international conservation.

To local people, the local culture cannot be separated from society, way of life, and environmental concerns. It is important for the spiritual dimension in the popular development and environmental conservation. It also has not been lost in alternative development. The word of revival of the sacred in nature of everyday life is consistent with the surroundings (Taylor. 1996: 50). Local people have concentrated in sustaining environment and building community consciousness. The awareness of individuality and society in terms of sustainable development are involved.

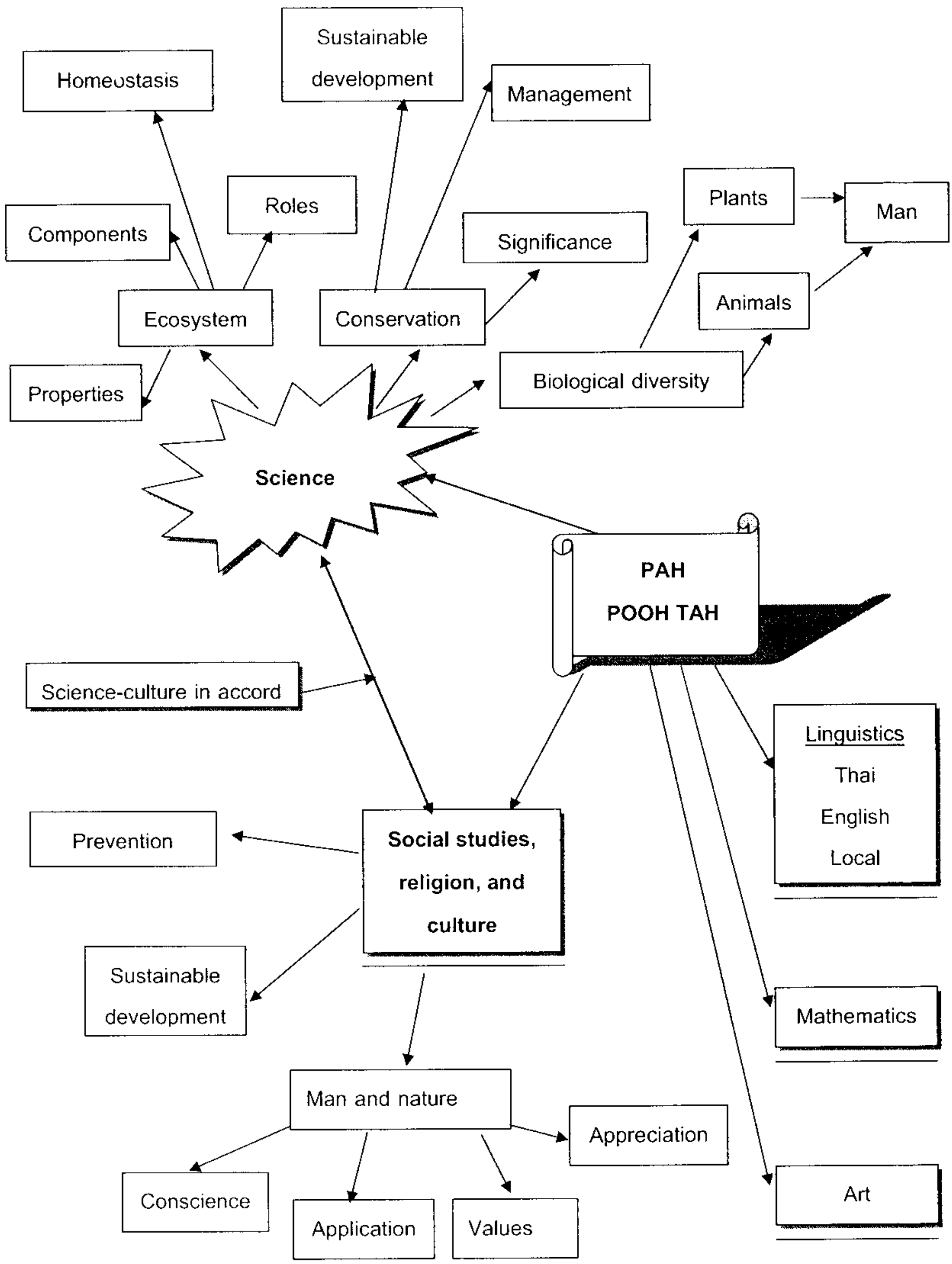


Figure 3 The relationship between science and local culture in *PAH POOH TAH*.

3. Science learning achievement

This topic presents the cognitive development in terms of science learning achievement. The psychology of learning and how to develop student knowledge, intellectual abilities and skills are focused. Because psychology is a part of curriculum decision-making especially the behavioral learning theories are concerned with the developmental aspects. Behavioral learning theories are based on the view of human mind. The effects of the environment and experience determine what is learned and why people do.

3.1 Cognitive development theory

Jean Piaget provides educators with a theory of cognitive development focusing on the construction of knowledge. Knowledge is not a copy of reality. It is not simply to look and make a mental copy or image of it, but it needs to know an object and to know an event. Knowing is to modify, to transform the object, to understand the process of transformation, and consequently to understand the way that object is constructed (Piaget. 1964: 176).

The classical theory in the cognitive development learning theory is Piaget's theory. Piaget (1952) described cognitive development in terms of stages from birth to maturity of human. The overall stages can be summarized as follows;

1. Sensorimotor stage (birth to age 2). The child progresses from reflex operations and undifferentiated surroundings to complex sensorimotor actions in relation to environmental patterns. The child comes to realize that objects have permanence and they can be found again. The child begins to establish simple relations between similar objects.

2. Preoperational stage (ages 2 to 7). This stage objects and events begin to take on symbolic meaning. The child shows an increased ability to learn more complex concepts from experience as long as familiar examples are provided from which to extract criteria that define the concept.

3. Concrete operation stage (ages 7 to 11). The child begins to organize data into logical relationships and gains facility in manipulating data in problem-solving situations. This learning situation occurs, however, only if concrete objects are available or if actual past experiences can be drawn upon. This child is able to make judgements in terms of reversibility and reciprocal relations and conservation.

4. Formal operation stage (age 11 onward). This stage is characterized by the development of formal and abstract operations. The adolescent is able to analyze ideas and

comprehend spatial and temporal relationships. The young person can think logically about abstract data, evaluate data according to acceptable criteria, formulate hypotheses, and deduce possible consequences from them. He or she can construct theories and reach conclusions without having direct experience in the subject. At this stage, there are few or no limitations on what the adolescent can learn because their learning depends on his or her intellectual potential and environmental experiences.

Implicating Piaget's theory for science education in the ages from 10 to 15 is important, the ages range from Piaget's concrete operational stage. Students can use rational thinking and abstract thought in the solution of problems (Clark. 1996: 35). Bruner (1960) considered that cognitive development consists of three related processes which are similar to Piaget's cognitive processes:

1. Acquisition is the grasping of new information and it mainly corresponds to assimilation. Such information may be "new" to one's store of data and it may also replace previously acquired information, or it may merely refine or further qualify previous information.

2. Transformation is the individual's capacity to process new information so as to transcend or go beyond it. Means for processing such information consist of extrapolation, interpolation, or translation into another form. This process mainly overlaps with accommodation.

3. Evaluation is the determination of whether or not information has been processed in a way that renders it appropriate for dealing with a particular task or problem. It closely corresponds with equilibration.

The taxonomy of educational objectives is constructed to facilitate communication. It is a selecting appropriate symbol and a giving the precision and usable definitions. Bloom et al (1964: 6-7) created threefold division of educational objectives: cognitive, affective, and psychomotor domains.

1. Cognitive domain: this objective emphasizes remembering or reproducing something which has presumably been learned. It involves the solving of some intellective task for individual who has to determine the essential problems. Then, it reorders the given materials or combines it with ideas, methods, or produces previously learned. Cognitive domain varies from simple recall of material learned to highly original ideas. It includes the creative ways of combining and synthesizing new ideas.

2. Affective domain: this objective emphasizes a feeling tone, an emotion, or a degree of acceptance or rejection. Affective domain varies from simple attention to selected complex phenomena, but it is internally consistent qualities of character and conscience. The number of affective domain covers interest, attitudes, appreciation, values, and emotional sets or biases.

3. Psychomotor domain: this objective emphasizes some muscular or motor skills, some manipulation of material and objects, or some act which requires a neuromuscular co-ordination. The number of affective domain covers handwriting, speech, physical education, trade, and technical courses.

The development of cognitive domain concerns the examinations for grading and evaluation purposes. This domain focuses most directly on the objectives emphasized by teachers and on the examination by examining staffs.

This topic will describe cognitive domain, which directly concerns science learning achievement. Bloom (1956: 201-207) wrote on the cognitive objectives, Taxonomy of education objectives: Book 1 cognitive domain. In this book, there are six aspects: knowledge, comprehension, application, analysis, synthesis, and evaluation.

1. Knowledge involves the recall of specifics and universals, the recall of methods and process, or the recall of pattern, structure, or setting. It can be measured by considering the recall situation, which involves little more than bringing to mind the appropriate material. Some alterations of the material may be required. The knowledge objectives emphasize most the psychological processes of remembering. Knowledge can be categorized into three categories: knowledge of specifics, knowledge of ways and means of dealing with specifics, and knowledge of the universals and abstractions in a field.

1.1 Knowledge of specifics are the recall of specific and isolated bits of information. The emphasis is on symbols with concrete references. This material is at a very low level of abstraction. It may be thought of as the elements from more complex and abstract forms of knowledge. This subcategory consists of two aspects: knowledge of terminology and knowledge of specific facts.

1.2 Knowledge of ways and means of dealing with specifics is knowledge of the ways of organizing, studying, judging, and criticizing. This includes the methods of inquiry, the chronological sequences, and the standards of judgement within a field as well as the patterns of organization. It is at an intermediate level of abstraction between specific knowledge on the one hand and knowledge of universals on the other. This subcategory consists of five aspects: knowledge of conventions, knowledge of trends and sequences, knowledge of classifications and categories, knowledge of criteria, and knowledge of methodology.

1.3 Knowledge of the universals and abstraction in a filed is knowledge of the major schemes and patterns by phenomena and ideas. These are large structures, theories, and generalizations. This subcategory consists of two aspects: Knowledge of principles and generalizations, and knowledge of theories and structures.

2. Comprehension represents the lowest level of understanding. It refers to a type of understanding or apprehension that the individual knows what is being communicated without necessarily relating it to other materials or setting its fullest implications. Comprehension can be divided into three categories and they are as follows:

2.1 Translation is a comprehension evidenced by the care and accuracy with the communication or rendered from one language, or forms of communication to another. It is judged on the basis of faithfulness and accuracy.

2.2 Interpretation is the explanation or summarization of a communication. Whereas translation involves an objective part-for-part rendering of a communication. Interpretation involves a reordering, a rearrangement, or a new view of material.

2.3 Extrapolation is the extension of trends or tendencies beyond the given data to determine implications, consequences, corollaries, effects, etc., which are in accordance with the conditions described in the original communication.

3. Application involves the use of abstractions in particular and concrete situations. The abstractions may be in the forms of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories, which must be remembered and applied. It can be generalized into two applications;

- Application of the phenomena discussed in one paper of the scientific terms or concepts will be used in other papers.

- The ability to predict the probable effect of a change in a factor on a biological situation which is previously at equilibrium.

4. Analysis involves the breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations among the ideas expressed. Analysis is intended to clarify the communication, to indicate how the

communication is organized and the way in which it manages to convey its effects, as well as its basis and arrangement. Analysis can be categorized into three categories and they are as follows:

4.1 Analysis of elements is the identification of the elements included in a communication.

4.2 Analysis of relationships is the connections and interactions between elements and parts of communication.

4.3 Analysis of organization principles is the organization, systematic arrangement, and structure, which hold the communication together. It includes the 'explicit' as well as 'implicit' structures. It also includes the bases, necessary arrangement, and mechanics which make the communication a unit.

5. Synthesis involves the putting together of elements and parts so as to form a whole. Synthesis is the process of working with pieces, parts, elements, etc., and of arranging and combining them in such a way in order to constitute a pattern or structure which do not clear before. Synthesis can be categorized into three categories and they are as follows:

5.1 Production of a unique communication is the development of a communication in which the writer or speaker attempts to convey ideas, feelings, and/or experiences to others.

5.2 Production of a plan, or proposed set of operations is the development of a plan of work or the proposal of a plan of operations. The plan should satisfy requirements of the task which may be given to the student or which he may develop for himself.

5.3 Derivation of a set of abstract relations is the development of a set of abstract relations either to classify or to explain particular phenomena, or the deduction of propositions and relations from a set of basic propositions.

6. Evaluation involves the judgements about the value of materials and methods for given purposes. Quantitative and qualitative judgements about the extent to materials and methods satisfy criteria. It uses a standard of appraisal. The criteria may be determined by the students or those which are given to them. Evaluation can be categorized into two categories:

6.1 Judgements in terms of internal evidence are evaluation of the accuracy of a communication from evidence such as logical accuracy, consistency, and other internal criteria.

6.2 Judgements in terms of external criteria are evaluation of material with reference to selected or remembered criteria.

3.2 Studies of cognitive development

The studies of cognitive domain are widely studied by many Thai educators. Jubjitt (1991: abstract) studied the effects of pre-class concentration upon an achievement in science, scientific attitudes, science process skills, and learning retention of Mathayomsuksa 2 students. Ramonudom (1994: abstract) studied the science achievement and scientific value of Mathayomsuksa 1 students through public relation process and the methods in the teacher manual. Singkeawsub (1995: abstract) studied the science learning achievement and attitude towards environment social studies of Mathayomsuksa 1 students through the environmental survey method and the method in the teacher's manual. Promsiri (1996: abstract) studied on Mathayomsuksa 1 students' achievement and environment – based values through field trips in social studies. Ludeerat (2003: abstract) studied learning achievement and attitude towards environment of level III students by using field site study for environmental conservation camp. These findings revealed that learning achievement and attitude towards the environment between experimental and control groups were significantly different.

Phothibundit (2000: abstract) studied the development of teaching/learning activities for science subject for 7th grade students based on cooperative learning model and development of the learning achievement in science. The results showed that students developed social skills and a feeling of self-esteem. They also made a higher learning achievement score in their study of the "ecosystem" topic. Chatwirakom (2003: abstract) developed a science instructional model by focusing on students' construction of knowledge for Mathayomsuksa 1 on ecosystem. The result reveled that students had a higher score of science learning achievement and attitude towards the science after they had learned.

Thimsak (2000: abstract) examined the response concerning nature and condition of interaction of learning process in community and school of basic education provision. This research found that patterns of school system consist of one-way learning or teacher center learning, standardization learning or uniformity learning, and transactional learning. The learning system in community consists of knowledge/wisdom, learning, transferring, and creativity. In addition, Suriyapom (2003: abstract) developed the instructional package by using 4 MAT activities system for enhancing attitudes on conservation of community forest and learning achievement of Prathomsuksa 6 students. The findings reveled that attitudes and learning achievement on community forest after experiment were significantly higher than before.

4. Values of science-culture in accord

The value is an idea about what someone thinks is important in life (Fraenkel. 1977: 6). The value involves affective objectives. It deals with the interests, which describes behavior all the way from student's awareness that phenomenon exists. The term "value" has the same range of behavior which is described for "attitude". Further, both terms ("value" and "attitude") may refer to behavior. They are still usually employed. The behavior is often better described as a bundle of attitudes or value (Bloom; et al. 1964: 25).

4.1 Value theory

Students act as they think because to do so is to satisfy themselves. They respond with commitment by accepting a value into their system by organizing the system, and by developing a value complexity that guides their behavior (Bloom; et al. 1964: 176-185). Bloom et al (1964) wrote on the cognitive objectives, *Taxonomy of education objectives: Book 2 affective domain*. In this book, there are five levels of value or value complexity: receiving, responding, valuing, organization, and characterization. The details of affective domain can be explained by beginning with the individuals being aware of the stimuli as shown in Figure 4.

1. Receiving. This level concerns the student in sensitizing the existence of certain phenomena and stimuli. The first step is crucial and if the student is properly oriented to learn what the teacher intends to teach. It is subdivided into three categories:

1.1 Awareness is almost a cognitive behavior dislike 'knowledge' at the lowest level of the cognitive domain. We do not much concern with a memory of or ability to recall, an item or fact, given appropriate opportunity, and conscious of something. Like 'knowledge', it does not imply an assessment of the qualities or nature of the stimulus. It does not necessarily imply attention. The individual may not be able to verbalize the aspects of the stimulus, which causes the awareness.

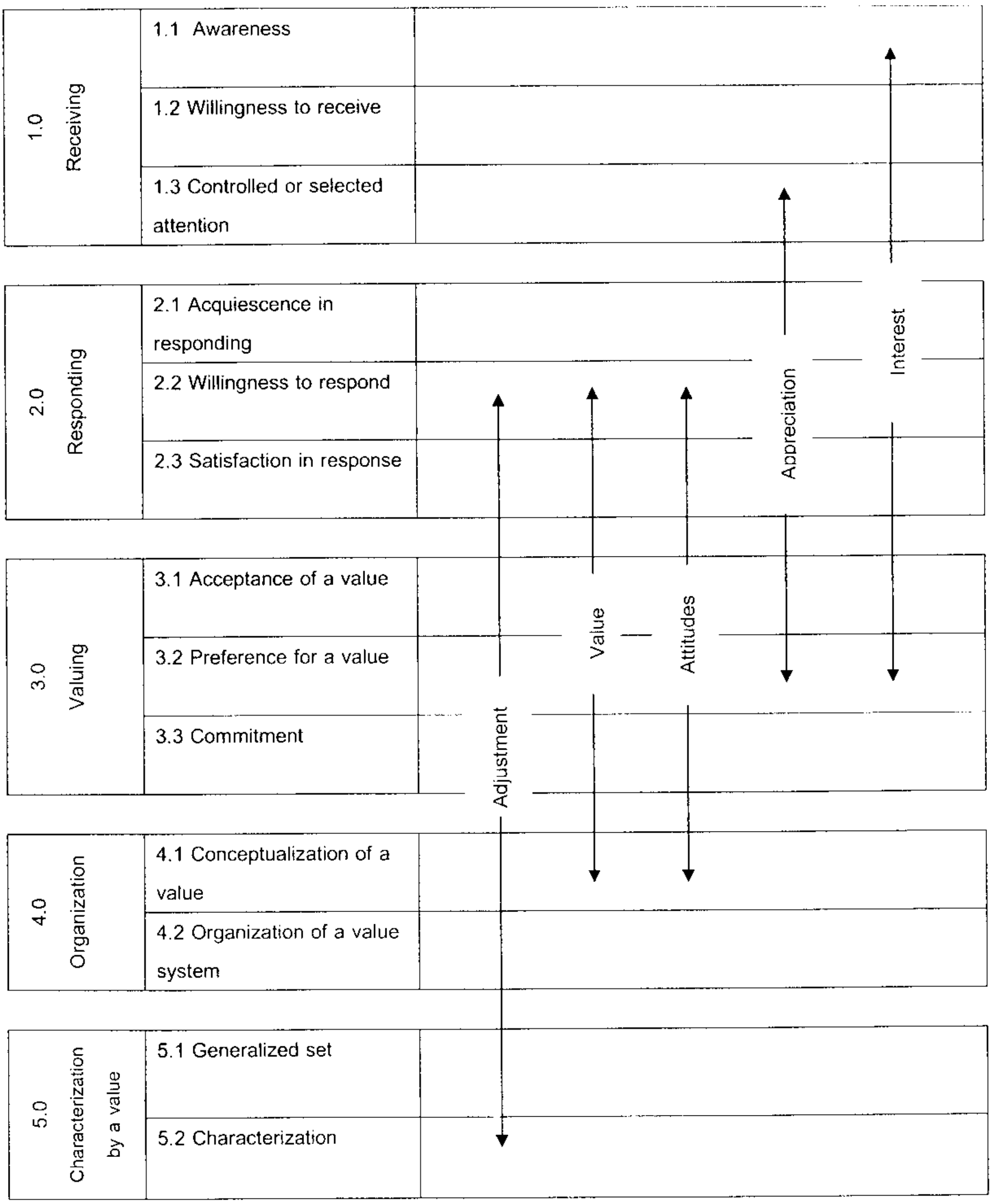


Figure 4 The range of typical meanings of commonly used affective terms measured against the taxonomy continuum.

(Source: Bloom; et al. 1964: 37).

1.2 Willing to receive is described as the behavior of willing to tolerate a given stimulus. Like 'awareness', it involves a neutrality or a suspended judgement towards the stimulus. At this level of the continuum the teacher is not concerned whether student seeks it out. The student does not actively seek to avoid it.

1.3 Controlled or selected attention is concerned with a new phenomenon. The differentiation of a given stimulus is perceived as clearly marking off from adjacent impressions. The perception is still without tension or assessment. Student may not know the technical terms or symbols which are used to describe to others.

2. Responding is a perception of individual for regularly responding to the affective stimuli. It concerns with responses which go beyond merely attending to the phenomenon. Responding is subdivided into three following categories:

2.1 Acquiescence in responding is a passiveness that the initiation of the behavior is concerned. The stimulus calling for this behavior is not subtle. The student makes a response but he does not fully accept doing that.

2.2 Willingness to respond is the implication that student is sufficiently committed to exhibiting the behavior. The element of resistance or unwilling to do something is possibly present at the previous level. It is replaced with consent or proceeding from one's own choice.

2.3 Satisfaction in response is a behavior accompanied with a feeling of satisfaction, an emotional response, a pleasure, zest, or enjoyment. The location of this category in the hierarchy has created a great difficulty.

3. Valuing describe increasing internalization. The students' behavior is sufficiently consistent that they come to hold a value. The worth abstract concept is in part of individual's valuing or assessment. It is much more social product that has been slowly internalized or accepted. It has come to be used by the student as a criterion of worth.

At this level, it is sufficiently consistent and stable to take on the characteristics of a belief or an attitude. The student displays behavior with sufficient consistency in appropriate situations. It is subdivided into three categories:

3.1 Acceptance of a value concerns the ascribing of worth to phenomenon, behavior object, etc. It describes quite well what may be thought of the dominant characteristic here. The behavior is consistent with the belief or attitude in terms of response to the class of objects, phenomena, etc.

3.2 Preference for a value is a level of internalization between the acceptance of value and commitment or conviction. Behavior at this level implies not just the acceptance of value, but the individual is sufficiently committed to the value to pursue it.

3.3 Commitment is a behavior that person displays a clear perception as holding the value. He acts to value further thing in some ways in order to extend the possibility of his development. He tries to convince other people and seeks converts to his cause. The tension needs to be satisfied. Action is the result of and aroused need or drive. The student is successively internalized values which more than one value. This category will be found appropriate for many objectives that use the term "attitude" (as well as "value"). The important element of behavior is characterized by valuing. It is motivated not only by the desire, but also by the individual's commitment to the underlying value guiding the behavior.

4. Organization, a prerequisite to interrelating values is the conceptualization. It is to be the proper classification for objectives, which describes the beginnings of building a value system. This level is divided into two subcategories:

4.1 Conceptualization of a value is the quality of abstraction or conceptualization. The individual is permitted to see how value relates to the hold or the new coming ones. It will be symbolic but it does not need to be verbal symbols.

4.2 Organization of a value system is the ordered relationship that is harmonious and internally consistent. The goal of this objective is that the student can formulate a philosophy of life. More likely, the relationship is better described as a kind of dynamic equilibrium. It depends upon the portions of the environment.

5. Characterization by a value or value complex, At this level of internalization, the values placing in the individual's value hierarchy, are organized into some kind of internally consistent system. Characterization controls the behavior of an individual for a sufficient time. It is divided into two subcategories:

5.1 Generalized set is selective responding at a very high level. It is sometimes called a determining tendency, an orientation towards phenomena, or predisposition to act in a certain way. It is a response to highly generalized phenomena. It is a persistent and consistent response. It may be thought of closely related to the idea of attitude cluster. It enables individual to reduce and order the complex world, and to act consistently and effectively in it.

5.2 Characterization is the peak of the internalization process. It includes objectives, which are broad with respect to the phenomena and the range of behavior. It concerns one's view of the universe, one's philosophy of life, a value system having as its object of what is known or knowable.

The internalization and the organization processes reach a point where individual consistently responds to value-laden situations with the interrelated set of values.

Eccles (Stipek. 1993: 22-23; citing Eccles. 1983) proposed three kinds of values relevant to achievement and they are attainment value, utility value, and intrinsic value. The details can be given below.

1. Attainment value is the subjective importance of doing well on a task or in an achievement domain. It is determined by how the task or the domain fulfills the individual needs. Attainment value concerns the relevance of an activity to an individual's self-concept. Students presumably engages in activities and develops competencies that are consistent with their concept of themselves.

2. Utility value concerns the usefulness of a task as a means to achieve goals that might not be related to the task itself. For example, a good grade in chemistry would have considerable utility value for a college student hoping to be admitted to medical school.

3. Intrinsic value is the immediate enjoyment that one can get from doing a task. When a task has intrinsic value it is engaged for its own sake rather than for other purpose. The development of a person's cognitive structure of crucial important is in that person's overall growth and development.

The formations of values and attitudes are dependent on the acquisition of certain knowledge, and interactions with objects as well as people. Acquiring the knowledge is not a sufficient condition of developing values and attitudes, but it is a necessary condition. Science courses refer to the acquisition of a scientific attitude, valuing the conservation of the environment, etc. (UNESCO. 1991: 4).

4.2 Studies of scientific value

The basic of development for guiding in the area of values and ethics in science and technology curriculum can be summarized into three issues: (1) values and ethics should be addressed as part of the science and technology curriculum at both primary and secondary level, (2) the treatment of values and ethics in the science curriculum should be seen in the broad context of moral education, values, and ethics in the whole curriculum, and (3) the science curriculum should take a broad view of science by attending not only to scientific knowledge, but also to its application and social context. This is consistent with the spirit of "Science for All", embracing Science-Technology-Society approaches, problem solving and experiential approaches, and views of the student as a theory-builder and practical problem solver (UNESCO. 1991: 1).

Pongsai (1994: abstract) constructed the scientific value test for Mathayomsuksa 2 students. The scientific value test is designed to measure 5 aspects: longing to know and understand, to be open-minded and tolerance, originality, honesty, and rationality. In addition, Ramonudom (1994: abstract) studied the science achievement and scientific value of Mathayomsuksa 1 students through public relations process and the methods in the teacher manual. The scientific value after experimentation is higher than before. It composed of knowledge-comprehension, curiosity, persistence, and accuracy. This study also reported that persistence was not significantly different between those of experimental and control groups.

Promsiri (1996: abstract) studied on Mathayomsuksa 1 students' achievement and environment – based values through field trips in social studies. This finding revealed that learning achievement and the values of the environment between those of experimental and control groups were significantly different. Ketku (1998: abstract) conducted the presentation ability in science and values on Thai wisdom in science by using an instructional science package. Students had the values on Thai wisdom at a good level.

Gosum (1999: abstract) examined the responses concerning nature and conditions of the process of participation between community and school in basic education provision. The study showed that the factor which is conductive to the process and pattern of community and school participation. These were contextual with conditions of the community includes basic on public participation in the community, community and environment and school performance. According to Hsiung et al (2001: 123-145), the ways of using science subjects as a core in developing and applying an integrated curriculum and the implementation of integrated curriculum into the classroom relied on the teachers' collaboration as well as parents' accommodation and students' attitude toward learning. In addition, Jitvigarn (2002: abstract) revealed that basic education management for sustainable environment in the next decade (2012) will develop students' intelligence, comprehension, attitude, and life skills to raise themselves up along with others and the world of nature to live happily in society.

Phothibundit (2000: abstract) found that the cooperative learning model in which various activities were organized to encourage the students to co-operate with one another, to specify the task for each member of the group clearly, to have created a situation in which the student were allowed to participate fully in the activities, to stimulate them to be interested in the subject, and to acquire a better comprehension of what they have studied.

The curriculum as a selection from local culture can be explained for every thing that is created by human beings themselves including tools and technology, language and literature, music and art, science and mathematics in effect, the whole ways of life of a society (Capel; et al. 2001; citing Lawton. 1989: 17). Every culture passes on its culture to the next generation, even in modern societies. School is one of the ways in which this is done, but school curriculum can accommodate the whole human cultures. A selection of what students should learn has to be made in accord with learning-based cultural conditions. Students can develop themselves to their utmost potential and nature.

In response to the Thai National Act 1999, this study aims to reinforce science learning through local culture by designing the science curriculum. Then, the study aims to implement the proposed science curriculum. Finally, it aims to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior of the student samples.

CHAPTER 3

METHODOLOGY

This chapter explains how the research goal has been achieved, how the data was obtained, how the school science curriculum was developed, and how the data from this approach has been analyzed. Four topics will be discussed and they are as follows:

1. Population and samples
2. Research instruments
3. Research procedures
4. Data analyses

1. Population and samples

1.1 Population

The population of this study can be divided into two groups;

1.1 Population for designing the reinforcement of science learning through local culture consisted of science curriculum developers, educational technologists or evaluators, ecologists or environmentalists, national science teachers or master science teachers, and indigenous specialists.

1.2 Population for studying the impacts of reinforcement of science learning through local culture were Mathayomsuksa 3 students of Khon Kaen Educational Region 3.

1.2 Samples

The samples of this study were selected by purposive sampling. They can be divided into two groups;

2.1 Samples for designing the reinforcement of science learning through local culture consisted of five science curriculum developers, five educational technologists or evaluators, five ecologists or environmentalist, four national science teachers or master science teachers, and five indigenous specialists.

2.2 Samples for studying the impacts of reinforcement of science learning through local culture were Mathayomsuksa 3 students at Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school of Khon Kaen Educational Region 3.

2. Research instruments

The research instruments of this study are;

1. Delphi questionnaire
2. Science curriculum
3. Science learning achievement test
4. Values of test for science-culture in accord
5. Environmental conservation behavior questionnaire

2.1 Delphi questionnaire

The opinion of expert panels on the model of reinforcement of science learning through local culture was studied. The Delphi questionnaire was developed for answering how to reinforce science learning and to design learning science through local culture for Mathayomsuksa 3 students. The theme life and environment in the science learning area was considered to ask the experts.

The data was developed from theories, which were related to science and local culture. Group discussion was prepared surveying the generalized opinion about the proposed model of reinforcement of science learning through local culture. Listed items concerning the reinforcement of science learning through local culture. Analysis and synthesis of the questionnaire were done by content validity technique. Likert scale was employed to design a questionnaire.

Three experts evaluated the proposed Delphi questionnaire. They read and commented on language, ambiguities, and vagueness. Then, the questionnaire was re-developed and passed to another group of experts to examine it. The aim was to use this proposed Delphi questionnaire to ask the experts of how to reinforce science learning through local culture.

Invitation letters were sent from Science Education Center, Srinakharinwirot University to 24 experts in the various kinds of field study. Then, the first round Delphi questionnaire was mailed with summary of the research project.

Experts independently reacted to a list of item about particular issues. The responses were tabulated, organized, and synthesized into topics. These categories were reported back to the experts. The study was initiated on January 2005 and concluded on June 2005. The experts mailed a set of surveys within one week after they received it. They indicated their level of agreement with the statement by choosing from four options: strongly agree, agree, disagree, and strongly disagree. The rated questionnaire was sent back to the researcher, it was analysed using Median and Interquatile range.

Second round, the ratings of research statements and rankings of major item categories by the group in the first round were compiled. Participants in this round again ranked the major research categories as they did in the first round. But this time the descriptive information about how the group responded was provided. Participant experts were asked to review each item in order to consider the group response and then re-rate the items for taking the information into account within one week after they received. The rated questionnaire was sent back to the researcher, it was analyzed using median, interquatile range, and mode-median.

The criteria to assess experts' opinion on Delphi study can be illustrated as follows;

Median above 2.50	means sentence was *very good*, and appropriate for reinforcement of science learning through local culture.
Median between 1.50 and 2.49	means sentence was *good*, and appropriate for reinforcement of science learning through local culture.
Median between 0.50 and 1.49	means sentence was *fair*, and appropriate for reinforcement of science learning through local culture.
Median below 0.49	means sentence was *not* appropriate for reinforcement of science learning through local culture.

The Interquartile range and Mode-Median were also considered for analyzing each sentence. If the score was more than 1.00, it means that expert panels disagreed. On the other hand, If the score was less than 1.00, it means that experts panels agreed.

2.2 Science curriculum

The science curriculum was developed for educational level III, reinforcement of science learning through local culture based on the national education standards was decided. The lesson plan was designed by giving principles, course description, intended learning outcomes, and learning activity plans. The ways to develop lesson plans were;

1. Studying and examining the detail of local ecology contents and the ways to promote science in classroom. Document study related to science learning assessment was done.

2. Analyzing science curriculum based on the Basic Education Curriculum 2001 of the national science education standards. Following the process of synthesis science curriculum as The Institute for the Promotion of Teaching Science and Technology (IPST) manual guide for science learning area management recommended. Also, related theories in science curriculum development were studied.

2.1 Developing concept mapping to draw the relationship of national science education standards and social studies, religion, and culture education standards, which reflect what students should learn science.

2.2 Analyzing the expected learning outcomes and the selected content based on national science education standards and social studies, religion, and culture education standards.

3. Analyzing the result of Delphi study on reinforcement of science learning through culture. It provided a framework to reinforce science into classroom. Five criteria were responded: relevant science topics, learning objectives, learning management, media and learning resources, and assessment.

4. Developing lesson plan for totally 20 class hours. Three subunits: biological diversity, ecosystem, and man and nature were constructed. Each lesson plans consisted of;

1) Learning objectives

2) Scientific concept

3) Teacher preparation

4) Learning process

5) Assessment

6) Media

7) Learning resources

5. Three experts checked content validity and language vagueness. They also independently assessed the appropriateness and congruency of developed science lesson plans. Then, the researcher developed the lesson plans by following the experts' suggestions.

Experts checked the appropriateness of the science lesson from the Likert scale with five opinion levels. The criteria to assess appropriateness of developed science lesson plans are as follows:

Mean between 4.50 and 5.00	means	sentence was *very good*, and appropriate for proposed science lesson plans, which would reinforce science learning through local culture.
Mean between 3.50 and 4.49	means	sentence was *good*, and appropriate for proposed science lesson plans, which would reinforce science learning through local culture.
Mean between 2.50 and 3.49	means	sentence was *medium*, and appropriate for proposed science lesson plans, which would reinforce science learning through local culture.
Mean between 1.50 and 2.49	means	sentence was *fair*, and appropriate for proposed science lesson plans, which would reinforce science learning through local culture.
Mean between 1.00 and 1.49	means	sentence was *not* appropriate for proposed science lesson plans, which would reinforce science learning through local culture.

The index of congruency was also considered for analyzing in each item. If the score was more than 0.50, it means that expert panels agreed. On the other hand, if the score was less than 0.50, it means that experts panels disagreed.

6. The pilot study was conducted in a classroom of Mathayomsuka 3 students at Waengyai Wittayakom school. The lessons were taught by researcher aiming to check the activity plans. The outcomes of the pilot study guide the researcher to revise the activity plans, related documents, learning resources, and research instruments.

7. Lesson plans were developed for conducting sample groups. Three classrooms from three schools, Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school were selected.

2.3 Science learning achievement test

1. Studying the theories of science learning assessment is related to local ecology.

2. Studying learning objectives and relevance science content is related to developed lesson plans. The researcher use the cognitive domain: knowledge, comprehension, application, and scientific process skills to develop an achievement test.

3. Multiple-choice with five selectors was constructed. Fifty items were listed based on learning objectives.

4. Three experts checked the questionnaire characteristics and assessed the congruency of achievement test between learning objectives and expected behavior. Index of Congruency was used to analyze the achievement test. The wording and pattern of each item was corrected.

5. One hundred students of Mathayomsuksa 3 at Waengyai Wittayakom school were selected to find difficulty, reliability, and discriminant.

6. The criteria to consider achievement test were: Difficulty (0.20-0.80), Reliability (more than 0.70), Discriminant (more than 0.20).

7. If some items did not fit the criteria, they were developed and repeated for difficulty, reliability, and discriminant.

2.4 Values of test for science-culture in accord

1. Studying the theories of science-culture in accord is related to local ecology.

2. The values of test for science-culture in accord were developed using the pattern of Saiyot and Saiyot (2000). This study was decided to use Likert scale questionnaire with 5 selective choices: Strongly agree, Very agree, Agree, Disagree, Strongly disagree.

3. Three experts checked questionnaire characteristics and assessed the congruency of values test between learning objectives and expected behavior. The analysis of values test was done by the use of Index of Congruency. The corrections of wording and pattern were made.

4. Fifty students of Mathayomsuksa 3 of Waengyai Wittayakom school were selected to find reliability and discriminant.

5. The criteria to consider value test were: Difficulty (0.20-0.80), Reliability (more than 0.70), Discriminant (more than 0.20).

6. If some items did not fit the criteria, they were developed and repeated for reliability and discriminant.

2.5 Environmental conservation behavior questionnaire

1. The researcher studied the theories of environmental conservation as related to local ecology.

2. The test had two-situation questionnaire. Students responded to the questionnaire by writing on a sheet for what they thought, what they would do, and what alternative choices they had.

3. Three experts checked questionnaire characteristics; assessed the congruency of environmental conservation test between learning objectives and expected behavior. Index of Congruency was used to analyze the test. Checking for content validity was done. The wording and pattern of each item were corrected.

4. Some items were revised and redeveloped. Then, pilot study was conducted with 50 students of Mathayomsuksa 3 at Waengyai Wittayakom school.

3. Research procedures

This study, One-Group Pretest-Posttest Design was considered for research designing (Saiyot; & Saiyot. 1995: 249).

Group	Pretest	Experiment	Posttest
Experimental	T_1	X	T_2

T_1 is Learning outcome before learning by the proposed science curriculum

X is the proposed science curriculum using reinforcement of science learning through local culture.

T_2 is Learning outcome after learning by the proposed science curriculum

This research aimed to study the reinforcement of science learning through local culture. The research procedure is provided in the following 4 stages.

Stage I: Collecting data

The researcher began to collect general information about school and community for understanding local culture. Data were useful for learning the nature of local culture. The steps of the study can be classified into 2 steps:

Step 1: Documenting the study

The researcher studied the indigenous knowledge, local culture, and *PAH POOH TAH* related to science learning area under the theme of life and environment. Books, journals, articles, magazines, and research reports were examined for collecting what they say about *PAH POOH TAH* and its practice and how it had a relationship between science and local culture. The content of the *PAH POOH TAH* in three domains of science: knowledge; process; and attitude towards science were analyzed.

Step 2: Community survey

Baan Don Hun, Baan Don Jode, and Baan Nonchantuek were the target groups for studying local culture, way of life, and science learning transaction. Gathering the data related to science context of indigenous knowledge for *POOH TAH* was done. The purpose verification letters from Science Education Center, Srinakharinwirot University were sent directly to the leader of community and school administrator to clarify research objectives as well as the researcher went to meet them. In addition, research project and its procedure were discussed between science teachers and the researcher. The data were collected by various methods:

1. Physical and biological mapping: The researcher walked around the village with local people. Maps were sketched to indicate the locations of important sites (such as temple, school, house distribution) and resources (such as paddy rice field, forestry village, bodies of water). Informal interviewing in physical and biological surroundings of ecological community was conducted.

2. Knowledge-based mapping: The researcher participated and observed special religious, ritualistic ceremonies and other daily social functions for descriptive detail of those practices. The researcher observed how local people interacted and what relationship

they had to each other in their family and community, as well as how they regarded nature. Informal interviewing on the environmental indigenous knowledge in terms of values and beliefs was included.

3. Teaching-learning transactions and communications: The researcher observed the teaching-learning process in Mathayomsuksa 3 science classroom and identified fundamental data such as subject matter, teachers' roles and their activities in school hours, and students' roles and their responsive learning science. Problems and needs in science subject were concluded. Knowledge, understanding, and attitude towards science related to indigenous knowledge were made. Data were gathered by using observation and informal interviewing.

The result of study in this stage was explained in chapter 4 in terms of an accordance between science and local culture. Documentary study and community survey were done by the researcher in terms of the *PAH POOH TAH* and community activities. The information provided background and general information of the study site as well as how science and local culture interacted.

Stage II: Modelling the reinforcement

The Basic Education Curriculum 2001 of the national science education standards was analysed and synthesized. A related theory in science curriculum development was also studied. The synthesized science curriculum was designed according to the national science education standards (subcategories 2 and 8) and national social studies, religion, and culture standards (subcategory 5). Then the data of synthesized science curriculum were used after verified by the experts in Delphi technique.

The Delphi technique was used to obtain a consensus from the experts in various field of study about the areas/issues that were most needed by this research. Linstone and Turoff (1978: 275) described the utility of the Delphi as a research technique particularly in the following situations: (1) the problem does not lend itself to precise analytical techniques but it can benefit from subjective judgements on a collective basis, and (2) the individuals who need to interact cannot be brought together in a face-to-face exchange because of time or cost constraints. Whereas a conventional conference tends to be dominated by particularly strong personalities or to give rise to an undesirable bandwagon effect.

1. Participant recruitment: The target of this study was to investigate the opinion of 24 experts who concern about the reinforcement of science learning through local culture. Twenty four experts were selected by purposive sampling from several fields of study: five science curriculum developers, five educational technologists or evaluators, five ecologists or environmentalists, four national science teachers or master science teachers, and five indigenous specialists. The invitation letters were sent directly to all experts by Science Education Center, Srinakharinwirot University. Also, the researcher verified the research objectives and methods.

All the experts' responses were analyzed numerically by calculating an average response in order to determine the degree of agreement between the groups. The numbers used to represent the consensus opinion of the group were the median and the interquartile range. The results from each step in the process were returned to the experts so as to collect their revised individual opinions.

2. Instrumentation: experts independently reacted with a list of item about particular issues. The response were tabulated, organized, and synthesized into topics. These categories were reported back to the experts. This cycle continued until a set of priority themes emerges. The study was initiated on January 2005 and concluded on June 2005. The panelists were mailed a set of surveys. The first round was generated from the researcher's knowledge about the reinforcement of science learning through local culture based on the subject of science (subcategory 2: life and environments).

There were two rounds of the survey and both are consisted of a list of Likert-scale items. First round, to each prompt the experts were to indicate their level of agreement with the statement by choosing from four options: strongly agree, agree, disagree, and strongly disagree. Once returned, descriptive statistics for the group ratings were calculated for the median, and interquartile range.

Second round, the ratings of research statements and rankings of major research categories by the group in the first round were compiled. Participants in this round again ranked the major research categories as they did in the first round. But this time the descriptive information about how the group responded was provided. Participant experts were asked to review each item, consider the group response and then re-rate the items by taking the information into account.

Stage III: Designing a science curriculum

Data from documentary study and community survey, synthesis science curriculum, and Delphi study were analyzed. The theories of science curriculum development were studied. Then the researcher explored the theories of lesson plan construction based on child-centered approach. Three subunits of lesson plan were made.

The lesson plans was designed by the use of Basic Education Curriculum 2001 of the national science education standards: subcategory 2 (Life and environment); subcategory 8 (Nature of science and technology); of the national social studies; religion; and culture standards: subcategory 5 (Geography), and using the data from the documentary and community studies. This curriculum focuses on the contents for level III.

This learning process was designed for lower secondary school with 20 class hours. The content focused on the interrelationship between *PAH POOH TAH* and local culture and this was used to reinforce science learning. The Delphi technique was employed to examine the validity of these proposed lesson plans by using 24 experts.

The Science Education Center sent directly invitation letters to three experts who can provide certain suggestions about the science lesson plans. Then, the researcher met directly all experts and clarified the objectives of the study. Quality of the lesson plans were assessed for both appropriateness and congruency.

The pilot study was employed with the students of Mathayomsuksa 3 at Waengyai Wittayakom school. The aims were to check the activity plans, and to prepare three teachers with the learning cycle strategies used in this study. The outcomes of the pilot study were to revise the activity plans, related documents, learning resources, and research instruments.

Stage IV: Implementing the proposed science curriculum

This stage seeks the effective of proposed science curriculum by conducting with 3 science classrooms of Mathayomsuksa 3. The study took place on the first semester of the academic year 2005 at Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nochantuek school, Amphoe Waengyai, Changwat Khon Kaen. The steps of implementation are as follows:

1) Preparation: Three selected science teachers from three schools were made orientation about science curriculum and ways of learning science through local culture. The

period of times and learning materials were set. Teacher provided informations to their students for what the research is all about.

2) Implementation: proposed science curriculum was implemented with three science classrooms during the first semester of the academic year 2005. The total periods were 20 hours per classroom. The learning process employed the LADDA instructional model (see Chapter 2) into science classroom. All periods were taught and manipulated by the researcher.

3) Evaluation: The one group pretest and posttest design were examined. The science learning achievement, values of science-culture in accord, and environmental conservation behavior were measured before and after curriculum implementation. The research scheme can be concluded and shown in Figure 5.

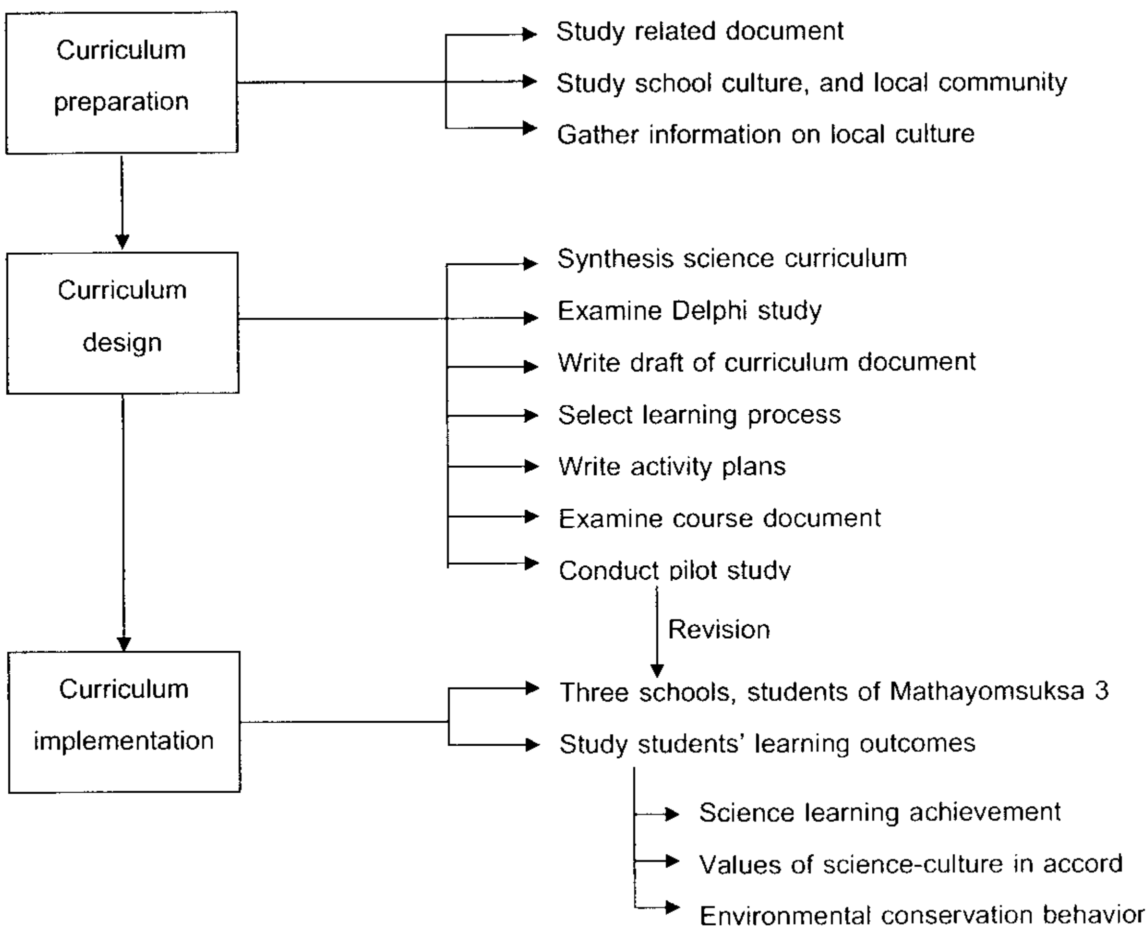


Figure 5 Summary of research scheme of the study.

4. Data analyses

4.1 Basic statistics

1. Mean was used to describe the individual student's score.
2. Standard deviation was used for the variation of individual students' score.
3. Median was used for analyzing an experts' opinion on Delphi technique.
4. Mode-Median was used for analyzing an experts' opinion on Delphi technique.
5. Interquartile range was used for analyzing an experts' opinion on Delphi technique.

4.2. Statistics for hypothesis testing

The t-test dependent was employed to compare students' pre- and post-tests scores in science learning achievement, values of science-culture in accord, and environmental conservation behavior.

CHAPTER 4

FINDINGS

This study aims (1) to reinforce science learning through local culture by designing the science curriculum, (2) to implement the developed science curriculum, and (3) to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior. The findings of this study are described as follows:

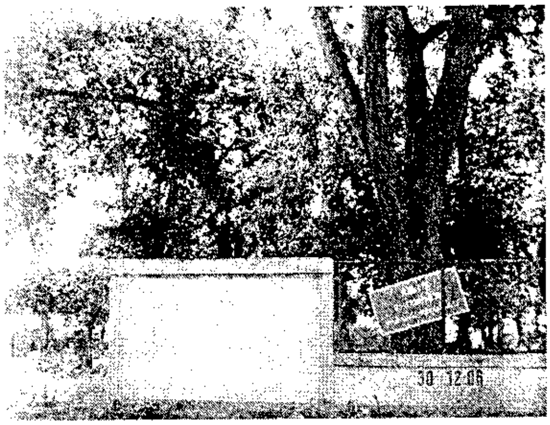
1. Accordance between science and local culture

1.1 Community activities and *PAH POOH TAH*

Even though science and technology play their role as a leader of civilization and lead human being to the reality, but natural resources from the forest community is still important in supporting local people. The indigenous knowledge related to scientific knowledge under the theme of life and environment is selected to represent the local culture. The *PAH POOH TAH* and its practices from Baan Don Jode, Baan Don Hun, and Baan Nonchantuek were selected to be a model of local culture for this study. The data was gathered by interviewing e.g. local people, indigenous specialists, and teachers. Also, activities done by local people in *PAH POOH TAH* were examined. The findings of the accordance between science and *PAH POOH TAH* are provided here.

The *PAH POOH TAH* (Figure 6) is one type of community forest where indigenous people agree to protect and grow trees and collectively maintain these trees and the other flora and fauna that they support. The *PAH POOH TAH* is widely distributed in northeastern region of Thailand. The location of *PAH POOH TAH* is mostly called "Khoke (prominent highland)". It protects flooding in the rainy season and it has various kinds of plants and animals. It looks like a gene bank for preserving biological diversity in local community when basic needs of human being still rely on the forest.

A traditional community forest is organized to conserve, sustain, and manage the forest area. Local people have full authority to decide on the rules and regulations for public users. The main purpose of *PAH POOH TAH* management is to pay respect for the ancestors who



(A)

(B)

(C)

(D)

(E)

(F)

Figure 6 General characteristics of *PAH POOH TAH* (A-C in wet season, D-F in dry season) passed away and the nature as well as to survive in the community. Natural resources and local environment are expected to manage efficiently and sustainably for local development.

The *PAH POOH TAH* has existed throughout the history of village settlement. New settlers normally agreed to set existing forest area, which is not far from the village. Local people will make their own rules and regulations regarding to the use of communal properties.

The belief and the way of life are related to human being under the natural phenomena. People in northeastern part of Thailand or "Khon E-Sarn" have believed about a primogenitor for a long time. The "*Phee* (ancestor ghost)" is grown, stored, and transferred from generation to generation. Descendants pay respect to it because *Phee* is a symbol of supernatural. Most people in northeastern region have a root of belief and closed culture to Laos. They believe that there are two groups of ghost. The first group is good ghosts e.g. *PHEE POOH TAH*, *PHEE TAH HAGH*, *PHEE POOH YAH TAH YAI*, and *HOUSE GHOST*. The second group is bad ghosts e.g. *PHEE PAO*, *PHEE POP*, *PHEE GHONG GHOY*, and etc.

The belief and the way of life of indigenous people is a root of learning. It is important for gaining sustainable development. The understanding about environmental conservation were collected and communicated from generation to generation by verbal communication and practical belief. It drives the habit of mind in scientific knowledge and indigenous knowledge for sustaining community.

The power of *POOH TAH* has influenced society for a long time. The symbol or practice to show how important the *POOH TAH* can be described by the way of the villagers thinking and doing. If you need wood or food in *PAH POOH TAH* area, you will be allowed to collect it for survival uses, but not for trade.

Northeastern society is sustained by agricultural practices, which are related to nature. In addition, the important identity of this society is full of gratitude to primogenitor and to nature. The great belief is concerned about *PHEE POOH TAH*, a favorite ancestor ghost which most northeastern people pay respect to *POOH TAH*. *PAH POOH TAH* have the word-by-word meaning as: *PAH* = forest or woodland, *POOH* = paternal grandfather, *TAH* = maternal grandfather.

POOH TAH ceremony will be conducted annually when the 6^{th} month of the year comes. On Wednesday that is not a full moon day of the 6^{th} month is selected. Villagers establish the ceremony for paying respect to *POOH TAH*. The aim of the ceremony is to respect for their ancestors.

The significant place for rite is called "*PAH POOH TAH*", which is the forest near the village. At this place, local people will construct small house for *POOH TAH* (Figures 6 E and F). The worship objects consist of a doll, which is supposed to be a symbol of *POOH TAH*, elephant model, cow model, buffalo model, pike, flower, joss sticks and candles.

The villagers prepare food and whisky. Lemon grass will be knoted for representation number of pet in each house. Also, cleaning *PAH POOH TAH* place is conducted in early morning. The offerings of *POOH TAH* include cologne, flowers, joss sticks, candles, whisky, boiled chicken, and boiled eggs.

THAO CHAM (Figure 7), a significant person who looks after the small house for *POOH TAH* and is supposed to be a messenger between people and *POOH TAH*. He/she will decide the date for the ceremony and tell the local people for 3-4 days before the ceremony starts. He/she is also a key person who designates "Boon" or good things to let the villagers do. Also, giving advises to the villagers to pay respect for nature, ancestor, and a good practical.

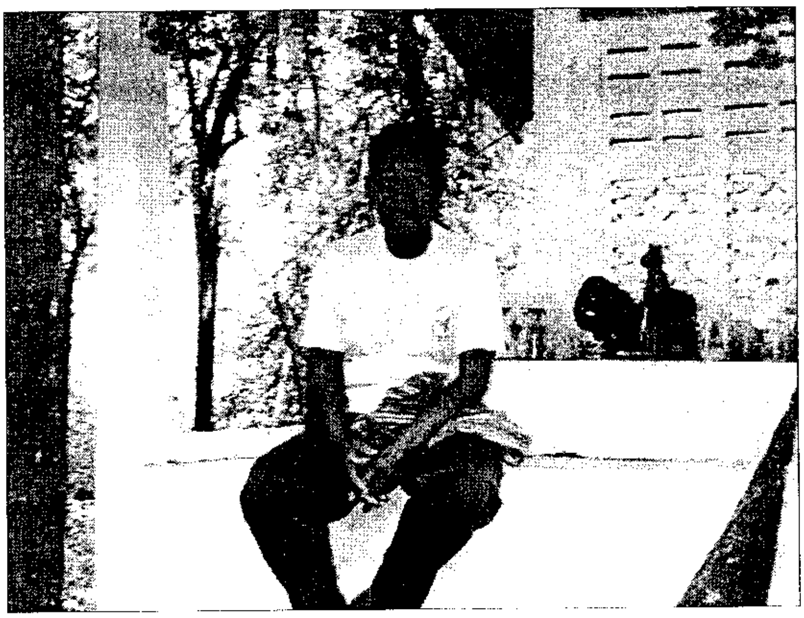


Figure 7 The *THAO CHAM* of Baan Nonchantuek.

To consult the oracles, it will be made on the same day of *POOH TAH* ceremony. *THAO CHAM* will light 2 candles and one joss stick at small house the shrine of the ghost *POOH TAH*. The rainwater volume will be predicted. If the chin of the boiled chicken is straight, they believe that the rainwater and productions will be productive as well as the people in community will be healthy. On the other hand, If the chin of boiled chicken is not straight, then the rainwater, productions will not be productive, and the well-being of the people in community will not be good.

To pledge *POOH TAH*, villagers put one's faith to *POOH TAH*. They pledge for positive mind and a good hope such as calling for new born, calling for army selection, calling for sickness. If the pledge is successful, they will have something to do as they have promised for repaying an obligation to *POOH TAH*. *THAO CHAM* is the leader of pledging ceremony by bringing whisky, boiled chicken, dessert, bananas, sugar cane, and other fruits.

Social rule to protect natural resources and environment is designed by the villagers. The leader of community announces and promotes the roles for all people to protect *PAH POOH TAH*. The taboo in *PAH POOH TAH* area is set e.g. courtship and mating, cuting a big tree, hunting birds and animals, and etc.

Gaining more sacred forest, *POOH TAH* is borrowed to be a symbol of protector natural resources and environment. *THAO CHAM* teaches the interrelationship system between man and nature, or man and man from old to youth. Also, he has a duty to communicate between villagers and *POOH TAH*. It is a trick to learn how to survive with balance of nature.

Forest community has a long history accompanied with each region. Northeastern part of Thailand also has a way of life related to the belief in the ancestor and forest community. *PAH POOH TAH* is close to local people life by supporting food, herbal plants, and raw materials for them. *PAH POOH TAH* concerns the belief and ceremony as well as science has emerged from nature and it also plays a role to human life, society, and culture. *PAH POOH TAH* can be presented as to how students learn science and local culture. Descriptions in terms of knowledge, process, and attitude towards science are analyzed.

Knowledge: some scientific knowledges explaining *PAH POOH TAH* show how science and local culture cannot be divided from local community. For example, The *POOH TAH* ceremony finds relationship between local people and the boiled chicken. *THAO CHAM* employ chicken chin as a predictor on an environmental condition. It seems to local people that

THAO CHAM has a potential to understand physiology of the chicken for prediction of some environmental conditions. If the villagers introduced contaminated food to the village, then the chicken rummage on the ground and uptake to its body, it will kink because it uptake that food. If the chicken chin changed, the villagers will try to save their local environment by solving the problem.

Also, the ceremony requires knots of the coconut leaf or knots of the lemon grass brought by the villagers to represent the domestic animals as many as they have i.e. cow, buffalo, goat, horse, and elephant. It can be explained by basic statistics in terms of animal population consensus. Every year the villagers will perceive the trend of domestic animals and find the way to manage them in terms of animal epidemics, animal populations, and etc.

Additionally, belief in *POOH TAH* can help the villagers unite. They are ready to do something for community development. The *THAO CHAM also* plays a role of a master teacher teaching the villagers to be good and to live harmoniously.

Scientific knowledge in *PAH POOH TAH* can be explained in terms of biological diversity. The sacred forest is a gene bank, ancestry heredity pool, diversity of plants and animals, and soil fertility area. The population of plants and animals are preserved. If there is over population, they will move away from the boundary of *PAH POOH TAH*. Local people can catch and collect them for food because they are out of the rule of *PAH POOH TAH*. At the moment, villagers can collect food or herbs in *PAH POOH TAH* for survival. The rule to save *PAH POOH TAH* has emerged from the villagers. It seems to local rule that local act is more effective to conserve environment than the government law. People can learn how to save money and save environment.

Process: *PAH POOH TAH* has been sustainable in accordance with village development for a long time. When we try to teach science based on the local culture to the students, we have to understand the culture. It can be described in terms of belief and way of doing.

Scientific process is harmonious in *POOH TAH* ceremony. Prediction of local environment, observation, measurement, classification, and the relationships between space and space, and between space and time are employed. Moreover, the hypotheses are formed and verified.

Local people will bring knotted coconut leaf or knotted lemon grass to join the ceremonial day. The representative knots of the coconut leaf can be referred to the number of population for demestic animals, and what will happen if animal population changes. They should have the skills of observation, measurement, using numbers, and prediction. These basic skills are related to scientific process skills and probability.

The scientific process skills influence the villagers' habit of mind to conserve environment. Belief and ceremony at *POOH TAH* can make villagers cooperate in protecting, observing, collecting, conserving, and learning. People participate in social activities by verbal communication and hands-on experiences.

Attitude towards science: *PAH POOH TAH*, a pubic forest community is a vital source supporting indigenous people. It is also a learning resource to study how local culture interacts with life. There are several plants, which indigenous people implement for food, herbs, energy, and wood. There are also many kinds of animals, which indigenous people use for food and for making ecosystem in balance.

In using space and collecting products from *PAH POOH TAH*, indigenous people can visit *PAH POOH TAH* any time when they want. It seems to indigenous people as a mini supermarket for i.e., mushroom, fruit, firewood, herbal plant, bird, chamaleon. It is clear for the purpose of conservation of natural resources to be fairly and efficiently used by the members. The incentive for members in the community is to only conserve *PAH POOH TAH* but not for commercial.

The appropriate price for the utilization of public property can be described in terms of property belonging to everyone. Any specific individual does not own it. The most effective way to manage this forest area is to allow all a fair use of the property by agreeing the rules for sustainable usage that all members of community must observe. These practices are more efficient and effective to conserve forest area than those if done through government agencies.

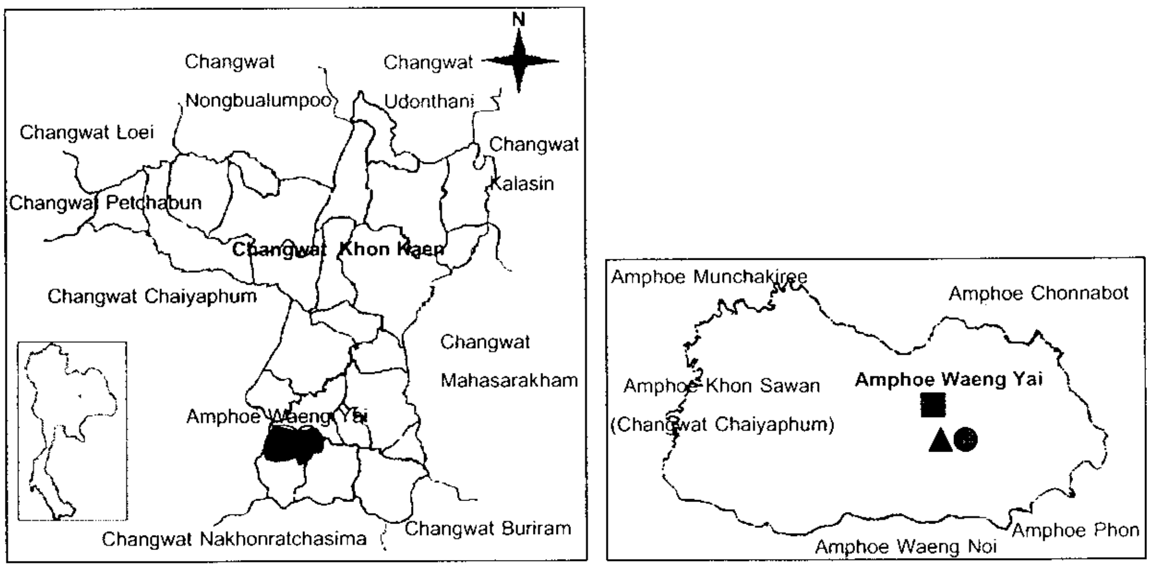
Focusing on the ways to conserve and manage natural resources, the balance of ecosystem can reflect the intelligence of indigenous people. They can preserve forest community by no means of destruction mind. Local rule and law are designed and used for all indigenous people.

1.2 Study site

In this study, three communities were selected from two Tambon; Tambon Khon Chim (Baan Don Jode) and Tambon Mai Na Pieng (Baan Don Hun and Baan Nonchantuek). These communities located in Amphoe Waeng Yai, Changwat Khon Kaen.

Amphoe Waeng Yai located in the northeastern region of Thailand. It is 372 km far from Bangkok and has an area of 189.069 km^2 or 118,168 rais. Geographically, it situated on the Korat plateau, which has the elevation of 100-200 m above mean sea level. Amphoe Waeng Yai is adjacent to the other Amphoes (Figure 8):

North	-	Amphoe Munchakiree and Amphoe Chonnabot
South	-	Amphoe Waeng Noi
East	-	Amphoe Phon
West	-	Amphoe Khon Sawan (Changwat Chaiyaphum)



(A) (B)

Figure 8 Showing map of study site (A) Changwat Khon Kaen (B) Amphoe Waeng Yai (● Baan Don Hun, ■ Baan Don Jode, and ▲ Baan Nonchantuek)

Amphoe Waeng Yai is subdivided into 5 Tambons, among these, they compose of 50 villages. There are 7 villages in Tambon Waeng Yai, 9 villages in Tambon Khon Chim, 14 villages in Tambon Mai Na Pieng, 9 villages in Tambon Non Sa-Ard, and 11 villages in Tambon Nonthong.

Amphoe Waeng Yai has 25 primary schools, 2 secondary schools, 8 temples, 14 bureaus of monk, 19 monk lodgings, one hospital with 30 bed-service, 5 health centers, and one police station.

Most people have faith in the Buddhism and are farmers. The soil in this region is Roi-Et Renu series according to the Department of Soil Development, Ministry of Agriculture and Cooperation. There is Chee river flowing in the eastern part of the Amphoe with the length about 20 km. The natural forest covers about 52,450 rais, which is protected by the 6th Forest Sanctuary (Non Sa-Orn). There was an exploration for oil and natural gas by the Ameraida Hess Exploration Company, but the reserve doesn't have economic value.

The study sites in this study were three schools community in Amphoe Waeng Yai. They are Baan Don Hun, Baan Don Jode, and Baan Nonchantuek which will be discussed as follows.

1.2.1 Baan Don Hun

Baan Don Hun is in the area of Tambon Mai Na Pieng. Khun Amphoe Vichit Bali established this Tambon in 1861. He leaded 10 households from Baan Sema Na Pieng, Amphoe Bua Yai, Changwat Nakhonratchasima to build a village. Mai Na Pieng is located about 9 km away to the south of the center of Amphoe Waeng Yai. It was separated from Tambon Khon Chim on May 9th, 1968 and is divided into 14 villages i.e. Baan Mai Na Pieng, Baan Non Daeng, Baan Don Hun, Baan Nonchantuek, Baan Jodeyai, Baan Sokephai, Baan Tha Lung Lek, Baan Non Thum, Baan Sokeluem, Baan Tha Yiem, Baan Non Bho, Baan Huaikae, Baan Rom Bhothong, and Baan Mai Na Pieng Pattana.

Baan Don Hun was established in 1895. The first cohort migrated from Changwat Roi Et. At that time, Mr. Seehanart, the leader, together with his friends built the village. The given name of a village was represented by geographical characteristics. The village is located in the small hill (Don) where there are plenty of trees called "Hun". It has an area of 4,767 rais and located about 7.5 km away to the south of the center of Amphoe Waeng Yai.

Chumchon Baan Don Hun school is located to the north of the village. The teaching services are available between early childhood and secondary education. There is *POOH TAH* house to the west of the school area. When indigenous people make a ceremony, students can learn what and how people pay respect to *POOH TAH* (Figure 9).

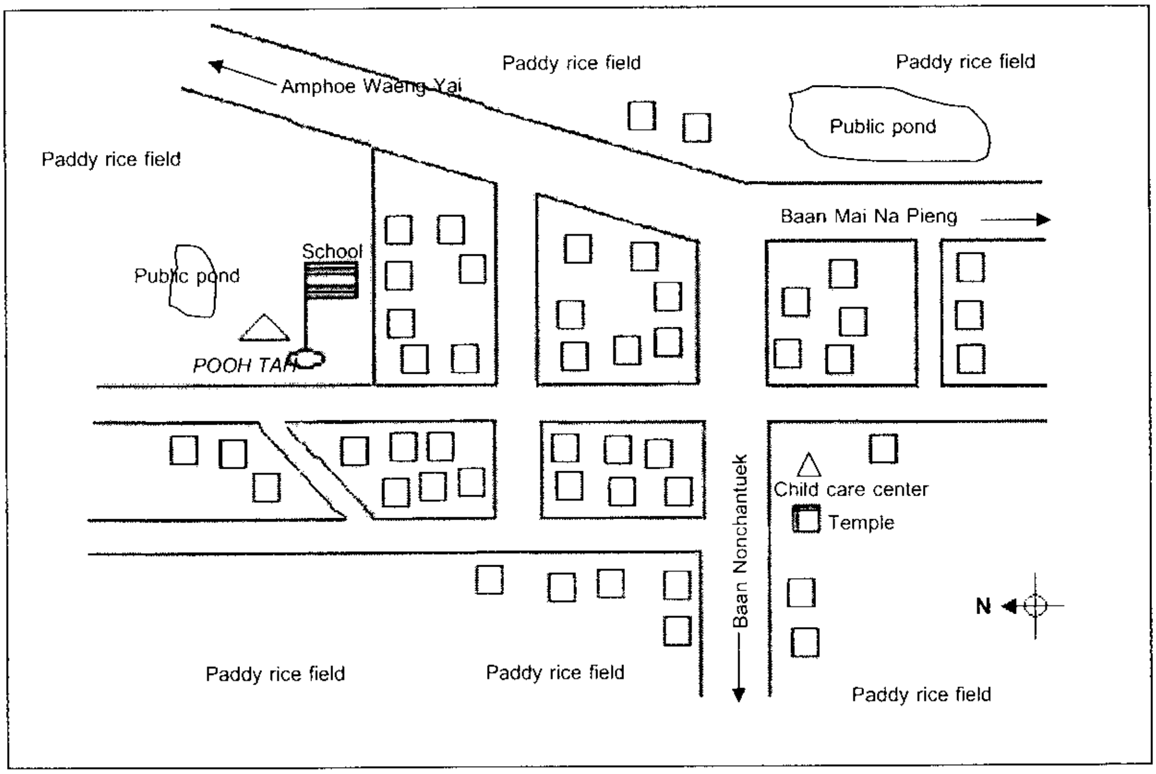


Figure 9 Map of Baan Don Hun (□ = House)

1.2.2 Baan Don Jode

Baan Don Jode is in the area of Tambon Khon Chim. The history of this area has started since 1771. Mr. Khun Munla was the first leader of the village. He brought a group of people from Amphoe Suwan Naphoom, Changwat Roi Et to Baan Khon Chim. The general physical geography has the characteristics of plain, small hill, and is close to Nong Ein stream. Three groups were categorized. First group settled at Baan Khon Chim. Second group settled at Baan Waeng Yai. Third group settled at Baan Dong Bang.

In 1892, Khun Munla established Tambon Khon Chim based on the administration of Amphoe Chonnabot. There were 13 villages in Tambon Khon Chim i.e. Baan Nonthong, Baan

Non Yai, Baan Mai Na Pieng, Baan Don Hun, Baan Waeng Yai, Baan Don Jode, Baan Non Sa-Ard, Baan Kud Maak Heb, Baan Nong Kra Rog, Baan Na Bho, Baan Nong Daeng, Baan Non Kao Noi, and Baan Dong Bang.

Baan Non Thong was separated and established as Tambon Non Thong in 1949. Baan Mai Na Pieng also was separated and established as Tambon Mai Na Pieng in 1968. Baan Waeng Yai was separated and established as Tambon Waeng Yai in 1979. Today, Tambon Khon Chim has 9 village members; Baan Khon Chim, Baan Nonyai, Baan Nonsawan, Baan Dongbang, Baan Pahdang, Baan Don Jode, Baan Koksawang, Baan Nonkaonoi, and Baan Khon Chimpattana.

Baan Don Jode was established in 1894. The first cohort, Poh Pradaeng Zan, Poh Tah Mode, and their relatives moved from Baan Khon Chim to Baan Don Jode. Many years later, people from Baan Khon Chim and Non Kao Noi immigrated to Baan Don Jode.

In 1933, Mr. Pa Chantapa and villagers provided a piece of land of 6 rais for building a temple in the eastern part of the village. Amphoe Pon chief officer, Khun Seraphum Pipat established the school on May 11, 1939. At that time the students used the temple hall as a temporary classroom. Thirty-seven years later (1976) the head of the village, Mr. Umkha Piriya and villagers built a new school hall at Don Mah Tai (the hill of dead dogs), which is located to the west of the village (Figure 10). In 1979, an area of 21 rais at Don Mah Tai was registered as a Crown property and preserved for school. The *PAH POOH TAH* is located near the village to the west.

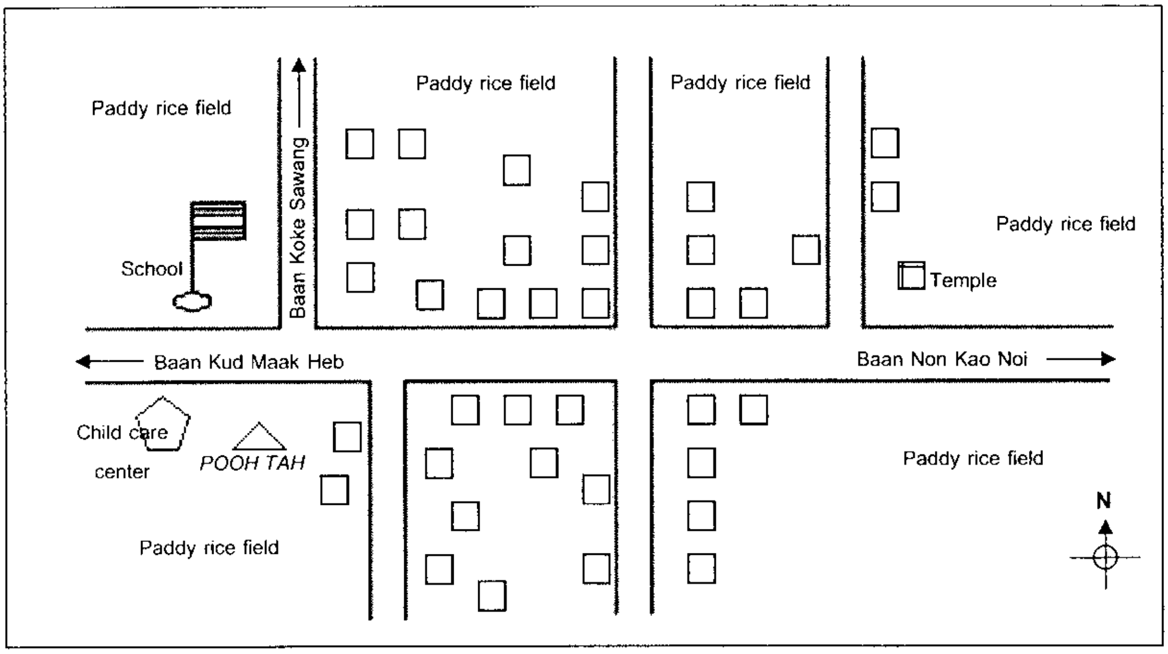


Figure 10 Map of Baan Don Jode (□ = House)

1.2.3 Baan Nonchantuek

Baan Nonchantuek was occupied by Tambon Mai Na Pieng. It was established in 1914. The first cohort consisted of 8 families. They moved from Baan Mai Na Pieng. Mr. Prab Bali was the first leader. He pursuaded his friends for settling the village by selecting Baan Nonchantuek based on the area for agricultural practice reasons.

The name of the village was represented by geographical characteristics. The village is located in the small hill (Non) with plenty of trees namely "E-Tuek" and near the stream. Mr. Prab Bali gave the name of the village is "Baan Ba E-Tuek". Baan Nonchantuek is located about 3 km to the west of the center of Amphoe Waeng Yai.

Baan Nonchantuek school was built in 1939. It was named "Pracha Bann Serm Si Ka Khon Chim 11 Bann Ba E-Tuek". The first principal is Mr. Suwan Wiengwongse. He changed the name of the village to be "Baan Nonchantuek" in 1943 based on the geographical characteristics. The school is located to the north of the village (Figure 11). *PAH POOH TAH* is located near the village to the east.

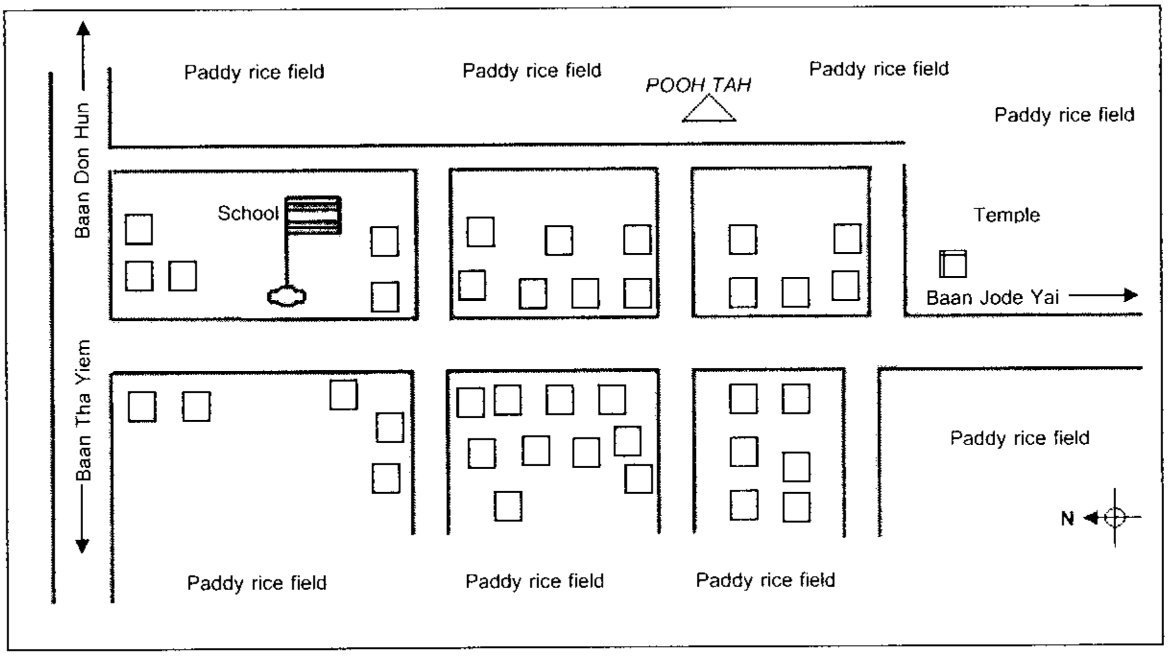


Figure 11 Map of Baan Nonchantuek (□ = House)

2. Modelling to reinforce science learning through local culture

The Institute for the Promotion of Teaching Science and Technology (IPST) analyzed the Basic Education Curriculum 2001 for the national science education standards. Then, the IPST made a manual guide for science learning area management. The researcher studied related theories in science curriculum development based on the framework of this manual guide.

The result of synthesis science curriculum is designed according to national science education standards (subcategories 2 and 8) and national social studies, religion, and culture standards (subcategory 5). Objectives are synthesized and clarified as follows;

Cognitive domain consists of; (1) students describe terminology of natural resources and environments, (2) students explain role and importance of natural resources and environments, (3) students describe terminology and explain the importance of biological diversity, (4) students explain the relationship between environments and living things, (5) students explain the relationship between living things and its ecosystem, (6) students explain the relationship between local culture and its role to conserve natural resources and environments, and (7) students explain the ways to sustain natural resources in local community.

Psycho-motor domain consists of: (1) students classify living things into groups, (2) students collect physical data and biological data in ecosystem, (3) students analyze the relationship between limiting factors and biological diversity in ecosystem, (4) students explore local culture for conserving local natural resources and environments, and (5) students present the ways to conserve and to sustain natural resources and environments

Affective domain consists of: (1) students promote environmental conservation mind, (2) students are aware of and accept local culture, (3) students promote values of science-culture in accord, and (4) students promote environmental conservation behavior.

The designed science curriculum integrated science and social studies. Expected learning outcome and science learning area for students' Mathayomsuksa 3 is analyzed. The expected learning outcome can be categorized into 3 issues: (1) students can explore, analyze, and explain about local environment and natural resources, (2) students can propose ideas on how to conserve ecosystem and to sustain natural resources, and (3) students participate in environmental monitoring in local community.

Science learning area for students' Mathayomsuksa 3 in the study consists of 6 issues: (1) students explore, observe, and analyze the diversity of plants and animals. They also discuss the importance of biological diversity and ecological niche, (2) students explore, discuss, and analyze about environmental problems and natural resources misuse in local community. They can understand why local culture can help sustain natural resources and environments in local community, (3) students discuss ways to make ecosystem balanced. They can use local knowledge and scientific knowledge to protect ecosystem balanced, (4) students explore and discuss biological diversity. They can understand ecosystem inbalance affecting way of life, (5) students protect and monitor local environments, and (6) students discuss and present the ways to manage natural resources in *PAH POOH TAH* sustaining the environments based on ecological principles.

Additionally, The result of analysis of science curriculum is useful for designing the lesson plan, which is used for reinforcement of science learning through local culture. The synthesized science curriculum gave the draft of curriculum framework. Then the data of the curriculum framework were used after verified by the experts in Delphi technique.

The Delphi technique was employed to study how to reinforce science learning through local culture. The opinions from 24 expert participants were considered. The analysis of Delphi study is provided here. The data is explained by Median (Mdn), Interquartile range (I.R.), and Mode-Median (Mo-Mdn).

The rest of this dissertation will discuss the research findings how to reinforce science learning through culture. The issues concerned science subject for Mathayomsuksa 3 in the study area of life and environments. Five issues were rated by the expert members and represented in terms of Median and Interquartile range in each statement.

2.1 Participants

The results of the two round Delphi study reflect the consensus of opinions from 24 expert participants. Topics related to reinforcement of science learning through local culture are developed. Then the data were analyzed and prepared for the first round of Delphi questionnaires.

The 5 issues, relevant science topics, learning objectives, learning management, materials and learning resources, and assessment were designed as a question. It was used to ask the member of experts by Delphi technique. Totally, 97 statements in the questionnaires, which the panel members were asked to rate them on a Likert-type scale as to degree of agreement (3 = Strongly agree, 2 = Agree, 1 = Disagree, 0 = Strongly disagree). In addition, this round allowed them to provide more suggestion and discussion in the end of each issue.

The second round questionnaire featured the panel rating for 90 statements. Median and Interquartile range were presented to all panel members. This round, panel members were asked to re-rate the items and taking the information into account.

The information of Delphi panel members can then fulfill the reinforcement of science learning through local culture and is presented in Table 3. Most of them are male in both first and second rounds. They are 30-60 year-old members with educational background of higher than bachelor degree, and teaching in universities. Their jobs are in different level of educational system.

Table 3 Demographic information of expert participants completing the Delphi study

Demographic item	First round		Second round	
	N	%	n	%
Gender				
Male	10	55.56	8	57.14
Female	8	44.44	6	42.86
Age				
30-40 years	4	16.67	2	14.28
41-50 years	8	33.33	6	42.86
51-60 years	6	25.00	6	42.86
More than 60 year	0	0.00	0	0.00
Education				
Master degree	7	38.89	6	42.86
Doctoral degree	11	61.11	8	57.14
Institutional afiliation				
University	15	83.33	12	85.72
School	2	11.11	1	7.14
Public organization	1	5.56	1	7.14

2.2 Relevant science topics

The relevant science topics for reinforcement of science learning through local culture in terms of life and environment issue were selected. They comprise of three topics: biological diversity, ecosystem, and environmental conservation. The Delphi panel experts expressed their opinion to the relevant science topics for reinforcement of science learning through culture. Seven issues are listed and selected by the panel members (Table 4); Man and environment, way of life and learning process of local people, natural resources and environments, natural resource and environmental conservation, biological diversity, and ecological system studies are considered for reinforcement science learning through local culture in Mathayomsuksa 3.

Table 4 Experts' rating for relevant science topics

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
1. Natural resources and environments	2.89	0.61	2.96	0.54	0.04
2. Biological diversity	2.93	0.57	2.96	0.54	0.04
3. Ecological system studies	2.79	0.71	2.85	0.64	0.15
4. Man and environments	2.89	0.61	3.00	0.50	0.00
5. Way of life and learning process of local people	2.89	0.61	3.00	0.50	0.00
6. Characteristics of geographical community	2.79	0.71	2.85	0.64	0.15
7. Natural resource and environmental conservation	2.89	0.61	2.96	0.54	0.04

2.3 Learning objectives

The learning objectives can be considered into three domains (Table 5). Cognitive domain consists of 5 items: (1) analyze the relationship between living things and environments, (2) analyze the interrelationship among living things in ecosystem, (3) conclude the relationship between local culture and natural resource and environmental conservation, (4) discuss how to sustain the natural resources in local community, and (5) propose the means to conserve natural resources and environments in local community.

Psycho-motor domain consists of 4 items: (1) observe and classify living things, (2) collect biological and physical data in ecosystem, (3) process the data to find out factors influencing the biological diversity, and (4) conclude the ways to sustainably conserve and manage natural resources and environments.

Affective domain consists of 5 items: (1) beware of environments, (2) beware of local culture, (3) accept local culture, (4) know the importance of the values of science-culture in accord, and (5) promote the behavior of environmental conservation.

Table 5 Experts' rating for learning objectives

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
1. Cognitive domain					
1.1 Explain meaning and importance of natural resources and environments	2.50	1.06*	-	-	-
1.2 Explain meanings and importance of biological diversity	2.60	1.10*	-	-	-
1.3 Analyze the relationship between living things and environments	2.94	0.56	2.92	0.58	0.08
1.4 Analyze the interrelationship among living things in ecosystem	2.86	0.64	2.80	0.77	0.20
1.5 Conclude the relationship between local culture and natural resource and environmental conservation	2.90	0.60	2.96	0.54	0.04
1.6 Discuss how to sustain the natural resources in local community	2.68	0.95	2.63	0.87	0.37
1.7 Propose the means to conserve natural resources and environments in local community	2.81	0.75	2.80	0.77	0.20
2. Psycho-motor domain					
2.1 Observe and classify living things	2.60	0.99	2.63	0.87	0.37
2.2 Collect biological and physical data in ecosystem	2.81	0.77	2.80	0.70	0.20
2.3 Process the data to find out factors influencing the biological diversity	2.75	0.88	2.72	0.91	0.28

Table 5 (continued)

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
2.4 Conclude the ways to sustainably conserve and manage natural resources and environments	2.86	0.64	2.92	0.58	0.08
3. Affective domain					
3.1 Beware of environments	2.97	0.57	3.00	0.50	0.00
3.2 Beware of local culture	2.86	0.53	2.86	0.63	0.14
3.3 Accept local culture	2.81	0.64	2.86	0.63	0.14
3.4 Know the importance of the science-culture in accord	2.75	0.76	2.72	0.98	0.28
3.5 Promote the behavior of environmental conservation	2.94	0.88	2.96	0.54	0.04

* = Panel members rejected the sentence

2.4 Learning management

Learning management can be classified into 4 criteria including (1) learning process, (2) reinforcement, (3) the role of student, and (4) the role of teacher. The details are given in Table 6.

1. Learning process: five steps of learning process called LADDA instructional model is designed. The LADDA stands for Learning, Analyzing, Deciding, Doing, and Application. Learning stage needs students to discuss the scientific environmental problems in the *PAH POOH TAH*, explain the importance of natural resources and environments, analyze the natural resource problems in local community, analyze the environmental problems in local community, and conclude the environmental problems relating to the way of life and of community. Analyzing stage requires students to collect and to categorize data, rank environmental problems, and seek issues based on the problem sequences. Deciding stage requires students

Table 6 Experts' rating for learning management

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
1. Learning management process					
1. Learning stage					
1.1 Students discuss the scientific environmental problems in the *PAH POOH TAH*	2.75	0.75	2.72	0.99	0.28
1.2 Students explain the importance of natural resources and environments	2.68	0.60	2.72	0.91	0.28
1.3 Students analyze natural resource problems in local community	2.86	0.88	2.92	0.58	0.08
1.4 Students analyze environmental problems in local community	2.86	0.88	2.86	0.63	0.14
1.5 Students conclude environmental problems relating to the way of life and of community	2.94	0.56	2.96	0.54	0.04
2. Analyzing stage					
2.1 Students collect and categorize data	2.60	0.99	2.50	1.00	0.50
2.2 Students rank environmental problems	2.60	0.99	2.63	0.87	0.37
2.3 Students seek issues based on the problem sequences	2.50	1.18*	-	-	-
3. Deciding stage					
3.1 Students choose question and list issues for investigating the learning resources	2.81	0.75	2.92	0.58	0.08
3.2 Student lists the problems based on scientific processes relating to the *PAH POOH TAH*	2.85	0.65	2.92	0.58	0.08

Table 6 (continued)

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
3.3 Students discuss issues to set the hypothesis	2.73	0.90	2.63	0.98	0.37
3.4 Students assess the possibility for investigation	2.85	0.65	2.72	0.91	0.28
4. Doing stage					
4.1 Students and teacher determine rules for investigation	2.60	1.05*	-	-	-
4.2 Students plan to collect data systematically	2.85	0.65	2.86	0.63	0.14
4.3 Students observe phenomena seriously	2.89	0.61	2.92	0.58	0.08
4.4 Students collect data systematically	2.85	0.65	2.86	0.63	0.14
4.5 Students analyze data without bias	2.85	0.65	2.80	0.77	0.20
4.6 Students discuss the findings of scientific searching	2.94	0.56	2.92	0.58	0.08
4.7 Students make the conclusions from their study	2.94	0.56	2.92	0.58	0.08
5. Application stage					
5.1 Students present their works in form of brochure	2.60	0.95	2.63	1.06*	0.37
5.2 Students make the conclusions for the conservation of the *PAH POOH TAH* via a concept map	2.75	0.93	2.72	0.99	0.28
5.3 Students are evaluated on their learning results by observation inquiry and checking the papers	2.86	0.64	2.80	0.77	0.20

Table 6 (continued)

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
5.4 Students assess the learning results without bias, reflecting the scientific process skills and values of scientific-cultural in accord	2.81	0.75	2.72	0.91	0.28
2. Reinforcement					
1. Teacher praises and encourage students	2.68	1.01*	-	-	-
2. Teacher accepts opinions and reasons of students	2.94	0.56	2.92	0.58	0.08
3. Teacher pay attention to the students	2.94	0.56	2.96	0.54	0.04
4. Teacher looks after the students to be safe while doing an experiment	2.90	0.60	2.86	0.63	0.14
5. Teacher pays attention to give some suggestions to the students while they study	2.90	0.60	2.86	0.63	0.14
6. Teacher builds the scientific learning atmosphere	2.94	0.56	2.92	0.58	0.08
7. Teacher understands feeling and nature of students	2.81	0.75	2.80	0.77	0.20
8. Teacher concerns and gives useful suggestion to the students	2.81	0.75	2.86	0.63	0.14
9. Teacher acts as a role model of a scientific mind	2.94	0.56	2.96	0.54	0.04
10. Teacher promotes environmental conservation behavior	2.86	0.64	2.92	0.58	0.08
11. Teacher promotes the students to accept local culture	2.75	0.88	2.80	0.77	0.20

Table 6 (continued)

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
12. Teacher promotes students to accept science-culture in accord	2.85	0.65	2.86	0.63	0.14
13. Teacher allows members of community to participate in educational management	2.79	1.84*	-	-	-
14. Teacher invites indigenous specialist into classroom to transfer the knowledge to the students	2.89	0.72	2.96	0.54	0.04
3. Roles of the students					
1. Students explore nature by employing scientific method	2.97	0.53	2.92	0.58	0.08
2. Students analyse environmental problems in local community	2.90	0.60	2.92	0.58	0.08
3. Students make scientific learning atmosphere	2.73	0.90	2.80	0.77	0.20
4. Students discuss what they have learnt creatively	3.00	0.50	3.00	0.50	0.00
5. Students pay attention to experiments	2.90	0.60	2.96	0.54	0.04
6. Students accept what teacher advises	2.68	1.01*	-	-	-
7. Students has a good attitude towards science	2.81	0.76	2.92	0.58	0.08
8. Students promote the values of science	2.75	0.88	2.86	0.63	0.14
9. Students promote environmental conservation behavior	2.81	0.77	2.92	0.58	0.08
10. Students aware of and accept local culture	2.75	0.88	2.86	0.63	0.14

Table 6 (continued)

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
4. Roles of teacher					
1. Teacher prepares learning environment	2.86	0.64	2.92	0.58	0.08
2. Teacher prepares learning materials	2.75	0.88	2.72	0.91	0.28
3. Teacher motivates students to observe natural phenomena and environment	2.94	0.56	2.92	0.58	0.08
4. Teacher cares for safety experimentation	2.81	0.75	2.96	0.54	0.08
5. Teacher pays attention and observes student's experimentation	2.94	0.56	2.96	0.54	0.04
6. Teacher tries to understand student's feeling and need, and teacher takes reasonable response	2.81	0.75	2.92	0.58	0.08
7. Teacher listens to the students and give valuable suggestion	2.97	0.53	2.96	0.54	0.04
8. Teacher admires and encourages to students	2.75	0.88	2.86	0.63	0.14
9. Teacher establishes the values of science for all students	3.00	0.50	3.00	0.50	0.00
10. Teacher promotes environmental conservation behavior	2.90	0.60	2.96	0.54	0.04
11. Teacher awares of and accepts science-culture in accord	2.86	0.64	2.92	0.58	0.08
12. Teacher is a role model of scientific mind	2.86	0.64	2.92	0.58	0.08
13. Teacher monitors scientific learning behavior of the students	2.90	0.60	2.92	0.58	0.08
14. Teacher monitors scientific learning achievement of the students	2.86	0.64	2.86	0.63	0.14

* = Panel members rejected the sentence

to choose question and list issues for investigating the learning resources, list the problems based on scientific processes relating to the *PAH POOH TAH*, discuss issues to set the hypothesis, and assess the possibility for investigation. Doing stage requires students to plan to collect data systematically, observe phenomena seriously, analyse data without bias, discuss the findings of scientific searching, and make the conclusions from their study. Application stage requires students to make the conclusions for the conservation of the *PAH POOH TAH* via concept map, evaluate on their learning results by observation inquiry and checking the papers, and assess the learning results without bias by reflecting the scientific process skills and values of scientific method.

2. Reinforcement include the way to reinforce science learning through local culture. Teacher should accept an opinion and a reason of students; teacher pays attention to the students; teacher looks after the students to be safe while doing and experiment; teacher pays attention to give suggestions while the students study; teacher builds the scientific learning atmosphere; teacher understands feeling and nature of students; teacher concerns and gives useful suggestion to the students; teacher acts as a role model of a scientific mind; teacher promotes environmental conservation behavior; teacher promotes the students to accept local culture; teacher promotes students to accept science-culture in accord; and teacher invites indigenous specialist into classroom to transfer the knowledge to the students.

3. The roles of student include student explores nature by employing scientific method, analyses environmental problems in local community, makes scientific learning atmosphere, discusses what they have learnt creatively, pays attention to experiments, has a good attitude towards science, promotes the values of science, promotes environmental conservation behaviour, and awares of and accepts local culture.

4. The roles of teacher include teacher prepares learning environment, prepares learning materials, motivates students to observe natural phenomena and environment, cares for safety experimentation, pays attention and observes student's experimentation, tries to understand student's feeling, takes reasonable response, listens to the students and gives valuable suggestion, admires and encourages to all students, establishes the values of science for all students, promotes environmental conservation behavior, awares of and accepts science-culture in accord, acts as a role model of scientific mind, monitors scientific learning behavior of the students, and monitors scientific learning achievement of the students.

2.5 Materials and learning resources

Materials and learning resources for reinforcement of science learning through local culture should be used diversely. Materials can motivate the student to express their feeling. Materials and learning resources can be easily found in local community. Materials should be related to the way of students' life. Materials should not harm students and environments. Learning resources are lively e.g. indigenous specialists, monks, and elders. Learning resources initiate holistic view of learning to the students and help students to accept local culture. The detail of Delphi study about materials and learning resources is shown in Table 7.

Table 7 Experts' rating for materials and learning resources

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
1. Teacher uses materials diversely	2.97	0.53	2.96	0.54	0.04
2. Teacher uses materials to motivate the student to express their feeling	2.86	0.64	2.77	0.73	0.23
3. Materials and learning resources can be easily found in local community	2.81	0.75	2.92	0.58	0.08
4. Materials should be related to the way of students' life	2.90	0.60	2.96	0.54	0.04
5. Materials should not harm the students and environments	2.81	0.75	2.80	0.77	0.20
6. Learning resources are lively e.g. indigenous specialists, monks, and elders	2.81	0.75	2.86	0.63	0.14
7. Learning resources initiate holistic view of learning to the students	2.86	0.64	2.86	0.63	0.14
8. Learning resources help students to accept local culture	2.90	0.60	2.92	0.58	0.08

2.6 Assessment

The assessment should be related to learning management by employing authentic assessment that reflects the knowledge skills, scientific process skills, and values of culture for scientific method of the students. To assess the students was done by observation for learning behaviors of the students in every learning step and by a variety ways e.g. questioning, observing, and checking the projects. Students also assess themselves in order to express their feeling and analyze their works and to let the results from the assessment return to the students. The detail of Delphi study about the assessment is shown in Table 8.

Table 8 Experts' rating for the assessment

Item	First round		Second round		
	Mdn	I.R.	Mdn	I.R.	Mo-Mdn
1. Authentic assessment that reflects the knowledge skills, scientific process skills, and values of culture for scientific method of the students	2.81	0.75	2.80	0.77	0.20
2. Assess the students by observation for learning behaviors of the students in every learning step	2.75	0.88	2.80	0.77	0.20
3. Assess in a variety way e.g. questioning, observing, and checking the projects	2.97	0.53	2.96	0.54	0.04
4. The students assess themselves in order to express their feeling and analyze their works	2.90	0.60	2.86	0.63	0.14
5. Let the results from assessment return to the students	2.86	0.64	2.86	0.63	0.14

The data from Delphi study provided a framework to design science curriculum based on the reinforcement of science learning through local culture. Lesson plans and activity plans were constructed.

3. Designing curriculum

The curriculum is designed by using Basic Education Curriculum 2001 of the national science education standards: subcategory 2 (Life and environment); subcategory 8 (Nature of science and technology); of the national social studies; religion; and culture standards: subcategory 5 (Geography), and using the data from the documentary and community studies.

The importance of science and its role in learning society were studied. The result of documentary study and community study provided local culture perspectives. The accordance between science and local culture in terms of *PAH POOH TAH* is considered. The analysis and synthesis of science curriculum presented how proposed science curriculum which reinforces science learning through local culture should be designed. Also, Delphi study provided a model of reinforcement of science learning through local culture. All of the study results mentioned above give an advise in appropriate ways to design the science curriculum. It also brings about a framework of lesson plan development.

There were three developed science lesson plans. Each lesson plans consists of (1) learning objectives, (2) scientific concept, (3) teacher preparation, (4) learning process, (5) evaluation and assessment, (6) media, and (7) learning resources. Three experts assessed the effectiveness of proposed science lesson plans. The result of the assessment on the developed science lesson plans is provided in Table 9 and 10.

The result of experts' assessment in the appropriateness and congruency provided valuable suggestion. The proposed science lesson plans were improved before pilot study and the implementation were conducted. The appropriateness of language, content, and format in each lesson plan were improved. Then, the developed science lesson plans were mailed back to the experts.

Table 9 The appropriateness of proposed science lesson plans

Item	Experts' assessment		Level of
	$\overline{X}$	SD	appropriateness
1. The correspondance between lesson plans and curriculum			
1.1 Expected outcomes are consistent with science learning benchmark for basic education curriculum	4.67	0.58	Very good
1.2 Expected outcomes cover knowledge, process skills, ethic, moral, and value	4.33	0.58	Good
1.3 Learning objectives are consistent with expected outcomes	4.33	0.58	Good
1.4 Learning objectives cover knowledge, process skills, ethic, moral, and value	4.00	0.00	Good
1.5 Science learning areas are consistent with expected outcomes	4.33	0.58	Good
2. Learning activities			
2.1 Activities response learning objectives	4.67	0.58	Very good
2.2 Activities cover science learning areas	4.33	0.58	Good
2.3 Duration of activities is suitable	4.67	0.58	Very good
2.4 Contents in activies are correct	4.67	0.58	Very good
2.5 Activies activate students to discover and create the knowedge by themselves	5.00	0.00	Very good
2.6 Activities activate students to do systematically practical science	5.00	0.00	Very good
2.7 Activities activate students to have direct experiences from nature and environment	5.00	0.00	Very good

Table 9 (continued)

Item	Experts' assessment		Level of
	$\overline{X}$	SD	appropriateness
2.8 Activities activate students to use and apply their knowledge into daily life after they have learned	4.67	0.58	Very good
2.9 Activities activate student to explore the nature	5.00	0.00	Very good
2.10 Activies activate students to choose method of learning based on their interest and skills	4.33	0.58	Good
2.11 Activities activate students to work with other people	5.00	0.00	Very good
2.12 Activities promote awareness of social responsibility	4.33	0.58	Good
2.13 Activities include ethic, moral, and value	4.33	0.58	Good
3. Media			
3.1 Media are consistent with contents and learning objectives	4.33	0.58	Good
3.2 Contents and language are appropriate to the students	4.33	0.58	Good
3.3 Media includes moral and value	4.33	0.58	Good
3.4 Media are low cost but appropriate quality	4.33	0.58	Good
3.5 Media are diversed and multipurposeful	4.33	0.58	Good
3.6 Media create new learning atmosphere	4.67	0.58	Very good
3.7 Media link modern science with local knowledge	4.67	0.58	Very good
3.8 Learning resources are generated in local community	4.67	0.58	Very good

Table 9 (continued)

Item	Experts' assessment $\overline{X}$	SD	Level of appropriateness
4. Assessment			
4.1 Assessment is consistent with learning objectives	4.33	0.58	Good
4.2 Assessment focuses on knowledge, process skills, and values	4.33	0.58	Good
4.3 Assessment is based on diversified data	4.67	0.58	Very good
4.4 Assessment covers the analytical skill	4.00	0.00	Good
4.5 Self-assessment is done by the students	4.33	0.58	Good

Table 10 The congruency of developed science lesson plans

Item	Experts' assessment $\overline{X}$	SD	Congruency
1. Objectives			
1.1 Practicable	1.00	0.00	Agree
1.2 Giving clear details	1.00	0.00	Agree
1.3 Activity objectives are clarified	1.00	0.00	Agree
1.4 Learning objectives are clarified	1.00	0.00	Agree
2. Content			
2.1 Clear	1.00	0.00	Agree
2.2 Continuity	0.67	0.58	Agree

Table 10 (continued)

Item	Experts' assessment		Congruency
	$\overline{X}$	SD	
2.3 Complete	1.00	0.00	Agree
2.4 Consistent with objectives	1.00	0.00	Agree
2.5 Suitable for time duration	1.00	0.00	Agree
2.6 Easy to understand	1.00	0.00	Agree
2.7 Promote the students to formulate scientific concept	1.00	0.00	Agree
2.8 Activate the students to concern environmental conservation	0.67	0.58	Agree
2.9 Activate the students to accept and aware of local culture	0.67	0.58	Agree
3. Learning activities			
3.1 Easy to understand	1.00	0.00	Agree
3.2 Suitable for duration time	0.67	0.58	Agree
3.3 In sequence	1.00	0.00	Agree
3.4 Consistent with objectives	1.00	0.00	Agree
3.5 Promote environmental conservation behavior	1.00	0.00	Agree
3.6 Promote values of science-culture in accord	1.00	0.00	Agree
3.7 Promote science and local culture learning	1.00	0.00	Agree
3.8 The nature of students	1.00	0.00	Agree
4. Media and learning resources			
4.1 Diversity	1.00	0.00	Agree
4.2 Motivate the students to express their potential	1.00	0.00	Agree
4.3 Related to real life of the students	1.00	0.00	Agree
4.4 Support the students to accept and aware of local culture	1.00	0.00	Agree

Table 10 (continued)

Item	Experts' assessment $\overline{X}$	Experts' assessment SD	Congruency
4.5 Easy to prepare and available in community	1.00	0.00	Agree
4.6 Motivate the students to learn the holistic science	1.00	0.00	Agree
5. Assessment			
5.1 Assessment based on real situation	1.00	0.00	Agree
5.2 By diversified methods	1.00	0.00	Agree
5.3 Feedback to the students	0.67	0.580	Agree
5.4 Assessment is consistent with objectives	1.00	0.00	Agree
5.5 Assess the students by observing their learning behavior	1.00	0.00	Agree
5.6 Self-assessment by students to reflect their feeling	0.67	0.58	Agree

A pilot study was employed in aiming to check the activity plans, and to prepare teaching strategy within science classroom. The researcher acted as a facilitator or a supporter for students while doing the pilot study. The students of Mathayomsuka 3 at Waeng Yai Wittayakom School participated this pilot study. The outcomes of the pilot study were used for revision of the activity plans, related documents, learning resources, and research instruments.

4. Implementing curriculum

Three science classrooms of Mathayomsuksa 3 from Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school were selected for the curriculum implementation. The study took place on the first semester of the academic year 2005. The initial implementation stage began by sending the purposive verification letter from Science Education Center, Srinakharinwirot University to the selected three science teachers and administrators. The researcher discussed with the selected three science teachers and prepared learning materials. Then, the researcher played a role as facilitator in science classrooms. The first period the researcher explained the research scheme for the students about how research would be and what benefits would be.

Course description and unit of learning were designed for 20 hours. Unit of learning was divided into 3 subunits i.e. biological diversity, ecological system studies, and man and environments. In learning process, the researcher employed the LADDA instructional model during the implementation. Learning outcomes were examined before and after curriculum implementation.

4.1 Learning process

Five steps of LADDA instructional model consist of learning, analyzing, deciding, doing, and application. Each step was observed in science classrooms. Students' activities and the details of learning process are provided here.

Learning: Students studied organisms in local community i.e. organims in soils of *PAH POOH TAH* (Figure 12A), soil samples from paddy rice field. Then, they identified organisms and classify according to the taxonomical level for illustrating biological diversity conception. They also interviewed the elders and indigenous specialists about the role and the importance of *PAH POOH TAH* (Figure 12B). The discussions in terms of beliefs and cultural aspects of *POOH TAH* affecting to the way of life were held.

Some students had never known what *PAH POOH TAH* was, how important it was, and how science could explain *PAH POOH TAH* in such a way of sustaining biological diversity and local environment. They were eager to learn both science and belief, which they needed reasonable explanation. The knowledge and understanding on *PAH POOH TAH* and scientific knowledge became clearly comprehended.

Analyzing: Teacher asked students about the relationship between science and local culture. Students shared how local culture of *POOH TAH* conserve biological diversity and local environment. They also proposed the ways to conserve local environment by employing scientific process (Figure 12E). Teacher acted as facilitator, advisor, and supporter.

Deciding: Students showed their opinion and express their feeling on the belief in *POOH TAH*. They set hypotheses to be proven that how *POOH TAH* could sustain local environment.

(A) (B) (C) (D) (E)

Figure 12 Students' activities (A - students were studying soil fauna, B - *THAO CHAM* and students were learning science in *PAH POOH TAH*, C - students were studying biological diversity in *PAH POOH TAH*, D - students were studying biological diversity in vegetable field, E - students were making a discussion)

Doing: Students had experimentation by sampling, collecting, identifying, and classifying organisms in soil in *PAH POOH TAH* (Figure 12C and 12D). They also had illustration about organisms in soil as they explored. The scientific process skills were used to gain experimental ability of students.

Application: Students concluded the relationship between local culture and biological diversity. Essays about *PAH POOH TAH* were written by the students. Teacher and students grew plants. A brochure to promote the way of conserving local environment was made.

The LADDA instructional model provides an alternative way of thinking and doing based on the accordance of science and local culture. The teaching-learning processes introduced local culture into science classroom by teacher acting as a facilitator.

4.2 Learning outcomes

The one group pretest and the posttest design was conducted. Science learning achievement and the values of science-culture in accord were measured before and after curriculum implemented. Also, environmental conservation behavior was monitored during the time of study.

4.2.1 Science learning achievement

Students' science learning achievement of three schools has been positively developed. There are significantly different in both pretest and posttest scores at 0.05 level (Table 11). Student's science learning scores in Baan Don Jode school is significantly different between pretest and posttest. The posttest scores are higher than the scores before the science curriculum implemented.

Table 11 Science learning scores of the students from three schools

School	n	Pretest			Posttest			df	t
		Max-Min	$\overline{X}$	SD	Max-Min	$\overline{X}$	SD		
Don Jode	21	30-11	18.67	4.67	33-12	22.29	6.35	20	17.33*
Don Hun	18	29-13	20.56	4.56	34-11	24.72	6.71	17	18.22*
Nonchantuek	26	27-10	19.46	4.59	33-15	24.42	5.30	25	22.57*

* Significantly different at 0.05

The analyzed data of students' science learning scores before proposed science curriculum implemented are between 11 and 30 with an average of 18.67. After the proposed science curriculum and the way to reinforce science learning through local culture were conducted. Then the students' science learning scores were measured. The scores after curriculum implemented are higher than those of before curriculum implemented. The posttest scores are between 12 and 33 with an average of 22.29. Also, t-test dependent was analyzed. It revealed that the pretest and posttest scores are significantly different at 0.05 level.

The students' science learning achievement in Baan Don Jode school was measured before and after curriculum implemented. Some students' scores decreased after they had learned. However, most of them could increase scores based on science learning through local culture (Figure 13).

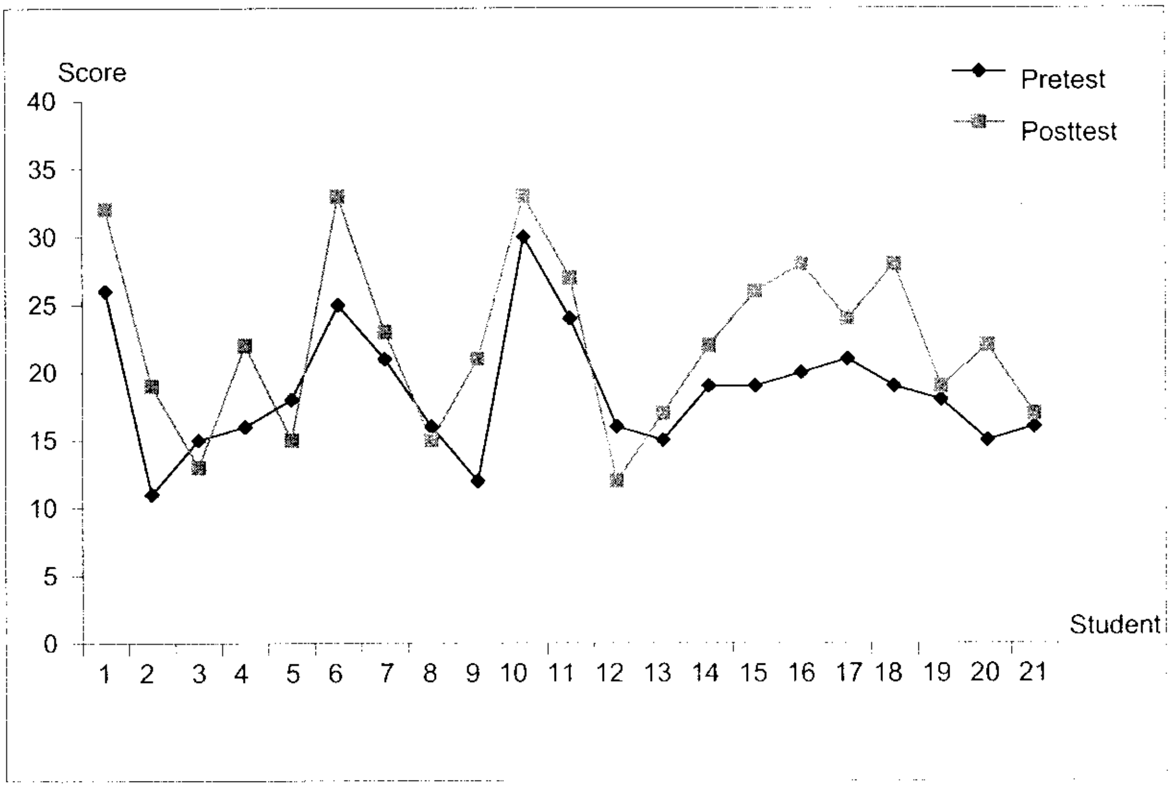


Figure 13 Student's science learning scores in Baan Don Jode school.

Student's science learning scores in Chumchon Baan Don Hun school are significantly different between pretest and posttest. Their posttest scores are higher than the scores before the science curriculum are implemented.

The analyzed data of students' science learning scores before proposed science curriculum implemented are between 13 and 29 with an average of 20.56. After the proposed science curriculum and the way to reinforce science learning through local culture were conducted. Then the scores after curriculum implemented were higher than those of before curriculum implemented. The posttest scores are between 11 and 34 with an average of 24.72. Also, t-test dependent was analyzed. It revealed that the pretest and posttest scores are significantly different at 0.05 level.

The students' science learning achievement in Chumchon Baan Don Hun school was measured before and after curriculum implemented. Some students' scores decreased after they had learned. However, most of them could increase scores based on science learning through local culture (Figure 14).

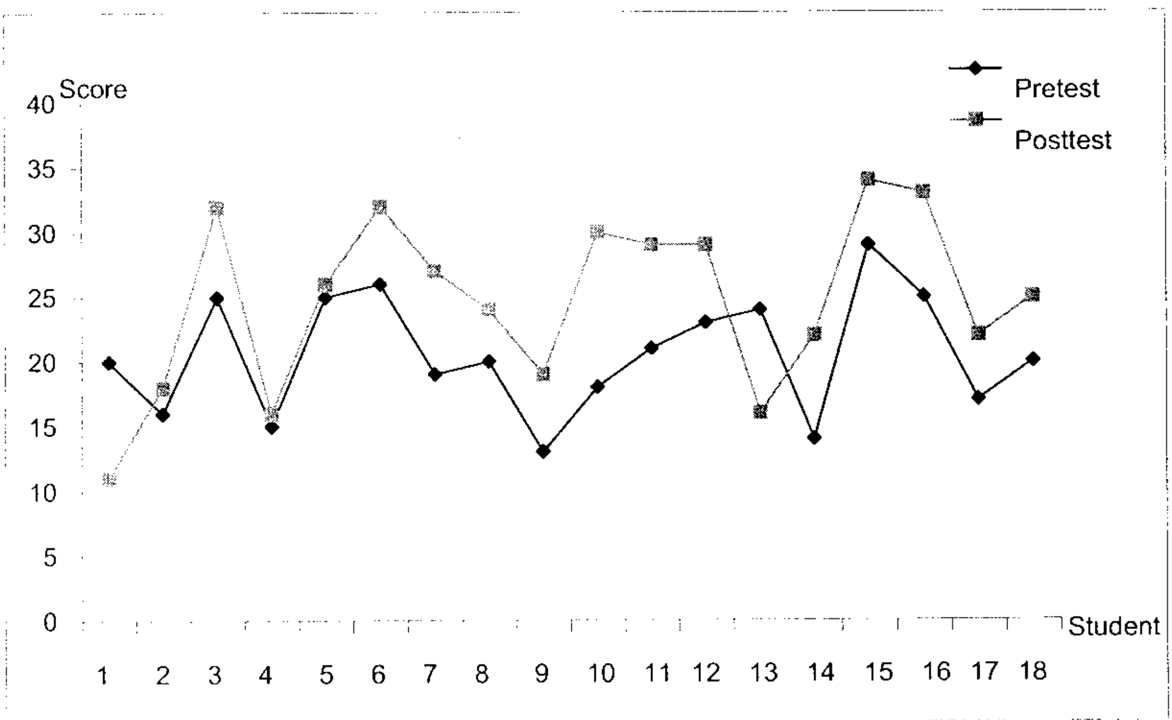


Figure 14 Student's science learning scores in Chumchon Baan Don Hun school.

Students' science learning scores in Baan Nonchantuek school are significantly different between pretest and posttest. Their posttest scores are higer than the scores before curriculum are implemented.

The analyzed data of students' science learning scores before proposed science curriculum implemented are between 10 and 27 with an average of 19.46. After the proposed science curriculum and the way to reinforce science learning through local culture were conducted. Then the students' science learning scores were measured. The scores after curriculum implemented are higher than those of before curriculum implemented. The posttest scores are between 15 and 33 with an average of 24.42. Also, t-test dependent was analyzed. It revealed that the pretest and posttest scores are significantly different at 0.05 level.

The students' science learning achievement in Baan Nonchantuek school was measured before and after curriculum implemented. Some students' scores decreased after they had learned. However, most of them could increase scores based on science learning through local culture (Figure 15).

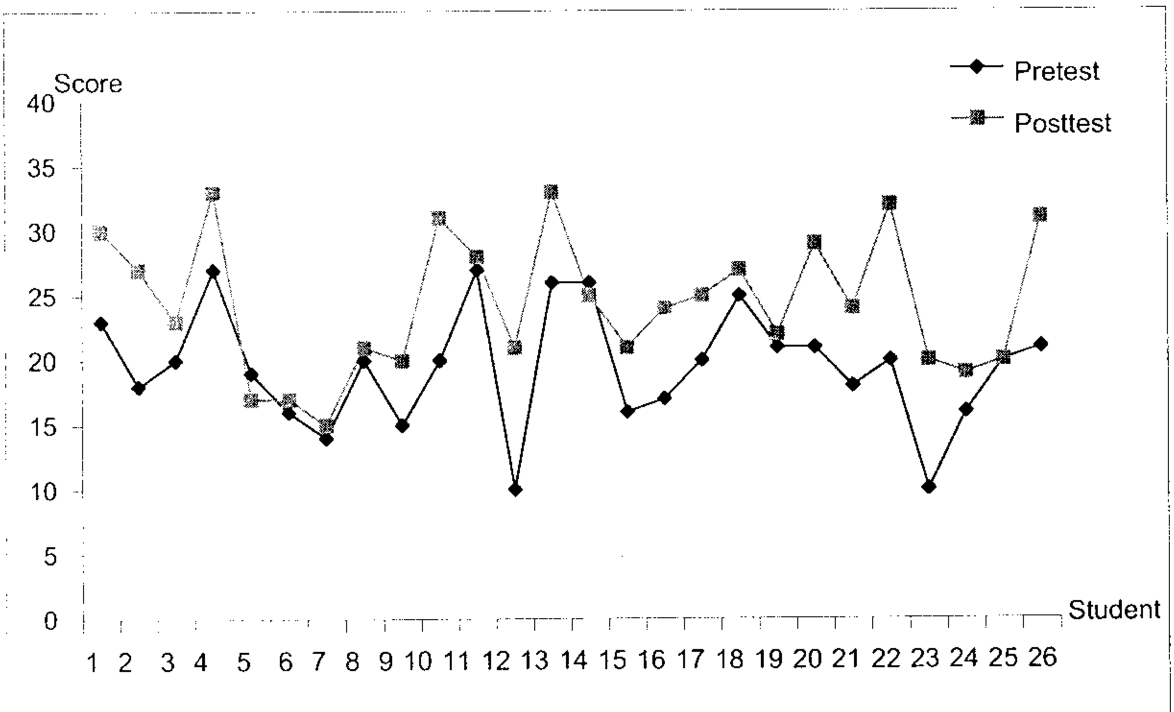


Figure 15 Student's science learning scores in Baan Nonchantuek school.

4.2.2 Values of science-culture in accord

The analysis of the values of science-culture in accord of the students from three schools consists of 3 criteria: moral and ethics, art and way of life, and self-sustainability. The scores for each criterion tend to be higher than those of before curriculum implemented. Three schools are significantly different in both pretest and posttest scores (Table 12).

The values of science-culture in accord score for students of Baan Don Jode school are significantly different between pretest and posttest. The scores after science curriculum implemented are higher than those of before implementation. The analyzed data of pretest scores are between 3.81 and 4.74 with an average of 4.26. The posttest scores are between 3.39 and 4.58 with an average of 4.27. The analysis revealed that the pretest and posttest scores are significantly different at 0.05 level.

Table 12 Values of science-culture in accord scores for students from three schools

School	n	Pretest			Posttest			df	t
		Max-Min	$\overline{X}$	SD	Max-Min	$\overline{X}$	SD		
Don Jode	18	4.74-3.81	4.26	0.72	4.58-3.39	4.27	0.64	17	53.28*
Don Hun	17	4.65-3.19	4.01	0.45	4.65-3.29	4.10	0.34	16	27.40*
Nonchantuek	25	4.42-3.03	3.83	0.36	4.71-2.84	3.98	0.45	24	39.66*

* Significantly different at 0.05

The values of science-culture in accord scores for students of Cumchon Baan Don Hun school are significantly different between pretest and posttest at 0.05 level. The scores after the proposed science curriculum implemented are higher than those of before implementation. The analyzed data before curriculum implemented of pretest scores are between 3.19 and 4.65 with an average of 4.01. The posttest scores are between 3.29 and 4.65 with an average of 4.10.

The values of science-culture in accord scores for students of Baan Nonchantuek school are significantly different between pretest and posttest at 0.05 level. The scores after the proposed science curriculum implemented are higher than those of before implementation. The analyzed data before curriculum implemented of pretest scores are between 3.03 and 4.42 with an average of 3.83. The posttest scores are between 2.84 and 4.81 with an average of 3.98.

4.2.3 Environmental conservation behavior

The analysis of environmental conservation behavior of the students from three schools consists of 3 criteria: using, preserving, and promoting. Three schools are significantly different in both pretest and posttest scores. The students' scores for each criterion of Baan Don Jode, Chumchon Baan Don Hun, and Baan Nonchanturk schools tend to be higher than those of before curriculum implemented (Table 13).

Table 13 The scores for environmental conservation behavior of the students from three schools

School	n	Pretest			Posttest			df	t
		Max-Min	$\overline{X}$	SD	Max-Min	$\overline{X}$	SD		
Don Jode	21	5.00-2.62	4.37	0.72	5.00-3.08	4.57	0.64	20	27.52*
Don Hun	18	4.92-2.85	4.15	0.71	5.00-2.85	4.25	0.84	17	20.85*
Nonchantuek	23	5.00-2.23	3.99	0.89	5.00-2.31	4.29	0.85	22	20.61*

* Significantly different at 0.05

The scores for environmental conservation behavior of the students from Baan Don Jode school are significantly different between pretest and posttest. The scores before proposed science curriculum implemented are higher than those of after implementation. The students' environmental conservation scores before proposed science curriculum implemented are between 2.62 and 5.00 with an average of 4.37. The posttest scores are between 3.08 and 5.00 with an average of 4.57. The analysis revealed that the pretest and posttest scores are significantly different at 0.05 level.

The environmental conservation behavior scores for students of Chumchon Baan Don Hun school are significantly different between pretest and posttest at 0.05 level. The scores after the proposed science curriculum implemented are higher than those of before implementation. The scores are between 2.85 and 4.92 with an average of 4.15. The posttest scores are between 2.85 and 5.00 with an average of 4.25.

The environmental conservation behavior scores for the students of Baan Nonchantuek school is significantly different between pretest and posttest at 0.05 level. The scores after the proposed science curriculum implemented are higher than those of before implementation. The scores are between 2.23 and 5.00 with an average of 3.69. The posttest scores are between 2.31 and 5.00 with an average of 4.29.

CHAPTER 5

CONCLUSION AND DISCUSSION

Conclusion

Objectives of the study

This study aims (1) to reinforce science learning through local culture by designing the science curriculum, (2) to implement the developed science curriculum, and (3) to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior.

Scope of the study

Population

1. Population for designing the reinforcement of science learning through local culture consist of science curriculum developers, educational technologists or evaluators, ecologists or environmentalists, national science teachers or master science teachers, and indigenous specialists.

2. Population for studying the impacts of reinforcement of science learning through local culture are Mathayomsuksa 3 students of Khon Kaen Educational Region 3.

Samples

1. Samples for designing the reinforcement of science learning through local culture consist of five science curriculum developers, five educational technologists or evaluators, five ecologists or environmentalist, four national science teachers or master science teachers, and five indigenous specialists.

2. Samples for studying the impacts of reinforcement of science learning through local culture are Mathayomsuksa 3 students at Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school of Khon Kaen Educational Region 3.

Hypotheses

1. The posttest scores of the science learning achievement are higher than the pretest scores.
2. The posttest score of the values of science-culture in accord are higher than the pretest scores.

3. The posttest scores of the environmental conservation behavior are higher than the pretest scores.

Methodology

The One-Group Pretest-Posttest Design is considered for research designing. The research procedure is provided here.

1. Collecting data: The researcher began to collect general information about school and community in order to understand local culture. The steps of the study could be classified into 2 steps: documentary study and community survey.

2. Modelling the reinforcement: The Delphi technique was employed to obtain a consensus from experts in a various fields of study about areas/issues that were most needed for research in the field of reinforcement of science learning through local culture.

3. Designing science curriculum: Data from documentary study and community survey, synthesis science curriculum, and Delphi study were analyzed. The theories of curriculum development and lesson plan construction based on child-centered approach were studied.

The science curriculum was designed by the use of Basic Education Curriculum 2001 of the national science education standards: subcategory 2 (Life and environment); subcategory 8 (Nature of science and technology); of the national social studies; religion; and culture standards: subcategory 5 (Geography), and the use of the data from the documentary and community studies. Then, pilot study was conducted on Mathayomsuksa 3 students for checking the activity plans, and preparing teachers with the learning cycle strategies.

4. Implementing proposed science curriculum: Conducting the science curriculum with 3 science classrooms of Mathayomsuksa 3 in the first semester of the academic year 2005 at Chumchon Baan Don Hun, Baan Don Jode, and Baan Nonchantuek schools, Amphoe Waengyai, Changwat Khon Kaen. The total periods were 20 hours per classroom. Learning outcomes were evaluated before and after implementation in terms of science learning achievement, values of science-culture in accord, and environmental conservation behavior.

Findings

1. Accordance of science and local culture

The *PAH POOH TAH* can be presented as to how students learn science and local culture. The accordance of science and local culture can be described in terms of knowledge, process, and attitude towards science.

Knowledge : some scientific knowledges explaining *PAH POOH TAH* show how science and local culture cannot be separated from local community. Belief in *POOH TAH* can help the villagers unite. They are ready to do something for community development. Also, The *THAO CHAM* plays a role of a master teacher teaching the villagers to be good citizens and living in balance with nature.

Scientific knowledge in *PAH POOH TAH* can be explained in terms of biological diversity. The sacred forest seems to be a gene bank, an ancestry heredity pool, a diversity of plants and animals, and a soil fertility area. The population of plants and animals have been preserved. If animals in *PAH POOH TAH* have over population, they will move out of the closed area. Then, local people can catch and collect them for feeding because it is out of the role of *PAH POOH TAH*. At the moment, villagers can collect food or herbs in *PAH POOH TAH* for survival. The rule to save *PAH POOH TAH* has generated by the villagers. The rule seems to be more effective to conserve the environment than the government law. People can learn how to save money and save the environment.

Process : *PAH POOH TAH* is sustainable in accordance with village development for a long time. When we try to teach students about science based on the local culture, we have to understand the nature of their culture. It can be described in terms of beliefs and way of doing.

The scientific process skills influence the villagers' habit and mind to conserve environment. Belief and ceremony on *POOH TAH* can make the villagers cooperate for protecting, observing, collecting, conserving, and learning in nature. People participate in social activities by oral communication and hands-on experiences.

Attitude towards science : *PAH POOH TAH*, a pubic forest community is a vital source to support local people. It is also a learning resource to study how local culture interacts with the way of life. There are several plants, which local people use for food, herb, energy, and wood. There are also many kinds of animals, which local people use for food and to maintain the ecosystem.

Focusing on the ways to conserve and manage natural resources, the balance of ecosystem can reflect the intelligence of local people. They can preserve forest community by no means of destruction. Local rules and regulations for forest preservation are designed and used for all local people.

2. Modelling to reinforcement of science learning through local culture

The Delphi study employed 24 experts in a various fields of study to rate their opinion on the reinforcement of science learning through culture. Two rounds of questionnaires responded and promoted way to develop students' developmental aspects. The questionnaire for the first and second rounds Delphi panel members to respond to the questions in five issues based on topics of life and environment.

Most experts are male with the ages of 31-60 years. The educational background of all experts is higher than bachelor degree. They are working on supporting students' learning in different levels of educational system and most of them are teaching in university.

The results of study show five criteria for reinforcing science learning through local culture. They are relevant science topics, learning objectives, learning process, media and learning resources, and assessment. These provide a framework for designing lesson plans and learning activities to reinforce science learning through local culture.

The learning process was then developed. There are five steps to promote students learn science through local culture, namely LADDA instructional model, which is consisted of Learning, Analysing, Deciding, Doing, and Application. It can raise students' ability in science learning achievement, values of science-culture in accord, and environmental conservation behavior.

3. Designing science curriculum

The science curriculum was designed by using Basic Education Curriculum 2001 of the national science education standards: subcategory 2 (Life and environment); subcategory 8 (Nature of science and technology); of the national social studies, religion, and culture standards: subcategory 5 (Geography), and by using the data from the documentary and community studies.

The results of experts' assessment in the appropriateness and congruency were of valuable suggestion. The proposed science lesson plans were improved before pilot study and implementation was conducted. The appropriateness of language, content, and format in each lesson plan were improved. Then, the curriculum and lesson plans were resent to the experts.

The pilot study was aiming to check the activity plans, and to prepare three teachers and learning cycle strategies for this study. Mathayomsuka 3 students of Waeng Yai

Wittayakom school participated. The outcomes of the pilot study helped to revise the activity plans, related documents, learning resources, and research instruments.

4. Implementing science curriculum

The study took place on the first semester of the academic year 2005. Course description and unit of learning took totally 20 hours. The learning process employed the LADDA instructional model for science curriculum implementation. Learning outcomes were also examined before and after implementation.

4.1 Learning process

The LADDA instructional model was employed for learning process. Five steps of its implications consist of learning, analyzing, deciding, doing, and application. It provides an alternative way of thinking and doing based on the accordance of science and local culture. The teaching-learning processes bring local culture into science classroom and the teacher acts as a facilitator.

Learning step designates the students to have general background in terms of *PAH POOH TAH*. The belief and way of doing with *POOH TAH* should be known by them i.e. interviewing the elders, directly observing the *PAH POOH TAH*, and making a group discussion. The cognitive of belief and cultural aspects in terms of science were raised.

Analyzing step assigned the students to share their opinions about the relationship between science and local culture. The role of *POOH TAH* was analysed in terms of conservation biological diversity and local environment. Students also proposed the way to conserve local environment by employing scientific process.

Deciding step needed the students to express their feeling and make an alternative way to save local environment. They learned how to make a decision by group meeting. Then, they prepared to explore the study.

Doing step needed the students to have experimentation by employing scientific method, and scientific process skills. They gained the experimental ability. At the same time, they had to illustrate what organisms in the soil they found. This step helps students learn how science works and how art expresses.

Application needed the students to make a conclusion of the relationship between local culture and science. They found that they could do something for local community to sustain

PAH POOH TAH such as growing plant, making a brochure promote the way to conserve local environment, and having oral communication between students and villagers.

4.2 Learning outcomes

4.2.1 Science learning achievement

Student's science learning scores in three schools are significantly different between pretest and posttest. The scores of after science curriculum implementation are higher than those of before implementation with the posttest scores are higher than the pretest scores for each school at the significant different level of .05.

4.2.2 Values of science-culture in accord

The scores for values of science-culture in accord of the students in three schools are significantly different between pretest and posttest. The scores of after science curriculum implementation are higher than those of before implementation with the posttest scores are higher than the pretest scores for each school at the significant different level of .05.

4.2.3 Environmental conservation behavior

Student's environmental conservation behavior in three schools are significantly different between pretest and posttest. Students' scores of Baan Don Jode, Chumchon Baan Don Hun, and Baan Nonchantuek schools have different scores. The scores for each school after science curriculum implementation are higher than those of before the implementation with the posttest scores are higher than the pretest scores for each school at the significant different level of .05.

Discussion

1. Accordance of science and local culture

Nature is the mother of scientific knowledge and local knowledge. It understood that the accordance of science and local culture are initiated in every time when natural phenomena affects human traits. The notions describing the relationship between science and local culture can be concluded in 3 dimensions; knowledge, process, and attitude towards science, which are discussed below.

Knowledge: The pattern of knowledge in local culture originated by practical science, which is passed by directed learning process. Local culture can be transferred from generation to generation in terms of indigenous knowledge through belief, ceremony, and verbal communication. The collective knowledge is taught by oral communication and way of practicing. Learning transaction is based on natural holistic view. Also, most indigenous knowledge has originated from local community. It is not only "Eureka !!!" phenomenon, but it is incubated and expanded by socialization.

Local culture is the base of learning and it can express its local identity indicating how indigenous people survive in a changing world as well as concerning sustainable development. It also focuses on mind-based learning, which promotes awareness, attitude, values, and behavior about the balance of nature. The "soul sibling" is commonly understandable among local people. Culture plays a role for resource management and cultural conservation. This is an integral part of environmental conservation (Narintararangkul Na Ayuthaya. 1996: 122-123).

Science can explain certain natural phenomena and make a universal induction. Science has the same conclusion, even though a kind of method or of management is different. While, indigenous knowledge can explain natural phenomena based on science and out of science boundary. However, both science and local culture play their roles as the way of life in daily activities. Their functions are responsible for human traits and nature.

Process: Local culture is a product of trial and error and discovery originated by direct experiences. Then its conclusion is preserved in non-writing evidences. It can be transferred by ceremonies, word-by-word, and practices from generation to generation. The production system influences the way of life of local people. It responses to the mind more than the rewarded money, public value, participation, management, and framework of natural resources.

Attitude towards science: The decision to use natural resources is based on a sustainable application. The awareness of nature is related to moral and value in each community. All social productions are generated from ceremonies, local culture, and doing. Local community builds a survival system by itself. Members of community can learn and construct co-operational creativity. Learning society is originated from learning resources and local culture. Also, self-esteem and appreciation in locally mind are the goals.

The local people can perceive their environment as a part of a complex system where people cannot be separated from nature. The concept and the management based on the local people's existing belief is related to supernatural including spirit, and holy matter. The belief makes deforestation prevention more effective (Suthisa. 1995). Taraporn (1995: abstract) proposed that the way of life of Kalung community was related to forest resources conservation. The ritual of feasting spirit consists of the spirit of *POOH TAH* and of forest. Local people have believed deeply in the supernatural and have learned from generation to generation through the nature system, socialization, and indigenous knowledge of community as well.

The relationship between science and local culture more often speaks both scientific literacy and worldview of local people. It can be explained that the concepts of knowledge and belief are not strictly separable. The understanding of worldview is directly influenced by conceptual development and change (Cobern. 1996: 591).

Science has served as an important instrument of the state in managing natural resources. The indigenous knowledge has been a well-integrated instrument of local people that has proven effective in the past. The *PAH POOH TAH* can coexist with local people based on two strategies. The application of traditional values to more formal practices and the adoption of scientific method are interrelated to the way of life (Ganjanapan. 1996: 263).

2. Modelling the reinforcement of science learning through local culture

The survey form a panel of many experts has the results of the framework about how to reinforce science learning through local culture in terms of life and environment. Five issues were rated: relevant science topic, learning objectives, learning management, materials and learning resources, and assessment. To students' life in their community, science learning should be developed in the ability of problem-solving, thinking globally, acting locally, and bringing science to serve the way of life (Hadzigeorgiou; & Konsolas. 2001: 40). It should be pointed out that science education should not only provide students with opportunities to answer questions e.g. "how do we know?", "why does it happen?", "what can we do with our knowledge?", "how can we communicate these ideas?", but also the question "why do we know?" will propose more important issues to discuss for the purpose of learning (Osborne. 1996: 54). Students will always feel what they are supposed to learn and live with community.

The results of Delphi method provided several issues about curriculum design, instruction, implementation, and assessment. The opinions of the experts in five issues meet the national science education standard subcategory 2, Life and Environment. The findings suggest how to create science learning atmosphere by the use of local culture and to serve students' development in both scientific knowledge and local culture traits. Students will merge the scientific knowledge from their own culture with the experimental techniques they have learned. Wanitchang (2005) studied the present situation, problems, and ways of using local wisdom in teaching and learning activities in schools at Khon Kaen Educational Region 4. The findings indicated that the state of applying local wisdom to the organization in forms of instructional activities, policy, work plans and application process, was at a moderate level.

Aikenhead (1997) provided a perspective view for science curriculum that learning results were the ever-changing interaction among the personal orientations of a students, the subcultures of a student's background (family, tribe, peers, school, media, etc.), the culture of his or her nature, and the subcultures of science and school science. In addition, Snively and Corsiglia (2001) proposed a cross-cultural perspective referring to traditional ecological knowledge. It increased interesting indigenous knowledge, local culture, culture traits of western science, and the growing need for environmental sensitivity.

This study shows the theoretical and practical ways to serve science learning for students. The reinforcement of science learning through local culture engages science and science education to meet local culture, the way of life, and daily life activities, which interact with science culture. Detailed responses from the experts provided valuable suggestion to promote process of science, pedagogical practice, content knowledge, conservation behavior, and value of science-culture in accord.

Also, the study emphasized how to reinforce science learning through local culture. It provides the ways to promote science learning and local culture studies. Teachers can bring these opinions into classroom by creating educational curriculum based on school and community contexts. Students will build a body of knowledge about the natural and physical worlds. Ways of thinking of indigenous people about the world reflect worldviews, which are distinctive from some scientific knowledge. Local culture and science are not separated from daily life. They are interspersed with ways of communicating, practicing, and thinking (Kawagley; et al. 1998: 137).

Thailand has diverse cultures which science can play its role in the classroom. Science disappears rapidly and alerts us to concern about the loss of biological diversity, environmental destruction, climate change, and species extinction. However, we know very little about how we are losing local culture and how we can teach our children about local culture. The Delphi technique helps science educators insert local culture into science classroom.

3. Designing science curriculum

The designed science curriculum in this study is based on the Basic Education Curriculum 2001 of the national science education standards: subcategory 2 (Life and environment); subcategory 8 (Nature of science and technology); of the national social studies, religion, and culture standards: subcategory 5 (Geography) as well as the documentary and community studies. The contents of curriculum are based on the local context which introduced indigenous knowledge into school community. It can gain students' awareness in terms of science and local culture.

Buasonte (1998) developed the curriculum for transmitting local wisdom into a school. He had 4 steps of the development process. He used the participatory research was employed to learn about local people thinking and doing on forestry village. Also, the participatory research was introduced by e.g. Maneekosol (1996) and Pranee (2002), to design the curricular for local community. They spent a long time for their study. This indicates that participatory research can be used for community study. The interesting criteria about community can be brought into a classroom. Because these people used the contexts of local community for curriculum development as in the present study but they used participatory technique whereas this study used Delphi technique.

The other group of people who used the contexts of local wisdom and real-life situations for curriculum development e.g. Bunsai (1998), Jansawang (2005), Pupaka (2005), and Thanaprayothsak (2005). They used focus group technique by allowing the experts to have a meeting. This technique spends a very short time (c.a. 1 week) to complete the process. It may cause the problems of e.g. conflicts, stresses, appointments, and dominance of a high-raking expert. In contrast, the present study used the Delphi technique to find the experts' opinion with anonymous discussion by no means of a meeting but it was taking a longer time (c.a. 3 months) to complete the process and there were no problems mentioned in the focus group technique.

4. Implementing science curriculum

4.1 Learning process

The LADDA instructional model was developed and introduced into science classroom. There are 5 steps of the instructional model i.e. learning, analyzing, deciding, doing, and application. It can be applied into science learning through local culture. The LADDA instructional model makes an understanding by stimulating the power to change learning environment appropriately.

The science learning process involves active construction of the representation in a problem-solving. Then, understanding how scientific concepts were developed aid the development of instructional strategies (Nersessian. 1991: 144-15). Students can learn science and construct scientific knowledge by the acquisition of interactions with the environments and the intervention of the school (Pines; & West. 1986: 585; citing Vygotsky. 1962).

The findings from observations suggested that students should pose basic ecology competency. It is noticed that *PAH POOH TAH* and ecological concepts are interrelated. From interviewing teachers and students, it is formed that they spent more explanation about *PAH POOH TAH* and some acquired additional ecological concepts.

Students obviously awared of what they were doing which was a part of their learning. Teachers need to know a range of teaching and learning strategies because different steps of teaching strategy will suit different students (Fairbrother. 2000: 8). Science teaching is based on certain assumptions about how students come to understand scientific knowledge and can use it in the community.

The LADDA instructional model works best with the meaningful learning science involving the understanding scientific and local culture. Thus teachers need to pursue class activities that engage students in using scientific concepts to describe, explain, or make predictions about the nature. This learning process is suitable for the learning management reinforcing science learning through local culture. Students living community have the ways of talking and thinking about the events and phenomena, which are influence to students to be interested in science.

Five steps of the LADDA instructional model provided an alternative way of thinking and doing based on the accordance of science and local culture. The positive reinforcement occurs when a stimuli is presented or added after the learning behavior is performed (Sternberg. 2004: 231). The learning science process originates in local community or social situations and language is a center of teaching and learning science. Teacher sometimes provides the local language to make more clearly explanation in terms of talk to local culture, which provides the conceptual tools for thinking about science. The socio-cultural practice and social interaction are privileged mechanisms for explaining. The area of communication as an agent of a particular action that uses an object to attract the attention are considered. The local language can influence the effective communication (Vila. 1996: 192). It increases the probability of operant behavior associated with the learning experiences in both indoor and outdoor activities.

The strength of the connection between response and stimuli of science learning is named as the *Law of effect*. The idea of reinforcement serves the strength not so much but rather to strengthen the response itself or intrinsic factors. It also has incentive motivation between science and local culture understandings (Petri; & Govern. 2004: 169).

However, local culture plays its role in science classroom by education allowing a genuine meeting place between local and universal aspects. Learning process might want to ensure a relevance to the student's experience, interest, capabilities and cognitive development. It may be very different from the context in which new conception, skills and attitude towards science developed (Swift. 1992: 7). The science learning for Thai society is challenging towards understanding the concept of learning and developing science for all. Science learning needs to have a collateral learning via local context as much as possible.

4.2 Learning outcomes

4.2.1 Science learning achievement

The findings indicated that the science learning achievement of students has been improved. The cognitive development was derived from the LADDA instructional model in which students were reinforced by science learning through local culture. It provided students to associate with a variety step of learning process and learning activities.

Science learning achievement test focuses on 1) knowledge and comprehension, 2) application, and 3) scientific process skills. It is found that the students can gain their cognitive abilities in which science learning plays its role in local culture. Students from three schools are significantly different in their developmental cognitive. The LADDA instructional model is a positive stimuli which responses student in knowledge, comprehension, application, and scientific process skills.

Regarding, students' science learning achievement, the pretest and posttest scores show that they are significantly different at .05 level. For the first hypothesis, the results show that posttest scores are higher than the pretest scores in three schools. However, there is one case i.e. the minimum of posttest score from Baan Don Hun school is lower than those of the minimum pretest score (pretest = 13, posttest = 11, referred to Table 12). This case, the student may confuse with the item of the test due to his reading skill. This student should have been given more time to learn the content in the proposed science curriculum. Brown et al (1996: 161) pointed that the main principle of reinforcement of science learning through local culture can work best when (1) classroom atmosphere invokes multiple zone of proximal development (2) a community of academic and eventually scientific discourse is developed (3) meaning is negotiated and refined (4) ideas are seeded and appropriate, and (5) common knowledge and distributed expertise are both essential.

Towards relationship between science learning and local culture, it is important to know how to develop Thai students in the changing world. The local cultures can produce knowledge for the students in terms of indigenous knowledge or local knowledge. The local context could be described by scientific knowledge (Bunsai. 2000; Saeng-Xuto. 2001). The result of this study agree with Ludeerat (2003) who claimed that the field site study for environmental conservation camp can gain students' ability in cognitive development.

Pupaka (2005) developed a high school chemistry curriculum incorporating with real-life situations by using inquiry cycle approaches to evaluate the learning outcomes. Students can raise their science learning achievement and manipulative skills scores after the study of learning units. Jansawang (2005) studied students who learned science based on the learning cycle with local wisdom and she found that learning science was enjoyable and the students also developed cognitive skills. These reports are well consistent with present study.

In the case of a student in this research, namely Mr. Duck who is an example for explanation that how student becomes paying attention in science classroom during the time of study. Before science curriculum implementation Mr. Duck felt so bored with the science classroom. He was often absent during science classroom and avoided school activities. The school administrator decided to talk about this situation with his parents. When science curriculum based on the accordance between science and local culture was implemented. I found that Mr. Duck decreased his negative behavior. He was ready to study and cooperate with friends in science classroom. The social reinforcers e.g. friends, teacher are included for science classroom. Also, activity reinforcers e.g. indoor or outdoor activities are transmitted by science curriculum and learning activities and the reinforcers can raise his learning abilities and attitude towards science learning.

The science curriculum and LADDA instructional model reinforced students' learning. Students can gain cognitive ability, which is explained in terms of zone of proximal development. They understood an accordance between science and local culture based on the diversity of learning activities in both indoor and out door classrooms. Science learning through local culture can raise students' scores of learning achievement. Science and local culture have the same origin or source of knowledge from the nature. They can be integrated and introduced into schools. However, this study needs more times for development to verify that students could probably gain more scores than this study.

4.2.2 Values of science-culture in accord

The test for values of science-culture in accord focuses on 1) moral and ethics, 2) art and way of life, and 3) self-sustainability. This research found that students can gain their values of science-culture in accord which science learning plays a major role in local culture. This resulted from the LADDA instructional model in which learning science through local culture was promoted.

The relationship between achievement and value is very strong. It can be discussed that when apply the LADDA instructional model then the achievement and value scores increase. Values of science-culture in accord of the students concern three kinds of the value (attainment value, utility value, and intrinsic value) that are relevant to achievement (Stipek. 1993: 22-23; citing Eccles. 1983). An activity of the attainment value can affect an individual to create self-concept. Students presumably engage in activities in order to develop competencies that are consistent with their concept. Utility value concerns the usefulness of a task by means of the achievement goals that might not be related to the task itself. Intrinsic value engages in for its own sake, rather than for some other purposes.

Regarding, the values of science-culture in accord of the students, the pretest and posttest scores show that they are significantly different at .05 level. For the second hypothesis the posttest scores are higher than the pretest scores in three schools. Boonsawadculchai (2002) revealed that using the local resource or outside classroom learning source can make the students enjoy the lesson and understand their own role in community.

Students build up their own mind and develop a process of learning when their inquiring mind is stimulated. The students' understanding of science and local culture is acquired by discovery. They can gain cognitive and affective development after learning thing. These agree with Ludeerat (2003) who studied learning achievement and attitude towards environment by using field site study for environmental conservation camp. She found that attitude towards the environment of the students was higher than those of before camping. Students gained development on their decisions based on values of science.

The scores of values of science-culture in accord and achievement are raised. The science curriculum and the LADDA instructional model influenced the mental development. Students are often stimulated by science curriculum. They appreciate in own their culture or community. The scores of values of science-culture in accord should be promoted by using diversity of learning activities. In addition, the dimension of mind or affective domain should have been conducted in longer time.

The goals of the relationship between educational science and learning science need to be critiqued. The technical and political issues should be concerned. Incorporating local culture into science curriculum may be one way of enhancing student self-esteem in local community as well as providing a bridge to modern science (Gaskell. 2003: 247).

4.2.3 Environmental conservation behavior

Environmental conservation behavior of the students in three schools is significantly different at .05 level. The scores after science curriculum implemented are higher than those of before implementation. The results of this study influenced by the LADDA instructional model in which environmental conservation behavior was promoted. Students concern about the currently declining of biological diversity in their community. They learned how human activities threaten the nature. The future practical uses and values of natural resources are unpredictable because biodiversity is more interesting and more attractive. Our understanding of ecosystem is insufficient such as there could be certain impact of removing any component (Glowka; et al. 1994).

The results of this study agree with those of Wongrasri (2001) that the activities allowed students to learn ecosystem and roused the students to be interested in studying science subject. Also, Thanaprayothsak (2005) studied a high school curriculum on natural resources and environmental pollution related to real life issues based on inquiry cycle approach. The result of the study revealed that developed science curriculum related to real life situations was effective and could be used in the classroom.

The importance of decision-making needs the best possible scientific information and people's awareness to sustain the environment (Grace; & Sharp. 2000: 49-50). The criteria of local culture and environmental conservation require consideration of how science is affected. They are practice, spiritual as well as moral (Bausor; & Poole. 2003: 311). The relationship between environmental concerns and conservation behavior is linked to values (Schultz; et al. 2005). The awareness of environmental concerns is considered in science education and social responsibility.

Science and culture originated from nature, which are inextricably linked. Students concern and aware of all life taking part in the environment. The rise of commercial interest in biodiversity and indigenous knowledge tends to increase greater problems, since the components or products of biodiversity and natural resources in each region are collectively destroyed. Students should obtain the suggestions about the best ways to conserve environment in terms of relearning ecological knowledge, local culture, or sustainable principles that our society has lost (Posey. 1998: 54).

Environmental conservation behavior is more effective based on the learning activities in both indoor and outdoor classrooms. Students are stimulated by the lesson about environmental conservation behavior, which includes the awareness of environment. The lesson influenced the intrinsic which later links to the extrinsic. However, limitation of this study depends upon writing skills of the students to express their feeling. Teacher should employ observation together with interviewing to monitor the environmental conservation behavior.

Recommendation

1. General recommendation

1.1 Recommendation for Teacher

1. The ways to apply the local culture into science subject and target group should be expressed as a favourable opinion in school hour. The strategies in applying local culture for teaching in particular region should use the culture originated in that region and the culture should be able to be explained by science. The diversity of teaching methods and of learning activities should be considered.

2. Teachers should encourage science learning through local culture based on the needs of students, students' attention, teachers' background, and community cooperation in

learning processes. It is important that teachers recognise and encourage local culture in relationship with scientific explanation.

3. Teachers should be aware of the subtle differences in thinking, verbal response, and behavior of their students. Teachers should give more perceptive learning approaches and more appropriate response to students. The other local cultures should be considered in science learning.

4. Teachers should be aware of the changing world as well as students' thinking is also shaping. The learning science through local culture needs to be encouraged due to the importance of its role in society. Students should have experiences of moral, ethics, and values of science-culture in accord in terms of science curriculum. Indigenous specialists should be invited to come into science classroom to teach local contexts, whereas teachers can teach universal contexts.

5. Teachers can prepare learning materials and learning resources found in local community. The learning resources should be found near schools because the students can visit easily.

6. Teachers should reinforce students in terms of local language when they face to difficult technical terms or situations. Students sometimes need a teacher to threat them friendly and help them happily understand the subject. The formal speeches from the students to the teacher should be deceased because the students feel more comfortable and convenient if local language is used.

7. Teachers have to develop new learning management for science learning through local culture. The LADDA instructional model is suggested for alternative choice for learning development. It is an innovative approach of science learning through local culture. Teachers can apply this learning process into the classroom.

1.2 Recommendation for administrator

1. The reinforcement of science learning through local culture has affected the structure and functioning of school, curriculum, teacher, student, and community. The school should be incorporated in science curriculum. At the same time, self-esteem and appreciation in local culture should be promoted. The most successful way is to introduce the importance of both local culture and learning science to students, parents, and teachers involved.

2. The values of science-culture in accord and environmental conservation behavior are the important factors in science learning through local culture. Students should have the opportunity to participate in some local cultures and get more information in terms of scientific explanation.

3. School should allow indigenous specialist to participate in science learning. Students will have new conceptual system that how science and local culture interact in their everyday life. Also, school should promote teacher to develop science curriculum including science and local culture.

2. Recommendation for further study

1. The reinforcement of science learning through local culture is more effective, if *PAH POOH TAH* is located near school. Students can easily visit the forest community and they can study the ecological knowledge. Also, the study in the different local culture should be considered. Socio-scientific issues in several areas require investigation by using other contexts and scenarios when dealing with different cultural groups.

2. The techniques of the future study might want to focus on how students can make enjoyment, awareness, and appreciation with what they can sustain social identity by employing science into day-to-day living. Methods of pure science and social science are educationally and culturally required.

3. The science learning through local culture is a way to develop the student's competency in science. The problem of students' literacy should be solved. Also, the appreciation and self-esteem of students are in community and they affects to science achievement, values of science-culture in accord or environmental conservation behavior should be studied.

4. The LADDA instructional model and its effectiveness should be employed to further research with other science content areas. Also, the study should be extended into larger samples or another stage of education. It might consider to allow the results of this study to be generalized to the future research projects.

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APPENDIX

Appendix A Lesson plan

แผนการจัดการเรียนรู้

นิเวศวิทยาท้องถิ่น **ชั้นมัธยมศึกษาปีที่ 3 ภาคเรียนที่ 1**

หน่วยการเรียนรู้ย่อยที่ 1 ความหลากหลายทางชีวภาพ **เวลา 7 ชั่วโมง**

จุดประสงค์การเรียนรู้

- ด้านความรู้ ความเข้าใจ
  1. นักเรียนอธิบายความหลากหลายทางชีวภาพได้
  2. นักเรียนระบุชนิดของสิ่งมีชีวิตได้
  3. นักเรียนบรรยายลักษณะของสิ่งมีชีวิตได้
  4. นักเรียนอธิบายถึงผลกระทบของการสูญเสียความหลากหลายทางชีวภาพได้
- ด้านทักษะกระบวนการ
  1. นักเรียนสำรวจความคิดเห็นของคนในชุมชนได้
  2. นักเรียนจัดจำแนกสิ่งมีชีวิตออกเป็นหมวดหมู่ได้
  3. นักเรียนเปรียบเทียบความหลากหลายของสิ่งมีชีวิตได้
  4. นักเรียนสังเกตลักษณะของสิ่งมีชีวิตแต่ละชนิดได้
  5. นักเรียนแสดงความคิดเห็นเกี่ยวกับความหลากหลายทางชีวภาพ
  6. นักเรียนสื่อสารและนำเสนอข้อมูลที่ได้จากการศึกษา
- ด้านคุณลักษณะ
  1. นักเรียนตระหนักยอมรับคุณค่าของการอนุรักษ์ความหลากหลายทางชีวภาพ
  2. นักเรียนรู้คุณค่าและเห็นความสำคัญของความหลากหลายทางชีวภาพ
  3. นักเรียนเสนอแนวทางในการอนุรักษ์ความหลากหลายทางชีวภาพ

แนวความคิดหลัก

ความหลากหลายทางชีวภาพเป็นคุณสมบัติของสิ่งมีชีวิตที่หลากหลายในระดับพันธุกรรม (gene) ระดับชนิด (species) จนถึงระดับความหลากหลายของกลุ่มสิ่งมีชีวิตเชิงนิเวศวิทยา (ecological community) สิ่งมีชีวิตทั้งหลายบนโลกล้วนมีผลมาจากกระบวนการเปลี่ยนแปลงวิวัฒนาการตามกาลเวลาและตามสภาวะสมดุลของธรรมชาติ

การเตรียมการล่วงหน้า

1. ครูสำรวจชนิดพืชและสัตว์ในบริเวณป่าปู่ตา

2. ครูเก็บรวบรวมข้อมูลวัฒนธรรมท้องถิ่นเกี่ยวกับป่าปู่ตาที่สัมพันธ์สอดคล้องกับวิทยาศาสตร์ เช่น ประเพณี การใช้ประโยชน์ และการดูแลรักษา

3. ครูสุ่มเก็บตัวอย่างดินจากบริเวณป่าปู่ตาและรอบนอกของบริเวณป่าปู่ตา เพื่อทดลองเปรียบเทียบจำนวนและชนิดของสัตว์ที่อาศัยอยู่ในดิน

4. ครูจัดเตรียมอุปกรณ์ต่างๆ เช่น สวิงดักจับแมลง กระป๋องตักดิน กล้องจุลทรรศน์ กรรไกร กระดาษ กระดาษกาว เป็นต้น

กระบวนการจัดการเรียนรู้

1. ขั้นเรียนรู้

1.1 นักเรียนแบ่งกลุ่มออกเป็นกลุ่มละ 4-5 คน เพื่อศึกษาตัวอย่างสังคมของสิ่งมีชีวิตที่นำมาจากท้องถิ่น เช่น ตัวอย่างดินจากป่าปู่ตา ตัวอย่างโคลนจากแหล่งน้ำสาธารณะ ตัวอย่างดินจากท้องนา

1.2 นักเรียนแยกตัวอย่างสิ่งมีชีวิตออกเป็นหมวดหมู่ เปรียบเทียบลักษณะที่เหมือนและแตกต่างกันของสิ่งมีชีวิตแต่ละกลุ่ม

1.3 นักเรียนสร้างแผนภาพความหลากหลายทางชีวภาพ โดยการวาดภาพเพื่อแสดงตัวแทนของสิ่งมีชีวิตในแต่ละกลุ่ม นำภาพตัวอย่างสิ่งมีชีวิตไปติดบนแผนภาพที่หน้าชั้นเรียน และร่วมกันอภิปรายความหลากหลายของสิ่งมีชีวิตในแต่ละแหล่งที่อยู่อาศัย

1.4 นักเรียนสัมภาษณ์ สอบถามผู้ปกครอง หรือผู้เฒ่าผู้แก่ในท้องถิ่นเกี่ยวกับความเป็นมา ความสำคัญ พิธีกรรม และวัฒนธรรมความเชื่อในป่าปู่ตา และเล่าให้เพื่อนฟังว่าป่าปู่ตามีความสำคัญต่อการอนุรักษ์ความหลากหลายทางชีวภาพอย่างไร

2. ขั้นวิเคราะห์

2.1 ครูกระตุ้นให้นักเรียนตั้งคำถามวัฒนธรรมท้องถิ่นมีความสัมพันธ์กับวิทยาศาสตร์อย่างไร ป่าปู่ตามีส่วนช่วยอนุรักษ์ความหลากหลายทางชีวภาพได้อย่างไร

2.2 นักเรียนร่วมกันอภิปรายประเด็นวัฒนธรรมป่าปู่ตามีส่วนช่วยอนุรักษ์ความหลากหลายทางชีวภาพได้อย่างไร เสนอวิธีการและวางแผนเพื่อตรวจสอบโดยใช้กระบวนการทางวิทยาศาสตร์

3. ขั้นตัดสินใจ

3.1 นักเรียนนำเสนอวิธีการตรวจสอบความหลากหลายทางชีวภาพในท้องถิ่น โดยใช้ป่าปู่ตาเป็นแหล่งเรียนรู้ และใช้กระบวนการทางวิทยาศาสตร์เป็นเครื่องมือในการสืบเสาะความรู้

3.2 นักเรียนตั้งสมมติฐานว่าถ้าป่าปู่ตาเป็นป่าที่เกิดจากวัฒนธรรมความเชื่อที่มีข้อตกลงร่วมกันในการใช้ทรัพยากรธรรมชาติ ดังนั้น ป่าปู่ตาจึงเป็นแหล่งกักเก็บพันธุกรรมและมีความหลากหลายทางชีวภาพสูง

4. ขั้นปฏิบัติ

4.1 นักเรียนแบ่งกลุ่มกันออกเป็นกลุ่มละ 5 คน แต่ละกลุ่มวางแผนสำรวจและทดลองดังต่อไปนี้

1. การศึกษาความหลากหลายของพืช โดยสุ่มตัวอย่างพื้นที่แหล่งละ 2 แห่ง จากบริเวณป่าปู่ตา และบริเวณที่ใกล้เคียงกับป่าปู่ตา ศึกษาชนิดและจำนวนโดยการจดบันทึกข้อมูลอย่างถี่ถ้วนสมบูรณ์ การเลือกบริเวณกระทำได้โดยกำหนดบริเวณที่จะศึกษา (Quadrat) ขนาด 9 ตารางเมตร

2. การศึกษาความหลากหลายของสัตว์บนดิน โดยสุ่มตัวอย่างพื้นที่แหล่งละ 2 แห่ง จากบริเวณ ป่าปู่ตาและบริเวณที่ใกล้เคียงกับป่าปู่ตา ศึกษาชนิดและจำนวนโดยการจดบันทึกข้อมูลอย่างถี่ถ้วนสมบูรณ์ การเลือกบริเวณกระทำได้โดยกำหนดบริเวณที่จะศึกษา (Quadrat) ขนาด 4 ตารางเมตร

4.2 นักเรียนแยกตัวอย่างสิ่งมีชีวิตออกเป็นหมวดหมู่ จากนั้นนับจำนวนพืชและสัตว์ บันทึกความหลากชนิด เปรียบเทียบทั้งจำนวนและชนิดของสิ่งมีชีวิต

4.3 นักเรียนสุ่มเก็บตัวอย่างดินในบริเวณป่าปู่ตา และบริเวณที่ใกล้เคียงกับป่าปู่ตา นำดินใส่ลงในกรวย ซึ่งมีแผ่นตาข่ายปิดที่ก้นปากกรวย และปลายกรวยอยู่เหนือภาชนะบรรจุแอลกอฮอล์ความเข้มข้นร้อยละ 10-20 แผ่นตาข่ายกั้นไม่ให้เศษใบไม้และดินร่วงร่วงผ่านไปได้ เหนือกรวยแขวนหลอดไฟห่างจากกรวยประมาณ 2-3 นิ้ว ประมาณ 7 วัน

4.4 นักเรียนจดบันทึก วาดรูปสัตว์ และนับจำนวนแต่ละชนิดเปรียบเทียบชนิดและจำนวนของสัตว์ที่พบในดินระหว่างบริเวณป่าปู่ตา และบริเวณใกล้เคียงป่าปู่ตา

5. ขั้นนำไปใช้

5.1 นักเรียนแต่ละกลุ่มนำเสนอผลการทดลอง สรุปว่าได้เรียนรู้อะไรบ้าง ความสัมพันธ์ระหว่างวัฒนธรรมท้องถิ่นกับความหลากหลายของสิ่งมีชีวิต ความสำคัญของป่าปู่ตาต่อการดำรงวัฒนธรรมชุมชนท่ามกลางกระแสสังคมที่มีความเป็นวิทยาศาสตร์ และเขียนเรียงความที่แสดงถึงความสัมพันธ์ระหว่างวัฒนธรรมปู่ตากับการอนุรักษ์ความหลากหลายทางชีวภาพ

5.3 นักเรียนและครูร่วมกันอภิปรายถึงผลการศึกษาเปรียบเทียบความหลากหลายทางชีวภาพ สรุปให้เข้าใจถึงความสำคัญของป่าปู่ตาในการสร้างความอุดมสมบูรณ์ให้แก่ท้องถิ่น ผลของการสูญเสียความหลากหลายทางชีวภาพ เสาะแสวงหาแนวทางในการอนุรักษ์พื้นที่และวัฒนธรรมปู่ตาต่อไป

5.4 นักเรียน ครู และผู้ปกครองร่วมกันพัฒนาพื้นที่ป่าปู่ตา ด้วยการปลูกต้นไม้ และการจัดทำป้ายนิเทศ

การวัดและประเมินผล

1. ประเมินกระบวนการเรียนรู้ของนักเรียน โดยการสังเกตระหว่างการทำกิจกรรมตั้งแต่การวางแผน การแบ่งหน้าที่กันทำงาน การร่วมมือปฏิบัติงาน การรับฟังความคิดเห็นของผู้อื่น และการเสนอแนวคิดเพื่อการอนุรักษ์โดยใช้แบบสังเกตพฤติกรรมการอนุรักษ์

2. ประเมินความรู้ความเข้าใจเกี่ยวกับความหลากหลายทางชีวภาพ โดยสังเกตจากการนำเสนอ การอภิปราย ลงข้อสรุป และแบบทดสอบวัดผลสัมฤทธิ์ทางการเรียนรู้วิทยาศาสตร์ประจำหน่วยการเรียนรู้ย่อย

3. ตรวจแบบฝึกหัดท้ายกิจกรรม และสนทนาซักถาม

วัสดุอุปกรณ์ – สื่อและแหล่งการเรียนรู้

วัสดุอุปกรณ์

1. เชือก
2. ปากคีบ
3. กรวย
4. รูปวิธาน
5. จานรอง
6. ถุงพลาสติก
7. ยางรัดของ
8. เครื่องวัด pH
9. เทอร์โมมิเตอร์
10. กล้องจุลทรรศน์หรือแว่นขยาย
11. กระดาษหนังสือพิมพ์
12. แอลกอฮอล์ความเข้มข้นร้อยละ 10-20
13. ดินจากป่าปู่ตาและบริเวณใกล้เคียง
14. กระป๋องขนาดเส้นผ่านศูนย์กลาง 5 ซม.
15. ใบงาน Spicesheet
16. วีดีทัศน์เรื่อง “ป่าวัฒนธรรมวิถีวิทยาศาสตร์”
17. ใบงานเรื่อง “ชีวิตใต้ดิน”
18. ใบงานเรื่อง “ป่าปู่ตาของฉัน”
19. ใบงานเรื่อง “พืชและสัตว์”

สื่อและแหล่งการเรียนรู้

1. ผู้เฒ่าผู้แก่ เฒ่าจ้ำ พระภิกษุในชุมชน
2. บริเวณป่าปู่ตาและชุมชนที่นักเรียนอาศัยอยู่
3. แหล่งการเรียนรู้ในท้องถิ่น สถานที่บุคคล และอินเทอร์เน็ต
4. เอกสาร แผ่นพับ รูปภาพเกี่ยวกับความหลากหลายทางชีวภาพ
5. สื่อสิ่งพิมพ์ทุกประเภทที่เกี่ยวข้องกับความหลากหลายทางชีวภาพ

APPENDIX B Science learning achievement test

แบบทดสอบวัดผลสัมฤทธิ์การเรียนรู้วิทยาศาสตร์ สำหรับนักเรียนชั้นมัธยมศึกษาปีที่ 3

คำชี้แจง

1. แบบทดสอบฉบับนี้เป็นแบบเลือกตอบมี 5 ตัวเลือก จำนวน 50 ข้อ ใช้เวลาในการทำ 40 นาที
2. ให้นักเรียนเขียนชื่อ-สกุล ชั้น เลขที่ ลงในกระดาษคำตอบให้ชัดเจน
3. ห้ามขีดเขียนใดๆ ลงบนกระดาษคำถาม
4. ให้นักเรียนเลือกคำตอบที่เห็นว่าถูกที่สุดเพียงข้อเดียว แล้วเขียนเครื่องหมาย X ลงในช่องตัวเลือกในกระดาษคำตอบ
5. หากมีข้อสงสัยใดๆ ให้สอบถามกรรมการที่คุมสอบ

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1. มนุษย์ใช้ประโยชน์จากความหลากหลายทางชีวภาพมากที่สุดในด้านใด
   ก. การเศรษฐกิจ และสังคม
   ข. การสาธารณสุข และสิ่งแวดล้อม
   ค. การท่องเที่ยว และการนันทนาการ
   ง. การสื่อสาร และเทคโนโลยีสารสนเทศ
   จ. การเมือง การปกครอง และการศึกษา
2. ข้อใดสามารถบ่งบอกถึงสภาพความหลากหลายทางชีวภาพได้ดีที่สุด
   ก. ชิงร้อยชิงล้าน
   ข. ร้อยพ่อพันแม่
   ค. ร้อยแปดพันเก้า
   ง. ร้อยเล่ห์เพทุบาย
   จ. ร้อยรักร้อยดวงใจ
3. สิ่งมีชีวิตกลุ่มใดใช้ประโยชน์จากความหลากหลายทางชีวภาพมากที่สุด
   ก. พืช
   ข. แมลง
   ค. มนุษย์
   ง. ราและจุลินทรีย์
   จ. สัตว์เลื้อยคลาน
4. ข้อใดไม่เกี่ยวข้องกับความหลากหลายทางชีวภาพ
   ก. บ่อน้ำหน้าวัดมีปลาหลายชนิด
   ข. ห้องสมุดมีหนังสือหลายประเภท
   ค. กบมีแหล่งอาศัยทั้งบนบกและในน้ำ
   ง. สวนหลังบ้านมีผักพื้นบ้านหลายชนิด
   จ. สหรัฐอเมริกามีคนอาศัยหลายเชื้อชาติ
5. ระบบนิเวศใดมีสิ่งมีชีวิตหลากหลายมากกว่ากัน เพราะเหตุใด
   ก. เขตหนาวมีความหลากหลายมากกว่าเขตร้อน เพราะเขตหนาวมีคนอาศัยอยู่น้อยกว่าเขตร้อน
   ข. เขตหนาวมีความหลากหลายมากกว่าเขตร้อน เพราะเขตหนาวมีความชื้นต่ำเหมาะแก่การขยายพันธุ์
   ค. เขตร้อนมีความหลากหลายมากกว่าเขตหนาว เพราะร่างกายของสัตว์มีขนาดเล็ก และไม่ต้องอพยพไปยังแหล่งที่อยู่อื่น
   ง. เขตร้อนมีความหลากหลายมากกว่าเขตหนาว เพราะเขตร้อนมีสภาพภูมิอากาศค่อนข้างคงที่ และมีความอุดมสมบูรณ์ของระบบนิเวศมากกว่า
   จ. เขตหนาวมีความหลากหลายมากกว่าเขตร้อน เพราะเขตหนาวมีสภาพภูมิอากาศที่ไม่ค่อยเปลี่ยนแปลงมากนัก และมีอาหารอุดมสมบูรณ์มากกว่า

6. ข้อใดเขียนชื่อวิทยาศาสตร์ของข้าวได้อย่างถูกต้องตามหลักการตั้งชื่อวิทยาศาสตร์
   ก. oryza sativa
   ข. oryza sativa
   ค. Oryza sativa
   ง. Oryza Sativa
   จ. Oryza Sativa
7. "กินล่าง ขี้เทิง แม่นหญัง" ความทวยนี้ นักเรียนจะสังเกตเห็นสัตว์ชนิดนี้ในบริเวณลักษณะอย่างไร
   ก. ชายหาดทะเล
   ข. กิ่งไม้และใบไม้
   ค. อาคารบ้านเรือน
   ง. ดินที่มีความชุ่มชื้น
   จ. โคลนตม มีน้ำชื้นแฉะ
8. ต้นไม้มีความสำคัญต่อมนุษย์มากในเรื่องอากาศ ดังนั้น เราจึงมักเปรียบต้นไม้กับอวัยวะใดของร่างกายมนุษย์
   ก. ปอด
   ข. จมูก
   ค. ปาก
   ง. หัวใจ
   จ. เส้นเลือด
9. เราจะทราบได้อย่างไรว่าป่าชุมชนของสองหมู่บ้านมีความหลากหลายของพันธุ์ไม้สูงกว่ากัน
   ก. กะคร่าว ๆ จากสายตา
   ข. สอบถามจากผู้นำชุมชน
   ค. นับจำนวนต้นไม้เพื่อเปรียบเทียบว่าบริเวณใดมีจำนวนต้นไม้มากกว่ากัน
   ง. สุ่มพื้นที่ป่าชุมชนทั้งสองแห่งแล้วนับจำนวนต้นไม้เพื่อเปรียบเทียบว่าบริเวณใดมีจำนวนต้นไม้มากกว่ากัน
   จ. สุ่มพื้นที่ป่าชุมชนทั้งสองแห่งแล้วเก็บตัวอย่างพันธุ์ไม้เพื่อจำแนกและจัดแบ่งหมวดหมู่ เพื่อเปรียบเทียบชนิดของต้นไม้
10. ความทวยใดที่สามารถบรรยายลักษณะของขนุน
   ก. บัวบ่มีน้ำ มีแต่หนามล้อมอยู่ แม่นหญัง
   ข. น้ำเต้าน้อยห้อยอยู่กกหลัก ตักกะเต็มบ่ตักกะเต็ม
   ค ขึ้นได้ ลงบ่ได้ ตายค้างดากโกน แม่นหญัง
   ง. หนังห่อขน ขนห่อกระดูก กระดูกห่อซิ้น ซิ้นห่อน้ำ แม่นหญัง
   จ. สับขอนกุงไปคุงขอนแก่น สับขอนแก่นเป็นน้ำจวงลวง แม่นหญัง
11. ข้อใด<u>ไม่ใช่</u>สาเหตุที่ทำให้สิ่งมีชีวิตเสี่ยงต่อการสูญพันธุ์
   ก. การผสมพันธุ์พืชและสัตว์ข้ามสายพันธุ์
   ข. การเพิ่มจำนวนประชากรของผู้ล่าในระบบนิเวศ
   ค. การทำลายแหล่งที่อยู่อาศัยของสิ่งมีชีวิตในระบบนิเวศ
   ง. การลดจำนวนประชากรของผู้ล่าในแต่ละถิ่นที่อยู่อาศัย
   จ. การขาดแคลนความหลากหลายทางพันธุกรรมของสิ่งมีชีวิตในระบบนิเวศ
12. เมื่อเกิดสภาพการสูญเสียความหลากหลายทางชีวภาพจะส่งผลให้เกิดปรากฏการณ์ต่าง ๆ <u>ยกเว้น</u>ข้อใด
   ก. สภาพภูมิอากาศแปรปรวน
   ข. ระบบนิเวศสูญเสียสภาพสมดุล
   ค. พลังงานความร้อนจากดวงอาทิตย์ลดลง
   ง. มนุษย์ขาดแคลนอาหารและยารักษาโรค
   จ. แหล่งท่องเที่ยวและการนันทนาการเสื่อมโทรม
13. ข้อใดเป็นแนวทางการแก้ไขปัญหาภาวะการสูญเสียความหลากหลายทางชีวภาพอย่างยั่งยืนที่สุด
   ก. ลดการใช้สารเคมีทุกชนิด
   ข. ปลูกต้นไม้เพื่อเพิ่มพื้นที่ป่า
   ค. ออกกฎหมายห้ามจับสัตว์ป่าทุกชนิด
   ง. ตัดต่อพันธุกรรมของพืชและสัตว์ให้มากขึ้น
   จ. ช่วยกันอนุรักษ์สิ่งแวดล้อมและใช้ทรัพยากรธรรมชาติให้คุ้มค่าและเกิดประโยชน์สูงสุด
14. ถ้าหากพื้นที่ป่าปู่ตาถูกบุกรุกทำลาย เหตุการณ์ใดที่ส่งผลให้เกิดการสูญเสียความหลากหลายทางชีวภาพได้ง่าย
   ก. อากาศเสีย
   ข. ดินเสื่อมสภาพ

ค. ปริมาณความชื้นลดลง

ง. จำนวนประชากรพืชลดลง

จ. จำนวนประชากรสัตว์ลดลง

15. บุคคลใดน่าจะเป็นตัวอย่างที่ดีในการอนุรักษ์ความหลากหลายทางชีวภาพ

ก. ลุงวิมลปรับพื้นที่เพื่อเพิ่มผลให้กับไร่มันสำปะหลัง

ข. ป้าวิกานดาชอบนำสัตว์เลี้ยงแปลกๆ มาเลี้ยงและขยายพันธุ์

ค. ลุงวิบูลย์ปลูกต้นไม้ตามหลักวนเกษตรโดยการปลูกพืชหลายชนิดรวมกัน

ง. ป้าวิภาปลูกถั่วลิสงหลังฤดูทำนาทุกปีเพื่อเพิ่มปริมาณไนโตรเจนให้กับดิน

จ. น้าวินัยกำจัดจิ้งจกที่เกาะตามฝาผนังบ้านเพราะคิดว่าจิ้งจกทำให้บ้านเรือนสกปรกเป็นแหล่งเพาะพันธุ์เชื้อโรค

16. ใครสามารถช่วยป้องกันการสูญเสียความหลากหลายทางชีวภาพได้ดีที่สุด

ก. ประสานงดใช้ประโยชน์จากทรัพยากรชีวภาพ

ข. ประสมทำการเพาะปลูกพืชโดยไม่ใช้สารเคมีใดๆ

ค. ประสงค์จัดสรรพื้นที่ป่าอันอุดมสมบูรณ์เพื่อการอนุรักษ์

ง. ประสพเลือกใช้ประโยชน์จากทรัพยากรชีวภาพอย่างคุ้มค่าและยั่งยืน

จ. ประสิทธิ์กำหนดพื้นที่ที่มีความหลากหลายทางชีวภาพสูงเป็นแหล่งท่องเที่ยวเชิงอนุรักษ์

17. ข้อใดเป็นการสำรวจเพื่อการพัฒนาระบบนิเวศและความหลากหลายของสิ่งมีชีวิต

ก. สุจินดาวัดความยาวลำต้นของถั่วเขียวที่เพาะในถาดทดลองทุกสองวัน

ข. สุชาติสังเกตพฤติกรรมและนับจำนวนนกที่ลำธารของหมู่บ้านทุกสัปดาห์

ค. สุจินตนาสังเกตการเคลื่อนที่ของตัวอ่อนแมลงปอในอ่างทดลองแทบทุกวัน

ง. สุชาดาสังเกตการกัดกินใบผักกาดของหนอนผีเสื้อที่แปลงทดลองทุกสามวัน

จ. สุรพลทดลองให้อาหารแก่สุนัขหลายพันธุ์ที่ห้องสังเกตพฤติกรรมสัตว์ทุกวัน

18. ข้อใดไม่ใช่องค์ประกอบของระบบนิเวศ

ก. ผู้ผลิต

ข. ผู้ทำลาย

ค. ผู้ย่อยสลาย

ง. ผู้บริโภคพืช

จ. ผู้บริโภคสัตว์

19. ประชากร หมายถึงอะไร

ก. ประชากร = สิ่งมีชีวิต + เวลา

ข. ประชากร = สิ่งมีชีวิต + สถานที่

ค. ประชากร = สิ่งไม่มีชีวิต + สถานที่

ง. ประชากร = สิ่งมีชีวิต + สถานที่ + เวลา

จ. ประชากร = สิ่งไม่มีชีวิต + สถานที่ + เวลา

20. ข้อใดจัดเป็นผู้ผลิต

ก. รา

ข. เห็ด

ค. แมลง

ง. แพลงตอนสัตว์

จ. หม้อข้าวหม้อแกงลิง

21. กลุ่มสิ่งมีชีวิตข้อใดมีทั้งผู้ผลิต ผู้บริโภค และผู้ย่อยสลายสารอินทรีย์

ก. หญ้า วัว เสือ ช้าง

ข. ข้าว หนู สาหร่าย นกฮูก

ค. ควาย นกเอี้ยง ตั๊กแตน กล้วย

ง. หนอน ไส้เดือนดิน มนุษย์ แมว เหา

จ. สาหร่าย แบคทีเรีย ปลานิล ปลาซ่อน

22. เหตุใดจึงเรียกพืชว่าเป็นผู้ผลิต

ก. เป็นอาหารของผู้บริโภค

ข. มีความสำคัญทั้งต่อพืชและสัตว์

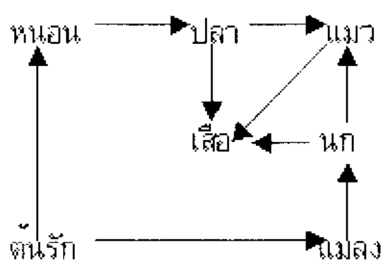
ค. สร้างอาหารเองได้โดยการสังเคราะห์ด้วยแสง

ง. ไม่สามารถเคลื่อนที่เพื่อล่าสิ่งมีชีวิตชนิดอื่นได้

จ. ไม่สามารถบริโภคสิ่งมีชีวิตชนิดอื่นเป็นอาหารได้

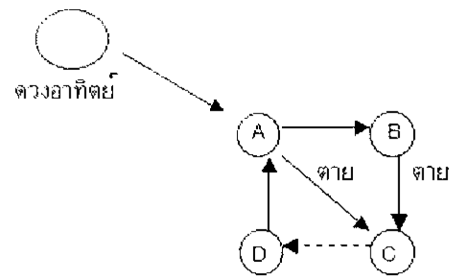
23. ทักษิณทิ้งขยะและเศษอาหารให้กลายเป็นปุ๋ยที่หลังบ้าน อยากทราบว่าสิ่งมีชีวิตใดที่ช่วยให้ขยะและเศษอาหารเหล่านี้กลายเป็นปุ๋ย
    ก. งู
    ข. สุนัข
    ค. จุลินทรีย์
    ง. หญ้าแห้ง
    จ. นกกระจิบ
24. ถ้าโลกเราปราศจากผู้ย่อยสลายซากอินทรีย์ ท่านคิดว่าจะเกิดอะไรขึ้น
    ก. สิ่งมีชีวิตบนโลกจะมีเฉพาะพืชและสัตว์เท่านั้น
    ข. ขยะจะล้นโลกและเต็มไปด้วยซากของสิ่งมีชีวิต
    ค. พืชตายเพราะขาดธาตุอาหารที่จำเป็นต่อการเจริญเติบโต
    ง. ไม่เกิดเหตุการณ์ใดๆ เพราะธรรมชาติสามารถปรับสมดุลด้วยตนเอง
    จ. ร่างกายของสัตว์จะอ่อนแอ เนื่องจากขาดแร่ธาตุที่จำเป็นต่อร่างกาย

จงใช้แผนภาพต่อไปนี้ตอบคำถามข้อ 25



25. จากแผนภาพข้างบนสิ่งมีชีวิตใดจัดเป็นทั้งผู้ล่าและเหยื่อ
    ก. นกและแมว
    ข. เสือและต้นรัก
    ค. แมลงและต้นรัก
    ง. หนอนและต้นรัก
    จ. หนอนและแมลง

จงใช้แผนภาพนี้ตอบคำถามข้อ 26-28



26. สิ่งมีชีวิตใดสามารถสร้างอาหารเองได้
    ก. A
    ข. B
    ค. C
    ง. D
    จ. A และ D
27. หน้าที่ของ C คือข้อใด
    ก. กิน A และ B
    ข. ให้พลังงานแก่ D
    ค. เป็นอาหารของ D
    ง. ย่อยสลาย A และ B
    จ. ย่อยสลาย A B และ D
28. ข้อใดไม่ใช่สิ่งมีชีวิต
    ก. A
    ข. B
    ค. C
    ง. D
    จ. C และ D
29. ใครสามารถนำความรู้เรื่องการปรับตัวไปใช้ประโยชน์ได้ดีที่สุด
    ก. สมใจชอบอาบน้ำร้อนในฤดูหนาว
    ข. สมชายใส่เสื้อสีดำปั่นรถจักรยานในเวลากลางคืน
    ค. สมหวังชอบใส่กางเกงสีสันสดใสในวันหยุดพักผ่อน
    ง. สมภพกินแอปเปิ้ลเพราะรู้ว่ามีประโยชน์ต่อร่างกาย
    จ. สมหญิงเดินชิดขวามือของถนนเพื่อจะได้มองเห็นรถที่วิ่งสวนมา

30. ถ้าท่านต้องการให้ต้นไม้ลำต้นสูงเรียว ควรทำอย่างไร
    ก. ปลูกห่างกัน
    ข. ปลูกใกล้บ้าน
    ค. ปลูกใกล้แหล่งน้ำ
    ง. ปลูกชิดกันไว้ในที่ร่ม
    จ. ปลูกบริเวณที่ราบลุ่ม
31. ข้อใดแสดงถึงความสัมพันธ์แบบพึ่งพาอาศัยกันระหว่างพืชและสัตว์
    ก. น้ำพึ่งเรือ เสือพึ่งป่า
    ข. เสือมีเพราะป่าปก หญ้ารกเพราะเสือยัง
    ค. นาดีถามหาข้าวปลูก ลูกดีถามหาพ่อแม่
    ง. ดินเย็นเพราะหญ้ายัง หญ้ายังเพราะดินดี
    จ. นกเอี้ยงเลี้ยงควายเฒ่า ควายกินข้าว นกเอี้ยงหัวโต
32. ผญาบทใดมีความหมายตรงกับการปรับตัวของสิ่งมีชีวิต
    ก. ย่างนำก้นผู้เฒ่า ผีเป้าบ่กัด
    ข. เงินเต็มพา บ่ท่อผญาเต็มปูม
    ค. เข้าเมืองตาหลิ่ว ต้องหลิ่วตาตาม
    ง. อย่ากินสมอยาก อย่าปากสมเคียด
    จ. คืดต่อน้ำบวกหน้า ดีฮ้ายส่องบ่เห็น
33. วัฒนธรรมท้องถิ่นอีสานเกี่ยวกับความเชื่อป่าปู่ตามีสำคัญต่อคนในชุมชน <u>ยกเว้น</u>ข้อใด
    ก. เป็นแหล่งอาหารและสมุนไพร
    ข. เป็นแหล่งช่วยรักษาสมดุลของระบบนิเวศ
    ค. เป็นแหล่งผลิตพืชผลเพื่อการค้าเชิงพานิชย์
    ง. เป็นแหล่งกักเก็บพันธุกรรมของพืชและสัตว์
    จ. เป็นแหล่งประกอบพิธีกรรมและสร้างความสามัคคี
34. ถ้าหากนักเรียนหลงทางในป่า นักเรียนควรจะรับประทานผลไม้ที่มีลักษณะเช่นไร
    ก. ผลมีกลิ่นหอม
    ข. ผลมีหนามเรียว
    ค. ผลมีสีสดน่ารับประทาน
    ง. เมื่อสัมผัสผลแล้วจะรู้สึกว่านิ่มๆ
    จ. ผลมีร่องรอยจากการกินของสัตว์
35. สิ่งแวดล้อม หมายถึงอะไร
    ก. พืช-สัตว์-สิ่งของ
    ข. สิ่งที่อยู่รอบตัวเรา
    ค. สิ่งที่อยู่บนพื้นโลก
    ง. สิ่งที่สามารถสัมผัสได้
    จ. สิ่งที่มีชีวิตและสิ่งที่ไม่มีชีวิต
36. ทรัพยากรธรรมชาติชนิดใด สามารถนำมาใช้และอนุรักษ์แบบยั่งยืนได้ง่ายที่สุด
    ก. ดิน
    ข. ป่าไม้
    ค. สัตว์ป่า
    ง. ถ่านหิน
    จ. น้ำมันเชื้อเพลิง
37. วิธีการใดน่าจะเป็นการอนุรักษ์ดินที่ดีที่สุด
    ก. ปลูกถั่วลิสงทั้งปี
    ข. ทำไร่นาสวนผสม
    ค. ทำไร่มันสำปะหลัง
    ง. ทำนาปีสลับกับนาปรัง
    จ. เผาหญ้าและฟางก่อนฤดูทำนา
38. "*เมื่อมนุษย์ทำลายธรรมชาติ ธรรมชาติจะทำลายมนุษย์ และถ้ามนุษย์อนุรักษ์ธรรมชาติ ธรรมชาติก็จะอนุรักษ์มนุษย์*" คำกล่าวนี้ ข้อใดอธิบายได้อย่างถูกต้องที่สุด
    ก. มนุษย์กำลังเป็นผู้ทำลายสมดุลธรรมชาติ
    ข. ธรรมชาติในปัจจุบันยังอยู่ในสภาวะสมดุล
    ค. เป็นไปไม่ได้เลยที่ธรรมชาติจะทำลายมนุษย์
    ง. ธรรมชาติและมนุษย์มีความสัมพันธ์ซึ่งกันและกัน
    จ. มนุษย์สามารถควบคุมและจัดการกับธรรมชาติได้
39. ข้อใดเป็นการทำลายสมดุลธรรมชาติและส่งผลกระทบต่อการดำรงชีวิตของมนุษย์มากที่สุด
    ก. การใช้สารเคมี
    ข. การทำลายป่าไม้
    ค. การใช้เครื่องจักรกล
    ง. การทิ้งขยะลงคูคลอง
    จ. การตัดต่อพันธุกรรมพืชและสัตว์

40. ถ้าหากนักเรียนพบป้าย **"ที่สาธารณประโยชน์"** ภายในบริเวณป่าปู่ตาหรือหนองน้ำประจำหมู่บ้าน แสดงว่าบริเวณนั้นมีความสำคัญอย่างไร
    ก. ทุกคนมีสิทธิในการใช้ประโยชน์จากบริเวณดังกล่าว
    ข. ทุกคนไม่มีสิทธิในการใช้ประโยชน์จากบริเวณดังกล่าว
    ค. ทุกคนมีสิทธิในการใช้ประโยชน์และร่วมกันรักษาบริเวณดังกล่าว
    ง. เจ้าหน้าที่ของรัฐเท่านั้นที่มีสิทธิในการใช้ประโยชน์จากบริเวณดังกล่าว
    จ. ทุกคนมีสิทธิในการรักษา แต่ไม่มีสิทธิในการใช้ประโยชน์จากบริเวณดังกล่าวใดๆ ทั้งสิ้น
41. ข้อใดไม่ใช่ความหมายของการอนุรักษ์สิ่งแวดล้อม
    ก. การใช้ทรัพยากรธรรมชาติอย่างสมเหตุสมผล
    ข. การใช้ทรัพยากรธรรมชาติอย่างประหยัดและคุ้มค่า
    ค. การใช้ทรัพยากรธรรมชาติเพื่อสนองความต้องการ
    ง. การใช้ทรัพยากรธรรมชาติเพื่อการพัฒนาอย่างไร้ขีดจำกัด
    จ. การใช้ทรัพยากรธรรมชาติเพื่อสนองความเป็นอยู่ของมนุษย์ตลอดไป
42. สหประชาติกำหนดให้วันใดเป็นวันสิ่งแวดล้อมโลก
    ก. 5 เมษายน ของทุกปี
    ข. 5 มิถุนายน ของทุกปี
    ค. 5 กันยายน ของทุกปี
    ง. 5 พฤษภาคม ของทุกปี
    จ. 5 พฤศจิกายน ของทุกปี
43. ปรากฏการณ์ใดที่ก่อให้เกิดผลกระทบต่อสภาพแวดล้อมมากที่สุด
    ก. เอดส์ (AIDS)
    ข. ซูนามิ (Tsunami)
    ค. เอลนิโญ (El~ Nino)
    ง. ไข้หวัดนก (Avian flu)
    จ. เรือนกระจก (Green house effect)
44. เหตุใดเกษตรกรบางคนจึงนิยมนำแมลงกระชอนหรือไส้เดือนดินมาปล่อยลงในแปลงเกษตร
    ก. ช่วยในการกำจัดวัชพืช
    ข. ทำให้ดินมีความพรุนมากขึ้น
    ค. ช่วยเพิ่มธาตุอาหารให้แก่ดิน
    ง. ทำให้ดินมีความเป็นกรดมากขึ้น
    จ. ช่วยให้ต้นไม้มีลำต้นไม่สูงมากนัก
45. ข้อใดน่าจะเป็นแนวทางที่ดีที่สุดในการอนุรักษ์และพัฒนาระบบนิเวศป่าปู่ตา
    ก. งดใช้ประโยชน์จากป่าปู่ตาทุกกรณี
    ข. ปรับปรุงให้เป็นสถานที่พักผ่อนหย่อนใจ
    ค. ชาวบ้านร่วมกันกำหนดข้อบังคับและเพิ่มบทลงโทษ
    ง. ร่วมกันปลูกฝังจิตสำนึกที่ดีในการอนุรักษ์สิ่งแวดล้อมแก่ประชาชน
    จ. เสนอให้หน่วยงานของรัฐเข้ามามีส่วนรับผิดชอบเกี่ยวกับการอนุรักษ์สิ่งแวดล้อมอย่างจริงจัง
46. "*ได้กินปลาแล้วอย่าลืมปูปะปล่อย บาดหาปลาบ่ได้ ยังสิได้ ป่นปู*" ผญาบทนี้สื่อความหมายในเชิงวิทยาศาสตร์เพื่อการอนุรักษ์อย่างไร
    ก. ใกล้เกลือกินด่าง
    ข. วัวหายล้อมคอก
    ค. ได้อย่างเสียอย่าง
    ง. เผื่อเหลือเผื่อขาด
    จ. ทำบุญหวังชาติหน้า
47. ข้อใดไม่ใช่เหตุผลที่ทำให้วัฒนธรรมท้องถิ่นมีส่วนช่วยในการอนุรักษ์สิ่งแวดล้อม
    ก. มีหลักการของวิทยาศาสตร์พื้นบ้านสอดแทรก
    ข. ตอบสนองความต้องการขั้นพื้นฐานอย่างยั่งยืน
    ค. ความเชื่อได้รับการพิสูจน์แล้วว่าเป็นจริงทั้งหมด
    ง. ก่อให้เกิดสภาพความหลากหลายขึ้นในระบบนิเวศ
    จ. สะท้อนระบบความสัมพันธ์เชื่อมโยงระหว่างคนกับธรรมชาติ และสิ่งที่อยู่เหนือธรรมชาติ

48. ข้อใดไม่ใช่แนวทางในการอนุรักษ์สิ่งแวดล้อมอย่างยั่งยืน
    ก. การใช้ทรัพยากรอย่างระมัดระวัง
    ข. การสร้างสิ่งทดแทนทรัพยากรบางประเภท
    ค. การปรับปรุงวิธีการใช้ทรัพยากรให้เหมาะสม
    ง. การให้การศึกษาและทำความเข้าใจเรื่องการอนุรักษ์
    จ. การนำทรัพยากรมาใช้ประโยชน์ให้สนองกับความต้องการของผู้บริโภคอย่างเต็มที่
49. ถ้าท่านพบว่าเปลือกของพืชต้นหนึ่งที่เจริญเติบโตในป่าปู่ตาสามารถรักษาโรคเอดส์ได้ ท่านจะทำอย่างไร
    ก. ไม่ทำอะไรเลย เฉยๆ เป็นทองไม่รู้ร้อน
    ข. แสวงหาแนวทางรักษาและพัฒนาร่วมกัน
    ค. ไม่ต้องบอกใครตัดเอาไปขายเองซะดีกว่า
    ง. ขุดมาปลูกในพื้นที่สวนหลังบ้านของตัวเอง
    จ. ผูกผ้าแดงแล้วตั้งกระถางธูปเทียนเพื่อบูชา
50. สมาชิกในท้องถิ่นควรปฏิบัติอย่างไร เมื่อพบว่าเกิดปัญหาสิ่งแวดล้อมขึ้นในท้องถิ่นของตนเอง
    ก. ไม่ต้องทำอะไรทั้งสิ้น
    ข. ให้กำนันหรือผู้ใหญ่บ้านเป็นผู้แก้ปัญหา
    ค. ส่งเรื่องราวร้องทุกข์ไปยังนายกรัฐมนตรี
    ง. แจ้งเจ้าหน้าที่ของรัฐเพื่อขอความช่วยเหลือ
    จ. ร่วมมือกันเสาะแสวงหาหนทางเพื่อป้องกันและแก้ไขปัญหา

........ขอให้นักเรียนทุกคนโชคดีในการทำข้อสอบ........

"รักเรา รักษ์โลก"

APPENDIX C Values of test for science-culture in accord

แบบวัดค่านิยมต่อวัฒนธรรมวิถีวิทยาศาสตร์

โรงเรียน...ชั้น..
ชื่อ-นามสกุล...เลขที่.......................................

คำชี้แจง ขอให้นักเรียนอ่านแต่ละข้อความและพิจารณาตามความรู้สึกจริงของนักเรียน โดยใส่เครื่องหมาย (√) ลงในช่องว่างเพียงข้อละ 1 ช่องเท่านั้น

ข้อความ	เห็นด้วยอย่างยิ่ง	เห็นด้วย	ค่อนข้างเห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
ด้านคุณธรรม จริยธรรม					
1. ท่านยินดีเข้าร่วมสังเกตและประกอบพิธีกรรมที่สำคัญของท้องถิ่น					
2. ท่านชื่นชอบการพิสูจน์แบบวิทยาศาสตร์มากกว่าแบบไสยศาสตร์					
4. ท่านยินดีแต่งกายและปฏิบัติตามกฎระเบียบของโรงเรียน					
5. ท่านพยายามแก้ไขข้อบกพร่องที่ควรแก้อยู่ตลอดเวลา					
6. ท่านพร้อมที่จะทำความสะอาดบ้านเรือนและชุมชน					
7. ท่านนิยมทักทายผู้อาวุโสด้วยการไหว้แบบไทย ๆ					
8. ท่านชอบไปก่อนเวลาที่มีการนัดหมายล่วงหน้า					
9. ท่านพยายามหาดูและทำตามตัวอย่างที่ดี					
10. ท่านชอบคบเพื่อนที่เป็นสุภาพชน					
ด้านศิลปะและขนบธรรมเนียมประเพณีท้องถิ่น					
1. ท่านชื่นชมการรดน้ำดำหัวและขอพรจากผู้ใหญ่ในวันสงกรานต์มากกว่าการเล่นสาดน้ำ					
2. ท่านพร้อมที่จะไปดูการประกวดการแกะสลักต้นเทียนเข้าพรรษา					
3. ท่านชอบลายสานกระติ๊บข้าวที่สามารถเก็บกักอุณหภูมิได้ดี					

คำถาม	เห็นด้วยอย่างยิ่ง	เห็นด้วย	ค่อนข้างเห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
4. ท่านชอบดูการแสดงหมอลำและดนตรีพื้นเมืองอีสาน					
5. ท่านนิยมชมชอบท่วงท่าลีลาและจังหวะในการรำเซิ้ง					
6. ท่านชอบการสวมใส่เสื้อผ้าลายพื้นเมืองอีสาน					
7. ท่านชื่นชอบการปลูกต้นไม้และจัดสวนหย่อม					
8. ท่านชื่นชอบเสียงดนตรีพื้นเมืองอีสาน					
9. ท่านชื่นชอบการประกวดตกแต่งขบวนแห่บั้งไฟ					
10. ท่านพร้อมที่จะทำโมบายเพื่อถวายให้วัด					
ด้านการพึ่งตนเอง					
1. ท่านพยายามถนอมอาหารโดยใช้วัตถุดิบและส่วนประกอบที่มีในท้องถิ่น					
2. ท่านพร้อมที่จะใช้รถจักรยานแทนรถจักรยานยนต์หรือรถยนต์					
3. ท่านชอบซ่อมแซมเครื่องมือเครื่องใช้ที่ชำรุดด้วยตนเอง					
4. ท่านพร้อมที่จะช่วยกันพัฒนาพื้นที่สาธารณประโยชน์					
5. ท่านนิยมเลี้ยงสัตว์ไว้เพื่อใช้เป็นอาหารและใช้แรงงาน					
6. ท่านยินดีที่จะปลูกผักปลอดสารพิษไว้รับประทาน					
7. ท่านชอบรับประทานอาหารที่มีส่วนประกอบจากปลาร้า					
8. ท่านชื่นชอบการนำส่วนประกอบของพืชมาทำสีย้อมผ้า					
9. ท่านพร้อมที่จะประดิษฐ์คิดค้นสิ่งของขึ้นมาใช้เอง					
10. ท่านยินดีที่จะปลูกผักพื้นบ้านเพื่อให้เป็นรั้วกั้น					
11. ท่านพร้อมที่จะลดการใช้สารเคมีในครัวเรือน					
12. ท่านนิยมขยายพันธุ์พืชในท้องถิ่นด้วยตนเอง					

APPENDIX D Environmental conservation behavior questionnaire

สถานการณ์ที่ 1

โรงเรียน...ชั้น..............ชื่อ-นามสกุล...

เปี๊ยกเป็นนักเรียนชั้น ม.3 สังเกตเห็นชาวบ้านนิยมเผาฟางข้าวก่อนฤดูทำนา ส่งผลให้หน้าดินเสื่อมสภาพเร็วขึ้น สัตว์บางชนิดถูกไฟคลอกตาย รวมไปถึงปัญหาอัคคีภัยและปัญหามลพิษทางอากาศ วันหนึ่งครูวิทยาศาสตร์ได้ให้นักเรียน ในชั้น ม.3 คิดหาวิธีการจัดการเศษฟางข้าวในท้องนาหลังฤดูทำนาอย่างยั่งยืน แล้วนำมาเขียนเป็นรายงานและหาแนวทาง ที่จะเผยแพร่ประชาสัมพันธ์ให้คนในหมู่บ้านได้ตระหนักถึงความสำคัญของฟางข้าวและการจัดการอย่างถูกวิธี

คำถาม

1. เปี๊ยกควรจะนำฟางข้าวมาใช้ประโยชน์อย่างไร

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2. เปี๊ยกควรจะเสนอแนะแนวทางในการแก้ปัญหานี้ให้กับชาวบ้านอย่างไร

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3. ถ้านักเรียนเป็นชาวบ้านจะแก้ปัญหานี้อย่างไร

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สถานการณ์ที่ 2

โรงเรียน...ชั้น..............ชื่อ-นามสกุล...

ป๊อกอาศัยอยู่ในหมู่บ้านแห่งหนึ่ง ทางหมู่บ้านได้ทำทางระบายน้ำข้างถนน เพื่อช่วยระบายน้ำเสียที่ใช้แล้วออกจากหมู่บ้าน ซึ่งทางหมู่บ้านได้จัดที่กำจัดขยะไว้ในทุ่งนาห่างจากหมู่บ้านประมาณ 1 กิโลเมตร คุณแม่ได้มอบหน้าที่การเอาขยะไปทิ้งให้ป๊อกเป็นผู้รับผิดชอบ แต่ป๊อกไม่ชอบหน้าที่นี้เลย เพราะขยะทั้งหนักทั้งเหม็นและระยะทางค่อนข้างไกล ต้องเดินย่ำโคลนไป ป๊อกสังเกตเห็นเพื่อนบ้านหลายคนเอาขยะไปเททิ้งที่ริมทางหน้าบ้านเสมอ ๆ ขยะส่งกลิ่นเหม็น บางส่วนตกลงไปในท่อระบายน้ำ แต่ก็ไม่มีใครทำอะไรกับคนพวกนั้น ป๊อกยังตัดสินใจไม่ถูกว่าจะเลือกทิ้งขยะที่หน้าบ้านหรือเอาไปทิ้งที่จัดไว้ให้

คำถาม

1. ป๊อกควรจะนำขยะไปทิ้งที่ไหน เพราะเหตุใด

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2. ท่านจะมีวิธีการแก้ปัญหานี้อย่างไร

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3. ท่านจะมีวิธีการช่วยลดปัญหาขยะได้อย่างไรบ้าง

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4. ท่านจะเสนอแนะแนวทางการจัดการกับขยะให้แก่ชาวบ้านอย่างไร

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VITAE

VITAE

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REINFORCEMENT OF SCIENCE LEARNING THROUGH LOCAL CULTURE

AN ABSTRACT

BY

PRASART NUANGCHALERM

Presented in Partial Fulfillment of the Requirements for the

Doctor of Education Degree in Science Education

at Srinakharinwirot University

April 2006

Prasart Nuangchalerm. (2006). *Reinforcement of Science Learning through Local Culture.* Dissertation, Ed.D. (Science Education). Bangkok: Graduate School, Srinakharinwirot University. Advisor Committee: Associate Professor Somchit Savathanaphaibul, Associate Professor Dr. Seriwat Saminpanya, Associate Professor Dr. Sunee Haemaprasith.

This study aims to three-fold (1) to reinforce science learning through local culture by designing a science curriculum, (2) to implement the developed science curriculum, and (3) to examine learning outcomes by focusing on science learning achievement, values of science-culture in accord, and environmental conservation behavior.

The samples were divided into two groups. Firstly, samples for designing the reinforcement of science learning through local culture using Delphi Technique consisted of 24 experts in the science curriculum developers, educational technologists or evaluators, ecologists or environmentalist, indigenous specialists, and national science teachers or master science teachers. Secondly, samples for studying the result of implementation of the developed science curriculum, which reinforced science learning through local culture, were Mathayomsuksa 3 students at Chumchon Baan Don Hun school, Baan Don Jode school, and Baan Nonchantuek school of Khon Kaen Educational Region 3.

The findings revealed that:

1. The developed science curriculum showed the integrated relationship between science and local culture in terms of knowledge, process, and attitude towards science. This study employed *PAH POOH TAH* (a small village's woodland in the northeastern part of Thailand) as a model of local culture and learning resource in local community.

2. The opinions of panel members in Delphi technique provided ways to reinforce science learning through local culture and to develop student abilities.

3. The LADDA Instructional Model (Learning, Analyzing, Deciding, Doing, and Application) gained higher posttest scores in science learning achievement, values of science-culture in accord, and environmental conservation behavior than the pretest scores.

4. The developed science curriculum gained higher posttest scores in science learning achievement, values of science-culture in accord, and environmental conservation behavior than the pretest scores with a statistical significant at .05.

การเสริมแรงการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่น

บทคัดย่อ

ของ

ประสาท เนืองเฉลิม

เสนอต่อบัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ เพื่อเป็นส่วนหนึ่งของการศึกษา

ตามหลักสูตรปริญญาการศึกษาดุษฎีบัณฑิต สาขาวิชาวิทยาศาสตรศึกษา

เมษายน 2549

ประสาท เนืองเฉลิม. (2549). *การเสริมแรงการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่น.* ปริญญานิพนธ์. กศ.ด. (วิทยาศาสตรศึกษา). กรุงเทพฯ: บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ. คณะกรรมการควบคุม: รองศาสตราจารย์ สมจิต สวธนไพบูลย์ รองศาสตราจารย์ ดร. เสรีวัฒน์ สมินทร์ปัญญา รองศาสตราจารย์ ดร. สุนีย์ เหมะประสิทธิ์.

การวิจัยครั้งนี้มีจุดมุ่งหมายเพื่อ (1) เสริมแรงการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่นด้วยหลักสูตรที่ผู้วิจัยพัฒนาขึ้น (2) เพื่อทดลองใช้หลักสูตรวิทยาศาสตร์ที่ผู้วิจัยพัฒนาขึ้น และ (3) เพื่อศึกษาผลลัพธ์การเรียนรู้หลังทดลองใช้หลักสูตร ซึ่งประกอบด้วย ผลสัมฤทธิ์ทางการเรียนวิทยาศาสตร์ ค่านิยมต่อวัฒนธรรมวิถีวิทยาศาสตร์ และพฤติกรรมการอนุรักษ์สิ่งแวดล้อม

กลุ่มตัวอย่างที่ใช้ในการศึกษาแบ่งออกเป็น 2 กลุ่ม ได้แก่

1. กลุ่มตัวอย่างที่ใช้ในการออกแบบการเสริมแรงการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่นด้วยเทคนิคเดลฟาย ประกอบด้วยผู้เชี่ยวชาญด้านการพัฒนาหลักสูตร ด้านเทคโนโลยีทางการศึกษาหรือการวัดและประเมินผล ด้านนิเวศวิทยาหรือสิ่งแวดล้อม ด้านวัฒนธรรมท้องถิ่น และครูแห่งชาติหรือครูต้นแบบที่สอนวิทยาศาสตร์ จำนวน 24 ท่าน

2. กลุ่มตัวอย่างที่ทดลองใช้หลักสูตร ประกอบด้วยนักเรียนชั้นมัธยมศึกษาชั้นปีที่ 3 จากโรงเรียนชุมชนบ้านดอนหัน โรงเรียนบ้านดอนโจด และโรงเรียนบ้านโนนจันทึก สังกัดสำนักงานเขตพื้นที่การศึกษาขอนแก่น เขต 3

ผลการศึกษาพบว่า

1. หลักสูตรที่ได้เป็นหลักสูตรวิทยาศาสตร์ที่มีความสัมพันธ์ระหว่างวิทยาศาสตร์และวัฒนธรรมท้องถิ่นเชิงบูรณาการด้านความรู้ กระบวนการ และเจตคติต่อวิทยาศาสตร์ โดยใช้ป่าปู่ตา (ป่าประจำหมู่บ้านในภาคอีสาน) เป็นตัวแทนทางวัฒนธรรมท้องถิ่นและแหล่งการเรียนรู้ในชุมชน

2. การเสริมแรงการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่นด้วยเทคนิคเดลฟาย กลุ่มผู้เชี่ยวชาญได้เสนอแนวทางในการส่งเสริมพัฒนาการของผู้เรียน และการออกแบบการจัดการเรียนรู้วิทยาศาสตร์โดยอาศัยวัฒนธรรมท้องถิ่น

3. กระบวนการจัดการเรียนรู้โดยใช้ LADDA Instructional Model (Learning, Analyzing, Deciding, Doing, and Application) ส่งผลให้นักเรียนมีผลสัมฤทธิ์ทางการเรียนวิทยาศาสตร์ ค่านิยมต่อวัฒนธรรมวิถีวิทยาศาสตร์ และพฤติกรรมการอนุรักษ์สิ่งแวดล้อมหลังทดลองสูงกว่าก่อนทดลองใช้หลักสูตร

4. หลักสูตรที่ได้รับการออกแบบสามารถนำไปใช้พัฒนาการเรียนรู้วิทยาศาสตร์ของนักเรียนได้ดีขึ้น ส่งผลให้ผลสัมฤทธิ์ทางการเรียนวิทยาศาสตร์ ค่านิยมต่อวัฒนธรรมวิถีวิทยาศาสตร์ และพฤติกรรมการอนุรักษ์สิ่งแวดล้อมของนักเรียนหลังทดลองสูงกว่าก่อนทดลองใช้หลักสูตรอย่างมีนัยสำคัญทางสถิติที่ระดับ .05

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