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THESIS

ENHANCING STUDENTS' UNDERSTANDING OF THE CONCEPTS OF SPECIES DIVERSITY THROUGH COMMUNITY FUNDS OF KNOWLEDGE

YANAPHAT PROMPRASIT

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
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Yanaphat Promprasit 2011: Enhancing Students' Understanding of the Concepts of Species Diversity through Community Funds of Knowledge. Doctor of Philosophy (Science Education), Major Field: Science Education, Department of Education. Thesis Advisor: Assistant Professor Naruemon Yutakom, Ph.D. 220 pages.

This research aims to develop teaching and learning species diversity based on community funds of knowledge to enhance students' understanding of species diversity concepts. This study has three phases. The first phase was to explore current situation in teaching and learning species diversity, students' understanding concepts of species diversity and existing situation of community funds of knowledge about species diversity in the students' community. The second phase was to design and develop a species diversity learning unit based on constructivist approach, socio-cultural perspective of learning, and community funds of knowledge. The last phase was to examine the impact of the implementation of the unit on teachers' teaching and students' learning. The learning unit was implemented by three biology teachers with one hundred and eight students in three secondary schools in suburban area of Ratchaburi province. Nine of the students were also selected purposively to be studied in depth concerning their development of species diversity understanding. The data collection used the surveys, observations and interviews to indicate students' learning based on the teachers' practice.

The findings indicated that the development of a species diversity learning unit which drew on community funds of knowledge enhance students' understanding of the concepts of species diversity. The implementation of the learning unit was used by each teacher based on their understanding in constructivist approach, community funds of knowledge, and socio-cultural perspectives of learning. The teachers, who understood in these approaches, were successfully intended and consistently implemented the learning unit. Their students understood and corrected their alternative conceptions and could apply species diversity knowledge to explain their community situation related species diversity. In addition, teacher's belief and content background was influenced on their implementation. School events and activities were the important causes of limitation of teachers' preparation to implement the learning unit.

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Yanaphat Promprasit

April, 2011

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CHAPTER I

INTRODUCTION

This chapter provides significance of the research study including significance of the research study, research aims, research questions, anticipated outcomes, context of the study, research methodology and description of terms delimitation. The chapter is completed by summary and organization of this thesis.

Significance of the Research Study

Background of the Study

Thai educational reform began in 1999. The reform had been implemented as a result of the economic crisis in Thailand since 1997. The crisis exposed lower international ranking of Thai education, including as well as export competitiveness. The education system based on the National Social and Economic Development Plan and the National Education Plan aims to improve life quality and to develop human resources in science and technology (Office of National Education Commission [ONEC], 2002). The chapter 4 of the National Education Act B.E. 2542 (1999) as a guideline of education which emphasizes on student centered approaches and self-development, should be responsibly related to the needs of the community and society (ONEC, 2000a.). The educational belief that all learners are capable of learning and developing themselves is regarded as the most fundamental principle of the National Education Act 1999. Therefore, the teaching-learning process should aim at enabling learners to develop themselves at their own pace, to the best of their potential. The educational emphasis is on developing knowledge about oneself and the relationship between oneself and society, religion, art, culture, and wisdom. It also focuses on the application of wisdom as well as knowledge and skills used in pursuing one's career as well as knowledge needed to lead a happy life.

About the study levels, based on the National Education Act in 1999, the Thai education system is divided into four levels supervised by the Ministry of Education: lower primary education: key stage 1 (7-9 years), upper primary education: key stage 2 (10-12 years), lower secondary education: key stage 3 (13-15 years), and upper secondary education: key stage 4 (16-18 years). Each key stage has the same goals and objectives but with different emphasis. The substance is divided into eight subject groups: (1) Thai language; (2) Mathematics; (3) Science; (4) Social studies, Religion, and Culture; (5) Health and Physical education; (6) Art; (7) Career and Technology, and (8) Foreign languages.

The educational reform in 1999 emphasizes students' learning processes between knowledge and community (ONEC, 2002). Students develop their understanding and experience in utilization, conversation and management of natural resources in their community. In biology education, students study biology as a unit of science subjects at the primary and secondary school levels. Biology has been separated as its own subject at the high school levels (Ministry of Education [MOE], 2002). According to the National Education Act B.E. 2542 (1999) and the National Science Content Standard, biology education was reformed in all levels of study contents and was schematized in the area of "Living Things and Life Processes" and "Life and the Environment" and integrated in the area of "Nature of Science and Technology" (The Institute for the Promotion of Teaching Science and Technology [IPST], 2002). In order to learn biology to be consistent with the reform, the students are expected to achieve not only an understanding of scientific content and the nature of science but also applying their knowledge to use natural resources in their community effectively (IPST, 2002).

Statement of Problems

Regarding to Thailand's environmental problems, human activities have caused thousands of animals and plants to become extinct during the past few centuries. Major drivers of future changes in biodiversity are land-use changes, climate changes, and biotic exchanges. The rate of decline in species diversity is

expected to remain high or even to increase in the future as human populations continue to grow, to consume resources, and to pollute the environment with their waste (Baimai, 1995). Thai people seem to lack knowledge of species diversity, and they fail to perceive a link between species preservation and improved quality of life for humans (Baimai, 1995; Jamaric, 2000).

Species diversity is a variety of life in various ecosystems on our planet. The concept of species diversity emphasizes the conservation of the diversity of life to improve the quality of human life, by meeting economic and medical needs (Baimai, 1995; Foster-Turley, 1996; St. Antoine and Runk, 1996; Jamaric, 2000). In addition, species diversity has become increasingly important for humans, when considering the impact of their activities on species diversity, and for developing and implementing ways to decrease extinction rates (Haury, 1998).

Species diversity is an environmental issue with consequences for the quality of human life. Knowledge of species diversity helps to conserve the diversity of life for medical and economic reasons (Bimai, 1995; Foster-Turley, 1996; St. Antoine and Runk, 1996; Jamaric, 2000). The concept of species diversity is also important to protect the diversity of life because it helps to maintain ecological functions, such as oxygen production, pollination, and flood control, which in turn help support all life on Earth. It has even been suggested that the current species diversity crisis may lead to the disruption and degradation of several basic processes of evolution (Myers, 1996). The biodiversity losses have been noted throughout the world primarily due to the over-exploitation of natural resources, habitat degradation, and climatic changes. The current species extinction rate has increased up to a few thousand times that of the background rate as inferred from fossil records (Barbaut and Sastrapadja, 1995) and is of the order of a thousand species per decade per million species (Pimm and Raven, 2000).

In Thailand, species diversity can improve the quality of life for Thai people. It also affects the ecological system, economic development, society, and the environment (Bimai, 1995). The loss of species diversity is a big problem because

people seem to lack knowledge of the importance of biodiversity that is related to their social and cultural contexts (Bimai, 1995). Therefore, the knowledge of species diversity has to begin in the educational system, with research and planning for developing the country (Jamaric, 2000). Species diversity has become part of the content in science education for school science programs in national and international documentation on science education; (AAAS, 1993; BSCS, 1993; NRC, 1995; IPST, 2002).

Therefore, species diversity has become an important content area in science education to help students' understanding of evolutionary relationships, potentially similar uses of related species, and management strategies of conservation (Jamaric, 2000). Species diversity is a component of the biology content standards in secondary levels (IPST, 2002). Species diversity is a basic concept for students' understanding of organisms, using of scientific inquiry, and communicating and applying knowledge for everyday life. The content of species diversity is based on the National Science Content Standards (IPST, 2002). The concepts include definition of species diversity, classification of organisms, kingdom animalia, kingdom plantae, kingdome protista, kingdom fungi, kingdom monera, species and species conservation. This content challenges science educators to consider methods to improve the scientific understanding of species diversity for students based on National Education Act 1999 (ONEC, 2003). In addition, species diversity education must include academic study of biological relationships, structural and functional diversity, and the processes of evolution and extinction (Noss, 1991; Wilson, 1992).

However, many students had low achievement on species diversity examinations and they lacked the knowledge to use concepts of species diversity in the conservation of life. The main cause of these problems is that public school systems are increasingly isolated from the local communities and thus fail to address or acknowledge local needs and characteristics (Ratanapojnard, 2001). Schools promote only a narrow set of academic skills. Students frequently reported that what they learned in school was not related to everyday life (ONEC, 2002). In addition, the

teaching and learning biodiversity in school do not emphasize concept of conservation of life and awareness in value of living (Ham and Kelsey, 1998).

The teaching about living things in local community and environment has influenced the awareness of species conservation (Baimai, 1995). The basic education institutions have responsibility for constructing their own curriculum in accordance with local community problems and wisdom (Basic Education, 2001; IPST, 2002). Parents, guardians and all parties in the community are encouraged to participate in the learning process to develop students to their fullest potential (ONEC, 2003).

Regarding to teaching processes, many researchers have suggested that when teaching science teachers should consider students' prior knowledge and that students should develop their own new knowledge through the interaction of what they have already known and believed. (Jaworski, 1993; Cannella and Reiff, 1994; Myers, 1996; Richardson, 1997). In social constructivist approach, student's knowledge comes from collaboration among practitioners in the classroom and society that emphasizes on relationships between people, communities, contexts, social and cultural relativity (Edwards, 2000). The development of flexible central curricula and teaching-learning processes with student-centered approaches and that apply to each school contexts and communities have been mentioned. However, the challenge of constructing curricula based on student and local knowledge still prevails.

In this study, the researcher use the term "community funds of knowledge" to promote students' understanding species diversity in their community. The community funds of knowledge are the cultural artifacts, resources or bodies of knowledge that existed in students' home (Moll, 1992; Gonzalez *et al*., 1995). It allowed students to use information familiar to them and teachers to develop appropriate lessons and materials in teaching. It can also become a method where students study topics which interested them and it is important to the teacher. It can be used to achieve curricular goals (Moll and Greenberg, 1990; Moll *et al*., 1992).

However, in-depth research on teaching and learning species diversity by using social and cultural contexts in high schools in Thailand has never been performed. In this study, the researcher uses a social constructivist approach to promote teaching and learning about species diversity. This study aims to develop a species diversity learning unit based on community funds of knowledge that takes into account the school/community context. In order to make the learning unit appropriate and effective, it is necessary to first acquire a clear understanding of the current state of education and environmental education field studies, including interviews with all practitioners in this study.

Research Aims

This research was divided into three phases. The aim of the first phase was to explore current situation in teaching and learning species diversity, students' understanding concepts of species diversity and existing situation of community funds of knowledge about species diversity in a students' community. Findings from this phase were used to design the unit. The aim of the second phase was to design and develop a species diversity learning unit based on constructivist approach, socio-cultural perspective of learning, and using community funds of knowledge to enhance students' understanding of the concepts of species diversity. In the last phase, the species diversity learning unit was implemented and evaluated in three schools. The aim of this phase was to examine the impact of implementing the learning unit on teachers' teaching and students' learning concerning with the concepts of the species diversity.

Research Questions

The research questions for the study include the following:

1. What is the current situation of teaching and learning species diversity concepts in high school as perceived by students and teachers?

2. What are the community funds of knowledge about species diversity in students' community?

3. What happens when a Species Diversity Learning Unit based on community funds of knowledge is planned, implemented and evaluated?

3.1 What are the characteristics of the Species Diversity Learning Unit based on community funds of knowledge?

3.2 What do teachers change after implementing the Species Diversity Learning Unit?

3.3 What are students' conceptual understandings of species diversity resulting from the learning unit?

3.4 What facilitates and constrains the implementation of the Species Diversity Learning Unit?

Anticipated Outcomes

This study is expected to show the following benefits:

1. Thai biology teachers and science educators would receive information of a new learning unit for learning in a specific context. This would enable them to adapt the process to create their own teaching unit.

2. Thai science teachers would have a learning unit that is based on the goals of the National Education Act B.E. 2544 (ONEC, 2002) and the National Science Curriculum (IPST, 2002). Then, they could adapt the teaching unit to teach about species diversity in their classrooms.

Context of the Study

This study comprised of three phases based on research questions. In the first phase, exploratory phase, the current state of teaching and learning was examined from five biology teachers from five schools in Ratchaburi Province and fifteen students of these teachers were interviewed about teaching and learning objectives, teaching methods, instructional medias, learning resources, problems and needs in teaching and learning species diversity concepts. In addition, four community leaders were interviewed about the utilization, conservation and management of species diversity as community funds of knowledge in their community. The first phase also explores the students' understanding about species diversity. One hundred and twenty three students in three science classrooms of Grade 12 in Ratchaburi province were selected to take the Species Diversity Concepts Survey and interview concerning species diversity related to their community during the second semester, academic year 2005. In the survey, the concepts of species diversity included definition of species diversity, classification, Kingdom Animalia, Kingdom Plantae, Kingdom Protista, Kingdom Fungi, Kingdom Monera, definition of species and conservation of species diversity. In the second phase, the state of teaching and learning the species diversity, community funds of knowledge about species diversity and along with the students' understanding of the concepts of species diversity from the surveys in the exploratory phase and the review of the literature were used to design and develop the Species Diversity Learning Unit [SDLU]. The last phase was the implementation and evaluation of the learning unit. Three volunteer biology teachers and their classrooms in three public high schools in the Ratchaburi suburban area were asked to implement and evaluate the species diversity learning unit during the second semester, academic year 2006. The researcher studied the effects of the unit on the teachers' teaching and the students learning of species diversity concepts. Three students from each school were selected to focus in the study in depth concerning their development of species diversity understanding after the implementation.

Research Methodology

This study is based on an interpretive methodology. This methodology aims to understand meaning in action of an individual in natural settings (Cohen, Manion and Morrison, 2000). The methodology is used to investigate the process of designing this unit, teachers' implementation and students' participation in learning activities. This study aims to describe what happens when a species diversity learning unit based on community funds of knowledge is planned, implemented, and evaluated. Teaching-learning activities during implementation were conducted for eight weeks in academic years 2007. Teachers' teaching and students' learning were observed by using videotape recording and field notes during every biology teaching period, two periods a week. Three teachers were interviewed about what and how teacher taught and students learned during the course of the unit. Additionally, three students for each teacher were examined in depth about their understanding about species diversity concepts. Information from these sources was coded into patterns related to the theoretical framework of curriculum development, constructivist learning theory and socio-cultural theory. Thematic analysis was used to analyze the data. The analysis focuses on identifiable themes and patterns of learning and/or behavior (Taylor and Board, 1984; Leininger, 1985). From the transcribed conversations, patterns of experiences can be listed. The next step is to identify all data that relate to the already classified patterns and to combine and categories related patterns into sub-themes. The final step is to build a valid argument for choosing the themes.

Description of Terms

Community Funds of Knowledge means the cultural artifacts and knowledge under the household activities (Moll, 2000). They are the cultural resources found in communities surrounding schools. In this study, the community funds of knowledge relate species diversity that emphasize students', parents' and community members' knowledge of household management, agriculture, economics, medicine, and religion. The community funds of knowledge probed through the survey**,** interviews and memory banking.

Species Diversity Learning Unit [SDLU] is based on constructivist approach, community fund of knowledge and socio-cultural perspective of learning. The learning unit is comprised of eight lesson plans, student manual and learning activities which are designed to promote the teaching and learning of the concepts of species diversity. The eight lesson plans were designed for twenty fifty-min teaching periods. The unit is based on the community funds of knowledge and allows the students to understand the species diversity in their community. Teaching and learning were examined by using observations and interviews with teachers to determine how they have implemented the unit and how the students have responded to the unit.

Students' Understanding of Species Diversity Concepts is the students' ideas concerning the concept of definition of species diversity, classification, Kingdom Animalia, Kingdom Plantae, Kingdom Protista, Kingdom Fungi, Kingdom Monera, definition of species and conservation of species diversity. Students can explain and describe species diversity in their social and cultural context. Understanding also included students' ability of using species diversity knowledge for species conservation and participating in learning activities that can be measured by Species Diversity Concept Survey and writing in assignments, interviews and in the classroom observations.

Summary and Organization of This Thesis

This chapter discusses the background and significance of the study. This study aims to examine Thai students understanding of species diversity, the existing teaching and learning species diversity in Thailand and to develop an intervention to promote scientific understanding of species diversity that is aligned with the National Science Curriculum Standards (2002) and suitable for Thai classroom contexts. In this study, three research questions are then considered. The first two research questions which deal with Thai students understanding of species diversity, the current situation of teaching and learning species diversity, and the existing situation of community funds of knowledge about species diversity are explored. The findings are used for designing and developing the Species Diversity Learning Unit [SDLU]. The last research

question looks into the effect of the SDLU on teaching and learning, and student learning outcomes in three science classrooms.

Chapter II provides a review of literature including Thai educational reform, species diversity in biology education in Thailand, students understanding of species diversity teaching and learning of species diversity. The review also provides the perspectives of learning science that are discussed: personal constructivism, social constructivism, the socio-cultural perspective of learning and funds of knowledge. The chapter makes an argument that teaching and learning species diversity for comprehension should take social and cultural aspect of learning.

Chapter III, research methodology, starts by reviewing the methodology of the study, interpretivism, characteristics of interpretive research, a case study design, and the research framework. It also presents the data collection and data analysis in each phase of the study. Finally, the researcher discusses the trustworthiness and ethical concerns of the study.

Chapter IV sets out the data related to the first phase: an exploratory phase. This chapter describes the findings of the survey on Thai students' understanding of species diversity, current situation of teaching and learning species diversity and existing situation of community funds of knowledge about species diversity. At the end of this chapter, the implication of survey results for intervention design is discussed.

Chapter V discusses the design and development of Species Diversity Leaning Unit [SDLU] which was used to promote scientific understanding of the concept about species diversity. The chapter starts with a number of guiding principles that SDLU is based on. The process of the unit design and development and the organization of content and activities of SDLU are discussed. The characteristics of each lesson in the unit are detailed.

Chapter VI presents the findings from the implementation of the SDLU from three cases in terms of teachers' implementation of the SDLU, students' learning, and student learning outcomes. The chapter introduces three case studies of the implementation. In each case, teacher background, school and classroom setting, and the students' background are described. The common findings from the three cases are used across the cases.

Chapter VII presents discussions, conclusions, and recommendations for further research study.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter begins by discussing the widening purposes of Thai educational reform, species diversity in biology education in Thailand, students' understanding of species diversity and teaching and learning of species diversity. The review also provides the perspectives of learning science that are discussed; personal constructivism, social constructivism, the socio-cultural perspective of learning and funds of knowledge. This thesis investigates the use of teaching strategies that consider constructivist's teaching and learning perspectives and the socio-cultural influences affecting the teaching and learning. Finally, this chapter provides the implications of social constructivism and socio-culture perspectives of learning on teaching species diversity what may enhance student's learning in species diversity.

Thailand Education

Educational Reform

Concerning the development of the economy, Thailand needs employees with higher-level of knowledge and skills in order to achieve new capabilities and to respond to the rapid change created by the globalization of the economy and the ongoing technological revolution (ONEC, 2002). The Ministry of Education launched the National Education Act [NEA], B.E.2542 (1999) which covers many aspects of education reform; in particular the teaching and learning approach, as well as the administrative system and management. In fact, the Thai education system has emphasized chalk and talk pedagogy, role learning, and places the importance on school-education with teachers as the centre of teaching-learning activities (ONEC, 2002). In addition, the knowledge provided was not relevant to the needs of learners

and community. Thus, Thailand needs to improve the education systems to prepare people for an increasingly global era (ONEC, 2003).

Thai education reform has emerged to push Thai education forward to keep up with global changes in this new century and to develop the potential of Thai people to live happily in the economic, social and cultural flow of change. The teaching and learning process should be gradually improved on a school-based curriculum that emphasizes the individual differences, the needs of learners and community and Thai local wisdom. The administrative system and management of education has responsibility for providing education to all children and funds for promoting teacher development. To reform both teaching and learning, teachers and learners must change their role in education. Teachers must change from lecturers to facilitators, while learners must become more independent in learning (ONEC, 2002). The government organized activities to support learning from actual practical experiences. The action plan and the establishment of lifelong learning, self-development and learner-centered education were promoted. The emphasis was not only on knowledge and skills in mathematics, science and technology, but also on the pride of Thai identity, history, and the origin of Thai society and democracy under constitutional monarchy is stressed. The reform was in a diversity of forms to meet with the requirement of the reform teaching and learning process, student's age and potential (ONEC, 2003).

The reform emphasizes on providing education to all groups of learners in society and on giving the rights to the parents, communities, and other groups of people to partially or totally participate in providing education for their children (ONEC, 2002). At present, based on the National Education Act in 1999, the Thai education system is divided into four levels supervised by the Ministry of Education: lower primary education: key stage 1 (7-9 years), upper primary education: key stage 2 (10-12 years), lower secondary education: key stage 3 (13-15 years), and upper secondary education: key stage 4 (16-18 years). Each key stage has the same goals and objectives but with different emphasis. The substance of Basic Education Curriculum B.E. 2544 is divided into eight subject groups: (1) Thai language; (2) Mathematics; (3) Science; (4) Social studies; (5) Health and Physical education; (6) Art; (7) Career and

Technology, and (8) Foreign languages. According to the National Education Act, student-centred approaches are the main concerns of the education reform (ONEC, 2003). The approaches are based on the constructivist learning theory. This emphasizes that the students develop their own understanding of different topics, and learning activities are prepared with regard to individual differences in classroom. The students have opportunities to participate with peers, communities and the environment, so they can apply their knowledge to real life situations (ONEC, 2002).

In the age of great advance information technology and world competition, education should not be confined only to the classroom, and teachers are not the sole knowledge source. Education should aim at cultivating within students the skills of searching for knowledge and gaining through self-learning, so they learn continually at any time and place throughout their lives (ONEC, 2000; ONEC, 20003; Kaewdang, 2003). According to the National Education Act, there are three types of education: formal, non-formal, and informal (ONEC, 2003). Educational institutions are authorized to provide any one or all of the three types of education. The Act also provides that the State should promote the running and establishment of all types of lifelong learning resources, such as public libraries, museums, art galleries, zoological gardens, and other sources of learning (Kaewdang, 2001; ONEC, 2002; IPST, 2002). Therefore, the Thai government has provided funds for supporting learning resources that are useful for all learners, and the utilization of local wisdom as well as knowledge is emphasized. In addition, teaching and learning strategies have to change from teacher-centered to student-centered instruction. Thus, the learners have important roles in determining the learning activities in their classroom with teachers.

Science Education

The National Education Commission [NEC] has raised concern about the quality of science education in Thailand and has drawn attention to deficiencies among students in essential science skills, such as higher order thinking, critical thinking, and problem solving skills (Boonklurb, 2000). Research is currently being done for the Thai education system in science and mathematics to improve the performance of

students. Through education in science, along with mathematics and technology, the country aims to achieve two important goals: scientific literacy for every student, and the provision of a higher degree of mastery in mathematics as well as science disciplines for the students who will specialize in these areas (ONEC, 2003).

In 1999, the Thai government established the National Education Act 1999. The Act emphasized on teaching and learning science and technology (ONEC, 2003). The IPST (2002) has responded to the government policy by developing the National Science Curriculum Standards to be the standard criteria for teaching and learning science. They have identified seven goals for science education which can be applied to science teaching (IPST, 2002).

1. To understand the principles and theories of basic science.

2. To understand the boundaries, nature and limitation of science.

3. To use skills to inquire about and explore science and technology.

4. To develop thinking processes and imagination, problem solving, and also communicative and decision-making skills.

5. To realize the influence and effects of the relationships between science, technology, people and the environment.

6. To use the knowledge of science and technology to advance society and everyday life.

7. To be a human who has scientific attitudes, moral ethic, and value utilization of science and technology creatively.

In view of these goals, primary and secondary school science should include the following key aspects for organizing teaching and learning science (Pravalpruk, 1999):

1. The understanding and application of scientific concepts: in the areas of scientific facts, concepts, principles and theories from life systems, physical systems and earth and space systems;

2. Investigative science: the study of scientific inquiry, providing a set of interrelated processes by which scientists pose questions which investigate phenomena and cultivate deeper understanding of natural phenomena;

3. Connective science: the study of the connections between and within the natural sciences, between science and mathematics, and between science and technology;

4. Science, technology and society: the study of how science and technology are influenced, and how they influence environment and society.

The IPST supported the government policy by establishing eight content standards in the National Science Curriculum to promote literacy in science education including biology education (IPST, 2002). The standards are 1) living things and living processes 2) life and environment 3) substances and their properties 4) force and motion 5) energy 6) earth changing processes 7) astronomy and space and 8) nature of science and technology. In addition, Thai science education also emphasizes school-based curriculum. In this curriculum, Thai schools have flexibility to develop curriculum that has consistency with their local environment and community (ONEC, 2003).

Biology Education in Thailand

From the idea of science for all in the 1980s, biology education was developed relating to technology and society. Biological knowledge needed an understanding of the nature of science including the nature of scientific knowledge, scientific inquiry and the relationship between science and society. Students should inquire and develop biological and technological knowledge, to have a positive attitude towards biology, to recognize relationships between biology and the environment, and to apply biological knowledge to society and life (Ministry of Education, 2002). However, there was little regard to the importance of other aspects of biology education such as the understanding of the nature of science and the application to solve problems in everyday life.

In the learning reform, the National Education Commission of Thailand (ONEC, 2000) reported that the implementation of the previous curriculum of biology teaching and learning could not achieve the social needs of Thailand. Students learned subject matter only from written texts, or from transmission methods. Thus, they failed to link local wisdom and modern technology in everyday life. The findings to be solved by the Thai government appeared in the National Education Act of 1999. The NEA emphasized the importance of biology education with a globalizing science view that all citizens in all societies should become literate in biology (Boonklurb, 2000). For the biology education, the students should understand both knowledge in biology and knowledge about biology for awareness of the relationships between science and society.

The Concepts of Species Diversity in Thai Biology Education

Species diversity is one topic which is a part of the biology curriculum in Thai science curriculum that is included in the learning areas called “living things and life processes” and “living things and the environment” (Table 2.1). The purposes of science education laid out in science content and standards based on the National Science Curriculum (IPST, 2002). The elementary (Levels 1-2) and junior high school

(Level 3) students are expected to have introduction to the knowledge about classifications of plants and animals (Table 2.2). In senior high school or Level 4, students focus on science study are expected to have advanced knowledge of species diversity including the concepts of definition of species diversity, classification of organisms, kingdom animalia, kingdom plantae, kingdome protista, kingdom fungi, kingdom monera, species and species conservation. The knowledge also includes understanding of relationships between science, technology, society and environment.

Table 2.1 Science content and standards related to species diversity concepts

Content	Standards
Content 1: Living things and living processes	Standard Sc 1.2 : The student should be able to understand the processes of reproduction and inheritance, evolution of living things, biodiversity, technological applications that impact man and the environment, carry out investigative processes, have scientific mind ,communicate what is learned and apply the knowledge gained.
Content 2: Life and environment	Standard Sc 2.1 : The student should be able to understand the local environment, relationship between living things and environment, interrelationship between living things in different eco-systems, master the investigative processes and possess a scientific mind, communicate the acquired knowledge for positive use. Standard Sc 2.2 : The student should be able to understand importance of natural resources, utilization of natural resources at local, national and international levels, master the investigative processes and possess a scientific mind, communicate the acquired knowledge for positive use and sustainable management of natural resources and local environment.
Content 8: Nature of science and technology	Standard Sc 8.1 : The student should be able to use the scientific process and scientific mind in investigation, solve problems, know that most natural phenomena have definite patterns explainable and verifiable within the limitations of data and instrumentation during the period of investigation, understand that science, technology and environment are interrelated.

Source: IPST (2002)

Table 2.2 Basic science content standards in each level related to species diversity study

Content	Level Content Standard			
	Level 1 (Gs 1-3)	**Level 2 (Gs 4-6)**	**Level 3 (Gs 7-9)**	**Level 4 (Gs 10-12)**
Content 1: Living things and living processes (Standard Sc 1.2)	1. explore, observe characteristics of living things in local areas, classify them according to external criteria and explain the importance of local plants and animals and their utilizations. 2. search for information, discuss and explain why various extinct species have disappeared and how others have survived as a result of their characteristics being appropriate to the environment, and apply the knowledge.	1. observe, explore various characteristics of living things in local areas, classify living things by using more detailed outward appearances and explain diversity of life forms in the region.	1. explore, search for information and explain the regional biodiversity that has maintained an equilibrium of life forms, also the positive and negative impacts, especially, infectious and contagious diseases affecting large populations.	1. search for information, discuss and explain positive applications of biotechnology, biodiversity, impacts of biotechnology and biodiversity on the society and environment. 2. create scenarios demonstrating effects of changes of various factors in the environment on the survival of each living species and relationships between survival of living things and biodiversity.
Content 2: Life and environment (Standard Sc 2.1)	None	None	None	1. analyze, discuss and explain succession of living things, importance of biodiversity, diversity and balance in the eco-systems.

Table 2.2 (Cont'd)

Content	Level Content Standard			
	Level 1 (Gs 1-3)	**Level 2 (Gs 4-6)**	**Level 3 (Gs 7-9)**	**Level 4 (Gs 10-12)**
Content 2: Life and environment (Standard Sc 2.2)	1. search for information, discuss and explain the exploitation of natural resources and the problems of local natural resources and environment. 2. discuss and suggest different methods of economical utilization of natural resources and participate in the implementation	1. observe, investigate, discuss and explain local natural resources, impacts of natural resource exploitation, changes in the environment caused by nature and man, show ideas and participate in the care and preservation of natural resources and environment	1. investigate and analyze degree of local environmental problems and natural resources, propose ideas for maintaining balance in the ecosystems, sustainable usage of natural resources based on knowledge of science and technology, also participate in protecting the environment and solving its problems.	1. investigate and analyze degree of Environmental problems and natural resources at the local, national and global level, identify causes, plan and participate in the protection, solving problems, monitoring, conserving and developing natural resources and environment
Content 8: Nature of science and technology (Standard Sc 8.1)	1. pose questions on subjects or situations as he/she is assigned or as interested in. 2. classify data into groups that can be investigated and compared and contrasted with preconceptions and present the study.	1. pose questions on issues or subjects or situations to be studied as assigned to one or as one is interested in 2. record data, analyze and evaluate data qualitatively and quantitatively and check the expected with experimental results, present results and draw conclusions.	1. pose questions that specify important issues and variables involved in the investigation or research subjects of interest comprehensively and reliably. 2. record and explain observed results and investigation, research additional sources to achieve reliable data, accept changes when new data and additional evidence or opposing views prevail.	1. pose questions based on knowledge and understanding of science or personal interest or issues arising which are subjectable to investigation or experimentation in a comprehensive way and with great confidence. 2. carry out research and collect data which involve important variables and factors, factors that affect other factors, factors that cannot be

Table 2.2 (Cont'd)

Content	Level Content Standard			
	Level 1 (Gs 1-3)	**Level 2 (Gs 4-6)**	**Level 3 (Gs 7-9)**	**Level 4 (Gs 10-12)**
Content 8: Nature of Science and Technology (Standard Sc 8.1)		3. freely express opinions, explain, infer and conclude what has been learned. 4. communicate and arrange to present the study orally or by writing on concepts, processes and results arising from projects and works carried out.	3. organize presentations, write reports and/or explain concepts, processes and results from projects and works done to others.	controlled and number of replicates to achieve sufficient reliability and significance. 3. collect data and record results from Investigation systematically, correctly and comprehensively both in qualitative and quantitative terms, while checking for probability, appropriateness or defects in data. 4. bring methods and new knowledge from investigation to bear on new questions, solve new problems in new situations in real life. 5. realize the importance of shared responsibility in explaining, expressing opinions and concluding for the scientifically correct presentation to the public.

Table 2.2 (Cont'd)

Content	Level Content Standard			
	Level 1 (Gs 1-3)	**Level 2 (Gs 4-6)**	**Level 3 (Gs 7-9)**	**Level 4 (Gs 10-12)**
Content 8: Nature of Science and Technology (Standard Sc 8.1)				6. record and explain with reasons results from investigation using referenced and researched evidence to obtain reliable support and concede readily that knowledge is subjected to change when new data and additional evidence crop up to challenge or oppose old views giving rise to the need of careful checking and perhaps to acceptance new knowledge. 7. prepare presentations, write reports and/or explain concepts, processes and results from the project or work to others.

Source: IPST (2002)

Students' Alternative Conception about Species Diversity

Many studies have been devoted to understand students' alternative conceptions of classification of species diversity, a concept of major importance in teaching and learning biology (Ryman, 1974a, 1974b; Trowbridge and Mintzes, 1985; Braund 1991; Kattmann, 2001). In many of these studies, students were rarely concerned about property and type when they were asked to classify organism. Students tended to use external morphology, habitat, movement and characteristic of living to classify organisms.

In the study of the conceptions of animal classification, a research has pointed out that children have many alternative conceptions of class concepts. For example, Natadze (1963) found that children mistook bats for "birds", and dolphins for "fish". Bell (1981) found that fewer than 25% of New Zealand middle-school children correctly identified a moth or butterfly as an animal. Braund (1991) pointed out that the narrowness of children's conceptions of animals also extended to the subclasses of animals. For example, having a hard shell made an animal "vertebrate"; having no appendages made one "invertebrate". This kind of misconception about animal classes was found in a research done on all age groups. The scope of animals was limited to those found in homes, farms, and zoos. In the United Kingdom, a comparable group of 12 year olds was asked to classify animals as a vertebrate or an invertebrate and, where appropriate, as a fish, amphibian, reptile, bird, or mammal (Ryman, 1974). A similar study was used with American middle school children (Trowbridge and Mintzes, 1988). The result showed that most of students classified the eel as an invertebrate and the turtle as an amphibian.

In students' classification schemes for plant, the major plant categories were used by students: plants, tree, bush, flowers, cactus, weeds, grass, and vines (Tull, 1992). The students' classification scheme differed from that of botanists. The students' explanation of natural phenomena appears naïve from the scientific viewpoint. We must not overlook the possibility that the child's explanation may be consistent with the viewpoint of the adult layperson. Hills (1983) has suggested that

the child's interpretation differs from that of the scientist because the child is working within a different theoretical framework, which Hills calls the "commonsense framework". In addition to students' alternative conceptions about relationship of living thing (Berthelsen, 1999), they think that each species can change body structures for appropriateness to live in a variety of ecosystem.

In Thailand, there have been a few studies conducted to investigate Thai students' ideas about species diversity. Sirisute (2001) found that some students had partial understanding. Students understood animals are movable and viable, mushroom as a plant, all species of bird can fly, and dolphin as a fish. Also, Sriprasert (2005) found that students had difficultly to understand about biodiversity concept in level 3 students. She mentioned that biodiversity concepts were abstract and complicated for students' understanding.

Teaching and Learning of the Species Diversity in Thailand

Naumjui *et al*. (1999) studied the achievement and retention of biological taxonomy in grade 10 students through cooperative learning. The findings showed that the achievements of students in biology using cooperative learning were higher.

Ratanapojnard (2001) developed and implemented the Community-Oriented Biodiversity Environmental Education [COBEE] program in Buriram, northeastern Thailand. He determined its effect on biodiversity-related knowledge, values, and behavior among rural fifth- and sixth-grade students. Three major findings are: (1) An environmental education program can be designed and implemented to produce positive effects not only on objectives identified as the foundation of environmental education (e.g., knowledge, attitudes, and behavior), but also on students' other academic attitudes and development. (2) Based on qualitative data, the relative success of COBEE indicates that curriculum, instruction, nature experience, and other facilitating components are critical to the effectiveness of an environmental education program. (3) Fifth- and sixth-grade children in rural northeastern Thailand have an environmental value system different from peers in Connecticut. The findings imply

that (a) to make an environmental education program successful and sufficient, supports must be provided, (b) the natural world is a heightened learning environment rich with potential teaching possibilities and diverse learning challenges, and (c) environmental education can have a significant role in general education reform efforts. The research findings show that teaching and learning practices use biodiversity courses to enhance students' understanding of biodiversity in their community.

Sriprasert's study (2005) developed the Biodiversity Learning Management for level 3 students based on constructivist theory and scientific learning standards. This Biodiversity Learning Management consisted of six stages: prior knowledge exploration, engagement, focus on concept, challenge the concepts, application and evaluation. The finding indicated that the Biodiversity Learning Management using constructivist theory promoted the students' behaviors in which interaction among themselves, their teacher, and their learning environment made them learn. The students could use scientific process, application and the value of biodiversity to increase respectively the six stages of Biodiversity Learning Management.

Implications for research in science education as well as design of curricula and technology are discussed. The development and implementation of an environmental education is an attempt to use the environmental issue of species diversity as the central component of an intervention flexible enough to be realized in differing environments while being tailored to local needs by the local community. There are various theoretical learning perspectives which this research would need to take into account in the basic principle of a new teaching intervention. In the constructivist theory of learning, the social constructivism and socio-cultural perspective of learning will be discussed to show how cognition is socially shared in enhancing scientific understanding of species diversity.

Constructivism

Constructivism is a definition provided by Von Glasersfeld (1997). It is recognized as views of learning. It assumes that knowledge is constructed by each student through interaction and active participation in the learning process (Tobin, 1990). The characteristic of constructivism is that the learners actively construct knowledge to an understanding of the world, and interpret new information by the use of their existing ideas and experiences. Knowledge cannot be transferred between individuals, and the teacher cannot transfer knowledge to students (Bybee, 1997). Student learning is more than memorizing of the knowledge. Understanding of the new knowledge and how to accommodate it with their experiences is needed as well. Individual students construct their own new understanding or knowledge through the interaction of what they already know, and what they believe about ideas, events, and activities with which they have contacted.

Brooks and Brooks (1993) identified the characteristics of constructivist teachers as followings.

- Encourage and accept students' autonomy and initiative.

- Use a wide variety of material, including raw data, primary sources, and interactive materials and encourage students to use them.

- Inquire about students' understandings of concepts before sharing their own understanding of those concepts.

- Encourage students to engage in dialogue with the teacher and with one another.

- Encourage students' inquiry by asking thoughtful, open-ended questions and encourage students to ask questions to each other and seek elaboration of students' initial responses.

- Engage students in experiences that show contradictions to initial understandings and encourage students' discussion.

- Provide time for students to construct relationships and create metaphors.

- Assess students' understanding through application and performance of open-structured tasks.

The constructivism has been discussed in science education and has been the theoretical framework for research into teaching and learning in science subjects (Mathews, 1998). Many science educators have considered the new methods for assisting students' learning (Bodner, 1986). Constructivist approaches are the ways for teaching and learning that have been focused on to highlight the importance of eliciting the students' existing ideas (Driver and Bell, 1986; Tytler, 2002). The constructivist view of knowledge lends teacher support to emphasize the investigation of students' views, and to seek the incorporate these viewpoint within teaching-learning dialogue (Pope and Gilbert, 1983).

The developments of the constructivist perspective, thus, depend on various understanding of learners' beliefs as well as the personal and social constructivism of their reality. In this study, the perspectives of learning science will focus on personal constructivism, social constructivism and socio-cultural perspective of learning.

Personal Constructivism

Personal constructivism was proposed by Von Glasersfeld. He argued that the knowledge is constructed through interaction with the outside world (von Glasersfeld, 1995). In the view of personal constructivism, the child acquires prior knowledge when interacting with the environment and constructs their knowledge through experience. This view assumes that students come to classroom with beliefs, ideas, and opinions that need to be modified by a teacher who facilitates this modification by creating tasks, questions and dilemmas for students. Knowledge construction occurs as

a result of working through these dilemmas. Von Glasersfeld (1995) views radical constructivism as two principles. In the first principle, the knowledge is not passively received either through the senses or by way of communication; knowledge is actively built up by the cognizing subject. In the second principle, the function of cognition is adaptive, in the biological sense of the term, tending towards fit of viability; cognition serves the subject's organization of the experiential world, not the discovery of an objective ontological reality. The basic views of personal constructivism are that the individual makes sense of experience in order to satisfy an essential need to gain predictability and control over their environment (Confrey, 1995). The learners will construct knowledge in their mind that is viable and fit with their own experiences (von Glasersfeld, 1995).

The limitations of the personal constructivism were argued by other researchers. The arguments are that personal constructivism does not emphasize how social environment influences a student construction of knowledge. Knowledge construction is not only making sense of the world, but focusing on finding out about the world (Matthews, 1997). Teaching and learning science involves the culture of science which need both individual and social processes (Driver *et al.*, 1994). The next section will discuss the concepts and characteristics of social constructivism.

Social Constructivism

Social constructivism was developed by Vygotsky. His work interested the researchers to understand the social context of cognitive development and emphasized the role of language and culture in the development of higher cognitive functions (Vygotsky, 1978; Howe, 1996; Hodson and Hodson, 1998). Individual development derives from social interaction within where culture meanings are shared by the group and are eventually internalized by the individual (Hodson and Hodson, 1998).

Vygotsky (1978) emphasized that language created and organized through speech was an initially important key for problem-solving in the social context. The problem-solving is planned to guide their action. When the child grows older and more

experienced, the action is externally performed, while the speech is organized and developed in his or her mind. The results of the language transformation process brings about cognitive development on the social level and then on the individual level (Vygotsky, 1978; Cobb and Yackel, 1996; Hodson and Hodson, 1998).

Vygotsky argued that the cognitive development could occur at almost any stage of development with the socially-interacting help of parents, family members, peers, knowledgeable adults and teachers, through social interaction (Hodson and Hodson, 1998; Berk and Winsler, 1995). A social constructivist perspective in learning science involves students to make meaning of the world through both individual and social processes (Driver, 1994). In support of this perspective, Vygotsky (1978) introduced the construct of the zone of proximal development (ZPD). Zone of Proximal Development was recognized as a general law of a cognitive developmental state for teaching, especially to understand how students acquired scientific knowledge. ZPD was defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978). An active collaboration between teachers and students and between students and their friends with teacher's assistance and appropriate suggestions and comments or other features of the learning environment, were the social context which played the role of scaffolding the students. They could progress further than would be possible without this support (Linn and Burbules, 1993; Hodson and Hodson, 1998).

According to social constructivist approach, the need for collaboration among learners to practice in the society is also stressed (Lave and Wenger, 1991; and McMahon, 1997). Group learning approaches such as collaborative learning and cooperative learning are based on social constructivism. In collaborative learning, all group members join to work out a problem-solving. There are positive views in cooperative learning on students' achievement. A number of studies show the success of group learning in promoting cognitive skills such as decision-making and problem-solving and motivation to learn (Johnson and Joshnson, 1987). Cooperative learning

encourages better attitudes towards peers and improved self-confidence (Slavin, 1990).

In summary, the constructivist perspectives have become an important reference for research in science education. The various backgrounds and interests of students are considered by educators to understand teaching and learning contexts. This view challenges educators to reconceptualize about how children learn in educational situations. In the implications of the constructivist perspectives, personal constructivism leads to an understanding of what knowledge is, and how students learn. Active learners and students' prior knowledge need to be considered in the process of this learning view. The students have to construct knowledge for themselves. As another consideration of the teaching implications, social constructivism, socially collaborative learning with effective language communication should be encouraged to develop students' ability to learn (John-Steiner and Mahn, 1996). The teaching should be moved from teacher-centered to student-centered learning (Hodson and Hodson, 1998).

The development of constructivist approach which is based on the social and cultural world influences students to learn in classroom. The approach helps more effective to develop teaching strategies. Teachers should know what students have already learned about their own society and culture in general. The implication of a socio-cultural perspective in teaching science is teaching students to be more knowledgeable about the economic, sociological, technological, and political role of science in the modern world (Lemke, 2001). In this study, the interpretation and application of socio-cultural theory might underpin the understanding and facilitating of teaching and learning about species diversity.

Socio-cultural Influences on Teaching Species Diversity

Socio-cultural theory originates in the work of Vygotsky and his Soviet colleagues in the early decades of the twentieth century (John-Steiner and Mahn, 1996). It is an approach that recognizes that child development which is a social process has historical and cultural relativity, with an emphasis on relationships

between people, contexts, actions, meanings, communities and cultural histories (Edwards, 2000), as well as cultural tools and artifacts (Robbins, 2002). Central to Vygotsky's theory is the idea that children's participation in cultural activities with the guidance of more skilled partners allows them to internalize the tools for thinking and to take more mature approaches to problem solving that children have practiced in the social context. Cultural inventions channel the skills of each generation, with individual development mediated by interaction with people who are more skilled in the use of the culture's tools (Rogoff, 1990).

Socio-cultural perspective proposed a larger-scale of social organization within an associated community to give us tools, including languages, belief and value systems and practices, for making sense (Lemke, 2000). The concept of learning in socio-cultural theory is that the individuals are not simply free to change their minds in a community. Learning is a constructive process that occurs while participating in and contributing to the practices of the local community (Cobb and Yackel, 1996; Lemke, 2000) and learning is an integral part of generative social practice in the lived-in world (Leve and Wenger, 1991). Students' interests and motivation toward science in particular conceptual accounts of phenomena depend on community beliefs and acceptable identities. The consequences for a student's life inside and outside the classroom are important factors. There are three aspects of the socio-cultural approach to human cognition. The first cognition is culturally mediated by material and artifacts such as tools, languages, symbols or signs. The second cognition is founded in purposive activity that is human action in the world. The last one is to develop historically as changes occur at the socio-cultural level (Packer and Goicoechea, 2000).

This socio-cultural development of social constructivism obviously shows that while students do learn by themselves, they are strongly influenced by their social and cultural environment. Their knowledge is constructed as they mature into their self-identity and an acceptance of responsibility for family, community and environment. Recognizing the role of these influences in student learning and allowing for teachers in planning teaching strategies, may give more complete help for students to

understand science. Therefore, use of socio-cultural perspective is addressed in this study as a basic principle of development for a new learning unit.

From this perspective, the possible impacts of Thai society and culture influencing teaching and learning about species diversity were also important. These are briefly discussed as Thai school society.

Thai School Society

Every morning students and teachers begin their day by standing in lines for singing the National Anthem, giving thanks to the country, to the Buddha and to the king. In school, a class of students has a teacher advisor. They spend 10 - 20 minutes for home room period. The advisor advises students how to behave. Normally the first teaching period starts at 8.30 a.m. There are 6 one-hour teaching periods and one hour for lunch.

In the classroom, the relationship between teachers and students is formal. The students rarely argue what the teachers tell them. Outside the classroom, students are expected to bow when walking past their teachers. On some special occasions such as on the Teachers' Day, students show their reverence by giving garlands or other presents to their teachers who have taught them.

There are high expectations between students and teachers to achieve the norms of society. The relationship between students and their teachers in school society could affect students' learning. The students may be puzzled when they have to learn in the new style classroom and the teachers may be afraid to change their teaching methods which are contrast to their old tradition. In this study, investigating the relationship between student and teachers is thus needed to be investigated to understand the real classroom culture and to evaluate students' understanding in the classroom.

Implications of Social Constructivism and Socio-Cultural Perspectives of Learning on Teaching Species Diversity

To enhance scientific understanding of species diversity, the teaching approaches, students develop their learning through social interaction in the contexts of the classroom and the family, the community and the culture. In this study, species diversity in biology classroom culture is taught relatively to Thai school society. First, Thai existing views or ideas about living things which the students learned from their parents, family and community as community funds of knowledge would be investigated and recognized before challenging them to study the new concepts of species diversity. The funds of knowledge were discussed in the next section. Second, application of the new concepts for the species conservation would be integrated in the teaching strategy of the new learning unit. Third, challenging students to learn biology for their everyday life would be discussed at the end of the implementation of the learning unit.

Funds of Knowledge

Overviews of Funds of Knowledge

Funds of knowledge refer to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being (Moll *et al*., 2001). Funds of knowledge are the cultural artifacts and bodies of knowledge that underline household activities (Moll, 2000). They are the inherent cultural resources found in communities surrounding schools. Funds of knowledge are grounded in the networking that communities do in order to make the best use of those resources. Moll (1990, 2000) and other colleagues have demonstrated the importance of communities of learners within large cultural and familial networks.

In order to gain about the students' households and social networks, teachers should visit the students' homes to find out their cultural and cognitive resources and these resources can be used in their classroom in order to provide culturally responsive

and meaningful lessons that tap students' prior knowledge. What the teachers learn about their students in this process is considered the student's funds of knowledge (Moll *et al*., 1992; Gonzalez *et al*., 1993; 2005). The teachers must be willing not only to talk more to their students but to their students' home to meet with their family members. Mercado and Moll (1997) showed that funds of knowledge are culturally responsive teaching that were built from the resources at home to improve student engagement and participation.

Many researches have focused on or tapped into students' households as the basis for developing classroom activities that are more comprehensive and contextualized (Moll, 1992; Gonzalez *et al*, 1995; Gonzalez and Moll, 2002). An example of how a teacher might go into a household to learn more about a child's background is as follows: This example of the case study of Moll (1992) focused on studying the implications of students' funds of knowledge for the classroom. Teachers conducted household visits to identify knowledge that existed in students' home. This study used field notes and interviews with families about the differences of cultivation of plants, seeding, and water distribution. Moll argues that these families and their funds of knowledge represent a potential major social and intellectual resource for schools. In the after-school settings created to enhance the collaboration between teachers and researchers, to discuss research findings, and to plan, develop and support innovations in instruction. The study also featured classroom observation to examine existing methods of instruction and implement innovations based on the household of funds of knowledge identified and conceptualized at the after school sites. There were many positive outcomes of this study. The emergence of teachers as qualitative researchers was clearly one by-product. A second involved increased access to the school felt by parents.

The purpose of this study was to set the emergence of curriculum units based on the community funds of knowledge. Teachers were able to sift through the household resources and found multiple elements that could be used as the basis for math, science, language arts or integrated units. For example, teachers formed mathematical units based on construction knowledge, ecology units based on

ethnobotanical knowledge of the home, a unit on sound and properties based on music, and a comparative history of clothing, including topics such as inquiry into absorbency of fabrics.

In the households' funds of knowledge, Gonzalez and Moll (2002) studied how household members used community funds of knowledge in dealing with changing, and often difficult, social and economic circumstances. Their study emphasized how families develop networks that interconnect them with their social environments and how these social relationships facilitate the development and exchange of resources, including knowledge, skills, labor and basic cultural values.

Additionally, Hammond (2001) and Chinn (2003) indicated that funds of knowledge have been employed as a source for developing social and culture context in science curriculum. Chinn (2003) developed science curriculum drawn on from community funds of knowledge. In another example, Osborn and Barton (1998) used students' experience with pollution in their drinking water as a "funds of knowledge" into starting point for teaching. In this study, the researcher used memory banking that served as a tool for teacher to collect and generate accounts of community funds of knowledge about species diversity for teaching.

Memory Banking

Memory banking was developed by a Filipino and cultural anthropologist, Virginia Nazarea (1998). From Nazarea's study, the researcher used memory banking as a botanical preservation tool to complement conventional practices of gene banking. Memory banking was served as a tool for collecting and documenting of knowledge and socio practices that regarded to several referents; economic practices, religious practices, health practices, educational practices, and political practices important to life in students' community (Nazarea, 1998) (see Figure 2.1). In addition, the work of Nazarea use memory banking as a tool to enhance artifacts and performances of actions that would be used in connection with the concepts or issues in a community – based approach to science teaching.

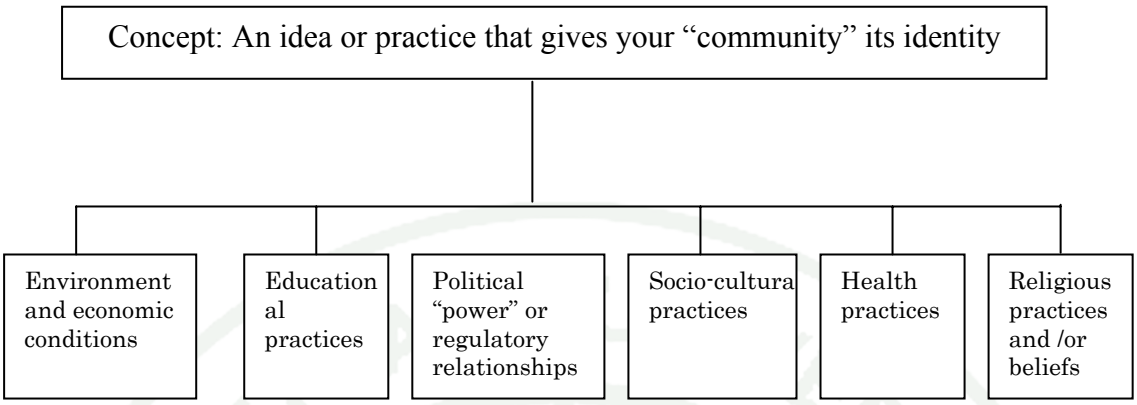

Figure 2.1 Memory banking in regards to several referents; socio-cultural practices, environment and economic conditions, religious practices, health practices, educational practices, and political practices

Source: Nazarea (1998)

The procedures can be used as a step-by-step guide to memory banking. Explaining the rationale and advantages of each method allows the individual researcher to modifications and adaptations to make to suit the research design to the research objectives field conditions, and other constraints. When the researcher learned about Virginia Nazarea (1998) work with memory banking, the tool might be adapted in creating a community-based approach.

The methods are outlined in the following sections: collection and preservation of specimens, preliminary participant observation, and benchmark socioeconomic survey. For the example of using memory banking in the collection and preservation of specimens, researcher or learner will walk around the village and talk to farmers about the crops or animals. He can ask what kinds of crops they can grow, where they are found, why people cultivate them. A survey is a way of finding out about the farming system in the area. The close-ended or open-ended questions can be used.

Research in the social science has sought to describe, analyze, and explain the phenomena of interest. In this research study, researcher used case study design to understand the relationship of school science to community knowledge and beliefs.

The data from memory banking is discussed and related issues, and awareness of environmental tensions in the community. Students asked questions and shared understandings of scientific concepts underlying environmental condition in the community.

In summary, this study drew specifically on funds of knowledge, including students', parents' and community members' knowledge about species diversity in their community to design learning activities in the learning unit and to response on the Thai National Education Act (1999). The Act emphasizes the development of knowledge about oneself and the relationship between oneself and society context. It is important to understand about students learning and beliefs that are supported by students' community. Community funds of knowledge, social constructivism, and the socio-cultural perspective of learning will be important for the learning process in this study.

Summary

In this chapter, the purposes of science education which guided the way to reforming science education in Thailand were discussed. Students were expected to learn biology for their everyday life. Research studies in science education on student's understanding and teaching and learning of the concept of species diversity; however, showed that students were having difficulty in understanding species diversity. A solution to this problem is to improve teaching strategies about species diversity. The teaching strategies need more attention, not only through a constructivist teaching perspective, but through a consideration of the socio-cultural perspective of learning. This may affect their ideas about species diversity through Thai school society. Moreover, this study drew specifically on funds of knowledge, including students', parents' and community members' knowledge by using memory banking as a learning tool to design learning activities in the learning unit in response to the emphasis on relevancy in the Thai National Education Act (1999).

In next chapter, Chapter III methodology will start by reviewing the methodology of the study. This chapter also presents the research framework data

collection and analysis in each phase of the study. Finally, the researcher discusses the trustworthiness of the research results and the ethical concerns of this study.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

This chapter details information about the research methodology for the study. The methodology of the study, interpretivism, characteristics of interpretive research, and research design, are first reviewed. These ideas are applied to the present research design. Then, the chapter presents research framework, three phases of the study: exploratory phase, learning unit design and development, and the unit implementation and evaluation. The data collection and analysis for each phase of study are presented. The instruments of data generations methods used in this study are surveys, interviews, students' pre and post tests, classroom observations. Finally, this chapter describes the data analysis, trustworthiness and ethical concerns of the study.

Research Methodology

Interpretivism

A paradigm is a way to understand the nature of reality and provides the basis on the researcher to build the framework within the research takes place. (Guba and Lincoln, 1985; Maykut and Morehouse, 1994). Although a paradigm is the guided way to provide an explanation of complexity of the natural world, the belief systems of the researchers also have had influence in choosing a paradigm (Cohen *et al.*, 2000).

There are two assumptions of a framework in order to conduct research based on beliefs. The first assumption is the epistemology – the beliefs, the origin and acquisition of knowledge. The second is the ontology - the beliefs about the nature of reality (Guba and Lincoln, 1994; Cohen *et al.*, 2000). These two assumptions have been viewed as a methodological concern for doing research. The researchers who adopt an positivist approach to the social world will choose the traditional option e.g.,

surveys and experiments, and the data gained will be predominantly quantitative, but the researchers who adopt a naturalistic approach to the social world, focusing on the individual interpretation of the world, will choose the techniques such as participant observation and personal constructs, and data will be predominantly qualitative (Cohen *et al.*, 2000).

In this research, there are two ways to view the world; positivist and naturalistic paradigm that are consistent with the three types of assumptions. These are discussed in the following section.

The positivist paradigm believes that reality is stable and be observed empirically and explained with logical analysis without interfering with the phenomena being studied (Merriam, 1998; Cohen *et al*., 2000). The phenomena will be isolated and the observations will be repeatable in a lab-like environment that decreases the complexity of the external world. The manipulation of the independent variables can be identified and studied independently of the others. Positivist prescriptions tend to treat the effect rather than the root cause of the problem. Positivist methodology is also associated with quantitative research, which gives numerical values to social phenomena (Merriam, 1998; Cohen *et al*., 2000).

In the contrary, the naturalistic paradigm believes that there are multiple interpretations of reality to construct the truth. The naturalistic paradigm is used to inductively understand how individuals construct their own reality within their social context (Patton, 1990). This paradigm allows for insisting that the research interaction should take place within the natural setting for understanding (Lincoln and Guba, 1985). There are many interpretations of reality that are dependent on individuals. Interpretive methodology is used as a tool to describe the complexities of each individual's interpretation of the social world (Lincoln and Guba, 1985). The inductive data analysis allows providing more understanding of the interaction of the realities and experiences of researcher and participant to influence the outcome of the study (Lincoln and Guba, 1985).

In summary, the positivist and naturalistic paradigm contain research methods that are useful in different setting and for different purposes. This study focuses on information from the participants about their own perceptions. The naturalistic paradigm is consistent with the interpretive research for studying. The aim of a paradigm is to seek information about the reality and understanding of the participants' perspectives.

Characteristics of Interpretive Research

Interpretive research is the research methodology of this study. It is based on a naturalistic paradigm. The interpretive research is interpreting the specific and understanding actions rather than causes (Cohen *et al*., 2000). Interpretive research allows the researcher to investigate relationship between teachers and students in science classroom as a construction of social and cultural environments. It also allows the researcher to examine the nature of teaching and learning environment which teachers and students make sense in educational process (Erickson, 1986). Interpretive researcher carries out research in a complexity of natural setting that cannot be understood in isolation from their contexts (Lincoln and Guba, 1985). The interpretive researcher needs to enter into long term relationships with participants about their experiences and works. The interview and observation are a research method which can be used in conjunction with other processes to help provide a wider meaning of actions (Cohen and Manion, 1994). The interpretive research uses inductive data analysis. This analysis helps the researcher to understand the interpreted data and to develop the research quality to show the trustworthiness, such as credibility, transferability, dependability, and conformability (Lincoln and Guba, 1985). In planning and conducting interpretive research, multiple data generation methods, ethics, trustworthy data generation are considered.

The multiple methods of data generation can help the researcher gain different insights into the participants and to build the descriptions of the participants' frameworks. Accomplishing interpretive research in context needs both useful qualitative and quantitative methods. Some researchers suggest that the combining of

more research methods encourage the process of triangulation and increase the trustworthiness of research study (Patton, 1990; Tashakkori and Teddlie, 1998). The interpretive research is used as a methodology in this study because it is consistent with the interpreting and understanding the meaning and perspective of participants.

Research Design: Case Study

A case study is employed to attain an in-depth understanding of the situation involved (Cohen *et al.*, 2000). The purpose of the case study is based on intensive descriptions and analyzes a specific situation, individual, or community, by looking in-depth within a context and describing contextual influences on the person, or program being studied (Bell, 1993; Stake, 1995; Merriam, 1998; Stufflebeam, 2000). The case study is focused on the process rather than the outcomes, in context rather than a specific factor (Bell, 1993; Merriam, 1998). The case study design is an appropriate opportunity for one aspect of a problem to be studied in depth within a limited time period (Bell, 1993). Yin (1994) suggested that there are three features of case study methods. The first feature of case study method is triangulating information from multiple sources of evidence. The particular methods for collecting and analyzing information and perspectives from multiple sources include testing, observation, interviews, documents and artifacts (Stake, 1995; Merriam, 1998). The data from each method were analyzed, and interpreted in terms of consistency presented across the data sources. The facts and conclusions are built from the consistency of data derived from multiple methods. The second feature of case study method focuses on collecting detailed contextual data that influence the case. Finally, the third feature of case study method described by Yin (1994) includes the single, collective, or multiple natures of case studies. A cross-case analysis was interpreted in terms of the patterns and meanings emerging from this feature.

The advantages of case study design are allowing the researcher to concentrate on a specific situation and to investigate the complex social units consisting of multiple variables of potential importance in understanding phenomena (Stake, 1995;

Merriam, 1998). In contrast, the findings from a case study may be too detailed (Merriam, 1998). The interpretation of data depends on the researcher that can exaggerate from a real situation (Stake, 1995; Merriam, 1998). In this further, the reader and the researchers need to be aware any bias that can affect the final product (Guba and Lincoln, 1981 cited in Merriam, 1998). The further limitation of case study involves the issues of reliability, validity, and generalizability (Stake, 1995; Merriam, 1998). Therefore, multiple case studies are used as a research design in this study. It involves with collecting and analyzing data from several cases (Merriam, 1998). Analyzing multiple cases as a cross-case analysis strengthens the validity, stability, and generalizability of the findings (Miles and Huberman, 1994; Merriam, 1998).

In this research, the case study method helped the researcher to understand the teachers' implementation and impact of the unit on the teachers and students in their real-life context. It helped the researcher to investigate how Thai science teachers are able to implement the Species Diversity Learning Unit [SDLU] and how teacher implementation of the SDLU influenced students' understanding of species diversity.

Research Quality: Trustworthiness

The criteria for establishing and assessing the quality of qualitative research are creditability, transferability, dependability, and confirmability. Lincoln and Guba (1985) propose that while trustworthiness is appropriate for positivist methodology, there are parallel criteria which are appropriate for interpretive methodology. These criteria are credibility instead of internal validity, transferability instead of external validity or generalizability, dependability instead of reliability, and confirmability instead of objectivity.

Credibility: Internal validity is defined conventionally as the extent to which variations in an outcome or dependent variable can be attributed to control variation in an independent variable (Guba and Lincoln, 1989). The internal validity is established by randomizing and controlling processes to diminish a number of threats including history, maturation, testing, statistical regression, experimental mortality, and

selection. Internal validity is unacceptable in naturalistic paradigm because of its realist ontology between a study's finding and the real world. According to naturalistic paradigm, internal validity is replaced by creditability criterion. There are several techniques for increasing creditability; that is persistent observation, peer debriefing and member checking.

Transferability: In traditional criteria for judging quantitative research, external validity is defined as the generalizability of the findings in particular inquiry to other contexts or subjects (Guba and Lincoln, 1989). To increase external validity, both sending and receiving contexts should be at least random samples from the same population. Transferability is an empirical process for checking the degree of similarity between sending and receiving contexts. In qualitative research, transferability refers to the degree to which the results can be generalized or transferred to other contexts or settings. To establish transferability, the researcher should present thick description: providing an extensive and careful description of the time, the place and the context. The transferability is judged by others who wish to apply the study of their own situation.

Dependability: Reliability means the consistency of an inquiry and is a precondition for validity (Guba and Lincoln, 1989; Maykut and Morehouse, 1994; and Cohen *et al*., 2000). Dependability is where the stability of the data (or the data gathering and analysis process) can be tracked and is traceable (Guba and Lincoln, 1989). To establish reliability, researchers should assure that very repetition of the same instruments to the same phenomena will yield similar measurements. On the other hand, naturalistic paradigm emphasizes the need for the researcher to account for the changing context within research study. However, the researcher is responsible for describing the changes that need to be tracked and publicity inspectable so the outside reviewer can understand how these changes affected in the context led the researchers to the decisions and interpretations during the process in the study.

Confirmability: Objectivity refers to the degree that the findings can be confirmed by other researchers who read or review the research results (Guba and

Lincoln, 1989; Bradley, 1993). Confirmability is determined by checking the internal coherence of the research product, namely: the data, the findings, the interpretations, and the recommendations. To enhance confirmability, the researcher can be checking and rechecking the data throughout the study. After the research study, researcher can conduct a data audit that examines the data collection and analysis procedures about the potential for distortion or bias.

Ethical Concern

An important issue in educational and social research is ethical dilemma or problems because the research concerns a part of human research (Cohen *et al*., 2000). Therefore, in planning research, researchers have to consider the social benefits, and possible benefits accruing from the research may take the form of crucial findings leading to significant advances in theoretical and applied knowledge. The benefits to participants could take the form of satisfaction in having made a contribution to science and a greater personal understanding of the research area under scrutiny (Frankfort-Nachmias and Nachmias, 1992). The access to personal records must be approached both ethically and legally (Anderson and Arsenault, 1998). The confidentiality and the safety of the participants are employed by a significant number of studies for ethical reasons (Cohen *et al*., 2000). The participants were informed about the purposes and procedures of the investigation in the study. In addition, in the final report, all participants are expected to use pseudonyms. Another person who can identify them from the information given must be provided.

Design for Current Research

Introduction

This section discusses research framework of the study which includes three phases; exploratory phase, design and development of the unit, and implementation and evaluation of the unit. The first phase includes the development of probing data collection, the current state of teaching and learning species diversity to explore

teachers' and students' opinion on the existing situation, species diversity concept survey to diagnose student understanding of species diversity in the academic year 2005 and the current situation of community funds of knowledge about species diversity to explore community members' opinion and experiences with species diversity including plants, animals and other living, how they use and what they learn with the organism in their community that were considered.

In the second phase, design and development of the unit, the guiding principles for instructional activities that incorporated community funds of knowledge, constructivist learning and socio-cultural perspective of teaching were described. This unit is called the Species Diversity Learning Unit [SDLU]. It includes content, activities and durations that are previewed. The full details of intervention design and development will be discussed in the next chapter: a part of the design and development of the Species Diversity Learning Unit [SDLU]. In the last phase, implementation and evaluation of the unit, there were discussions that workshop was set up to introduce and demonstrate SDLU to biology teachers. The researcher describes the data collection process and analysis in each phase of the study. A number of criteria are then discussed for evaluating the learning unit such as the results from testing, interviewing, and observing classrooms etc. The section describes the strategies adopted in this study to assure ethical concern and enhance the trustworthiness of the research outcomes.

Research Framework

This study is divided into three phases: the exploratory phase, the design and development of the unit, and the implementation and evaluation of the unit. The exploration phase aims to explore Thai students' understanding of species diversity and explore the situation of teaching and learning species diversity in Thailand. In the first phase, students' understanding of species diversity is explored by testing. Three classes from each of three schools took the Species Diversity Concept Survey [SDCS] in January 2006 (second semester, academic year 2005). These students had been exposed to formal instruction on species diversity in accordance with the former

curriculum. As for the survey on current situation of teaching and learning species diversity, five teachers from five schools in Ratchaburi Province and fifteen students of these teachers were in-depth interviewed on the issues. In community funds of knowledge about species diversity, the purpose of this study was to explore the existing situation of species diversity in students' community in terms of importance, problems and needs about species diversity. Students, parents and community leaders were used memory banking and interviewed on the issues.

The unit design and development phase aims to design and develop an intervention called Species Diversity Learning Unit to promote scientific understanding of species diversity. The unit was designed during March-November, 2006 under the supervision of research committee which consists of three university lecturers: one from the faculty of science who specialized in the content of species diversity; and the two from the faculty of education who had expertise in curriculum planning and design, pedagogy, as well as assessment and evaluation, based on the test and survey results from the exploratory phase

The unit implementation and evaluation phase examines how the teachers implemented SDLU and the effect of the unit on student understanding of species diversity. In December 2006, a workshop was set up for the three biology teachers who had participated in the study. The workshop aimed to demonstrate the use of SDLU and to ask the teachers to comment on it. In January-February, 2007, in the second semester, academic year 2006, SDLU was implemented by the three teachers. The researcher conducted multi-site case study to examine how SDLU was implemented in the classroom setting and how the unit could enhance students' understanding of species diversity concepts. In the study, participant observation was the key data gathering method. Testing, interviewing, classroom observation, were combined to make meaning for answering the research questions. The data was used in evaluating the effectiveness of the unit to promote scientific understanding. The data collection and timeline of study are summarized in Table 3.1.

Table 3.1 Data collection and timeline

Phases of study and Research Questions	Participants	Data Sources	Timeline
Exploratory phase **RQ1:** What is the current situation of teaching and learning species diversity concepts in high school as perceived by students and teachers?	123 grade 12 students from three schools in Ratchaburi	Species Diversity Concept Survey (SDCS)	January 2006
	Five teachers and fifteen students from five schools in Ratchaburi	Interview questions	January 2006
RQ 2: What are the community funds of knowledge about species diversity in students' community?	Four community leaders in Ratchaburi	Memory Banking and Interview questions	February 2006
Design and Development		Designing the SDLU	March-November, 2006
Implementation and evaluation of the unit **RQ 3**: What happens when a Species Diversity Learning Unit based on community funds of knowledge is planned, implemented and evaluated?	Three biology teachers from three schools in Ratchaburi	Workshop	December 2006
	Three biology teachers and their classroom	Classroom observations, field notes, teacher focus group meetings, and interviews	January – February, 2007
RQ 3.1: What are the characteristics of the Species Diversity Learning Unit based on community funds of knowledge?			
RQ 3.2: What do teachers change after implementing the Species Diversity Learning Unit?	Three classroom students from 3 schools and nine high school students (3 in each school)	Concept tests and classroom observations, student's work sheets and interviews	January – February, 2007
RQ 3.3: What are students' conceptual understandings of species diversity resulting from the learning unit?			
RQ 3.4: What facilitates and constrains the implementation of the Species Diversity Learning Unit?			

Data Gathering Methods

This section presents all data sources, data collection, and data analysis used in three phases of the study. The data sources used in this study include:

1. Species Diversity Concept Survey [SDCS]

2. Memory Banking and Interview questions to explore existing situation of the community funds of knowledge about species diversity

3. Interview questions to explore current state of teaching and learning the species diversity

4. Species Diversity Learning Unit [SDLU]

5. Workshop and Teaching Support Meeting

6. Participant observation

7. Students' work sheets

Species Diversity Concept Survey [SDCS]

Species Diversity Concept Survey [SDCS] is an instrument which was completed by 123 Grade 12 students in 3 classrooms from 3 high schools. They were selected by stage sampling from high schools located in Ratchaburi Province to determine their understanding of the concept of species diversity in the 2005 academic year. There were 14 open-ended items in SDCS. This survey probed students' understanding of concepts of species diversity including: the definition of species diversity, classification, 5 Kingdom of living organisms (monera, protista, fungi, plantae and animalia), species, and conservation of species diversity.

The process of development of Species Diversity Concept Survey:

1. Relate of propositional knowledge statements from National Science Content Standards (IPST, 2002) to species diversity concept.

2. Send the list of the propositional knowledge statements related to species diversity concept to the content experts to accurate and relevant to high school students. The experts are the advisors from the faculty of science and education and an experienced biology teacher in high school.

3. Write open-ended questions that will be asked as a concept test about biodiversity and its related concept. This will also be validated by advisors.

4. Conduct individual interviews with small groups of 50 students in high schools and analyze data.

5. Construct test items by adopting the interview schedule. The items cover all concepts of biodiversity. The tests will be in a multiple choice format. Each question is designed to test an understanding of a student on only one concept. The options are derived from pattern of the students' answer from the interview session.

6. Send the test and the answer key to the advisory committee for comments on the test format, the clearness of the instruction, appropriateness of the question, stimulus and the language used. The researcher revises the test and sends the test items to the advisors to consider content validity.

7. Revise and pilot the test.

8. Revise the test and collect data.

The students' responses and explanations related to species diversity concepts were analyzed into five categories. These were: Sound Understanding [SU], Partial Understanding [PU], Partial Understanding with Specific Misunderstanding [PU-SM], Specific Misunderstanding [SM], and No Understanding [NU].

Memory Banking to Explore Existing Situation of the Community Funds of Knowledge about Species Diversity

The existing situation of the community funds of knowledge about species diversity was designed to explore the funds of knowledge, including students', parents' and community members' knowledge about species diversity in their community in February 2006. The memory banking was served as a tool for collecting and documenting of knowledge that related species diversity issues in terms of economic practices, religious practices, health practices, educational practices, and politic practices, problems and needs in students' community. The memory banking was used to gather 1) background information; 2) data on the current state of using species diversity in students' community such as framing, local wisdoms, local products and etc., and 3) problems and needs of community related to the species diversity. The interviews and survey can be used in this method too.

Interview Questions to Explore Current State of Teaching and Learning the Species Diversity

Five teachers and fifteen students were interviewed in-depth about 1) background information; 2) the current state of instruction including the use of curriculum, teaching and learning processes, teaching methods, as well as measurement and evaluation, and 3) problems and needs of the teachers and students related to teaching and learning species diversity. The process used to construct the teachers' and students' interview protocol was:

1. Formulate the purpose of the interview, which was to explore the current state of teaching and learning species diversity.

2. Study criteria and theories of constructing the types of questions and responses that fit with teachers' and students' definitions of the exploration of the current state of teaching and learning the species diversity.

3. Construct items regarding the exploration of the current state of teaching and learning the species diversity and revise interview protocol based on the committee's and science teachers' feedback and suggestions.

4. Revise and try out the interview protocol

5. Implement interview questions with individual teachers and students.

To analyze the data, transcripts were categorized. The responses of all teachers and students to each of the questions were then compared to determine similarities and differences among their answers.

Species Diversity Learning Unit [SDLU]

The unit is called Species Diversity Learning Unit [SDLU]. The unit consists of 8 lessons covering 20 classroom periods (50 minutes for each period). The findings of the exploratory phase; Thai students' understanding of species diversity, the existing situation of community funds of knowledge related species diversity in students' community and the current situation of teaching and learning species diversity, were used to design the unit. The unit is ready to be used as it includes lesson plans, a student manual, instructional materials, and resources. Each lesson plan contains information about the content, learning outcomes, teaching guidelines, instructional materials, worksheets and suggestions on formative assessment. The content of the unit follows the National Science Curriculum Standards (IPST, 2002). The activities included in all lessons are social interaction between teacher and students, and also students and peers. Group work and classroom discussion were the main strategies of the unit. The organization of the content and the activities of the species diversity learning unit are shown in table 3.2.

Table 3.2 The organization of content and activities of Species Diversity Learning Unit [SDLU]

Lessons	Activities	Periods
Lesson One: Species Diversity in Community	Investigate and collect data species diversity around in school and students' community Identify group of organism such as animal, plant and other living things All activities are done working in groups	2
Lesson Two: Scientific Name	Compare the local name and scientific name Group work; to study the history, principle and characteristics of scientific name All activities are done working in groups	1
Lesson Three: Definition of Species and Classification of Living Things	Game; matching sequence of organism classification Discuss the criteria of scientists to classify the organism Compare and identify living things from the collecting data Group and classroom discussion about classification and species concept All activities are done working in groups	3
Lesson Four: Dichotomous Key	Identify the insects or other organism using dichotomous key Group discussion about meaning and characteristics of dichotomous key All activities are done working in groups	1
Lesson Five: Kingdom Animalia	Use jigsaw technique for teaching and learning Group discussion the six criteria to classify animal Present the findings of the investigation All activities are done working in groups	5
Lesson Six: Kingdom Plantae	Round table activity is used to discuss the key characteristics of plant Group work; to classify plants Present the findings of the investigation All activities are done working in groups	3

Table 3.2 (Cont'd)

Lessons	Activities	Periods
Lesson Seven: Kingdom Protista, Kingdom Fungi, and Kingdom Monera	Use the jigsaw technique for teaching and learning Observe and perform laboratory activities Group discussion about the characteristics of three groups of organism All activities are done working in groups	3
Lesson Eight: Conservation of Species Diversity in the Local Community	Create school news to present the importance and conservation about species diversity Round table activity for assisting students to explain the importance of conservation in their community All activities are done working in groups	2

Workshop and Teacher Support Meeting

The biology teachers from three schools participating in the first phase were asked to implement Species Diversity Learning Unit. Before implementing the intervention, the researcher set up two day workshops in late December 2006 to demonstrate the teachers how to implement SDLU in their classroom practice. The workshop started with the teachers reflecting on their current practice of teaching species diversity in the former curriculum (IPST, 1990). The findings of students understanding of species diversity, the existing situation of community funds of knowledge related of species diversity in students' community, the current situation of teaching and learning species diversity from the first phase of study, as well as their implications for teaching species diversity were presented and discussed. The guiding principles of the unit were discussed. Each lesson and its activities were demonstrated and the teachers were asked to comment on the demonstration. The teachers were given opportunity to ask any questions about the activities and materials in the unit. Then, the researcher set up three meetings (the second week of January 2007, the first week of February 2007 and the last week of February 2007) for providing continuous support for the teacher during the implementation. In the meetings, teachers could raise problem and share their experience and ideas on a practical aspect of the unit. In

the end of the workshop, the researcher discussed his role in this study and then he summarized data collection and timeline to the teachers.

Participant observation

A major data gathering technique during the implementation of SDLU is participant observation. The participant observation was used in three schools in January 2007, second semester, academic year 2006. It was used in this phase to investigate how the teachers implemented SDLU in their classroom setting. All the lessons in three classrooms of each school were observed as much as possible. This technique aimed to gain a close familiarity with the teachers and students and their practices through an intensive involvement during the implementation of SDLU. In the characteristic of researcher as a participant-observer, the researcher did not act as a teacher. The researcher also did not interrupt teaching in progress. During group work, the researcher participated in a group and observed what happen within a group of students. After finishing each lesson, the teacher was asked to give feedback on the implementing the unit about the appropriateness of the content, teaching strategies, and assessment. Feedback from the students was also taken to examine students' understanding and to make learning activities in the unit evaluation satisfying.

In the participant observation, informal interviews with teachers and students, participation in group, and field notes were used to collect and record the data. The videotape recording and audiotape recording were collected during the implementation of the unit. The data from observation were analyzed by using coding process to explore the relationships and patterns across the categories for participants' understanding.

Students' Work Sheets

Students' worksheets were used to reflect their understanding of the concepts about species diversity. The students wrote their ideas in the worksheets in the students' book. These worksheets were used to support as an evidence for evaluating their understanding in the Species Diversity Learning Unit [SDLU].

Data Analysis

Qualitative data is subjective, rich, and in-depth information normally presented in the form of words. The most common form of qualitative data is derived from semi-structured or unstructured interviews, observations, documents and journals. Qualitative data can be analyzed for content by using content and thematic analysis.

Content analysis is an approach to the analysis of documents and texts that seek to quantify content in terms of predetermined categories and in a systematic way (Bryman, 2001). In this study, content analysis was used to analyze data from students about knowledge species diversity related to their community. The researcher calculated the percentage of respondents who chose particular options in each question that indicated the proportions of students who had scientific or alternative conceptions on a species diversity concept in their community. Researcher was able to use these kinds of information as a basis to design the species diversity instructional unit. Patton (1990) also proposes that content analysis is the process of identifying, coding, and categorizing the primary patterns in the data.

Thematic analysis is a form of inductive analysis that has no predetermined categories. The categories of data are derived from the data (Kellehear, 1993) and the themes are then sought after data emerges from the narrative of the interview or written observation of behaviors (Kellehear, 1993). Thus, thematic analysis is used to analyze the data from observations and unstructured interviews (Aronson, 1994). Steps of thematic analysis are discussed as follows: 1) transcribe conversations and patterns

of data that are derived from direct quotes or paraphrasing common ideas; 2) relate and identify all data that are related to intellectual schemes or ideas; 3) combine and categories the data pattern into themes; 4) create a valid argument for choosing the themes based on the literature review and results.

Ethical concerns

Ethical concerns are an important topic in this study. Informed consent, confidentiality, and the safety of participants were presented in the study. All participants including both teachers and students were informed about the aims and procedures of the data collection such as testing, interviewing and implementing the unit. In being interviewed, the students were guaranteed that their answers would not have any effects to their scores or grades. The teachers, students and schools were used under pseudonyms. In the study, the researcher was aware of the significant differences within the participants including cultures, religions, gender, and others in any steps of the research procedure. Additionally, the researcher avoided any form of harassment to the participants such as threatening students and research assistants for any advantages in conducting research. At the end of the study, the findings of the study were reported to all participants clearly and appropriately to the public.

The Trustworthiness of this Research Study

To increase creditability, the data was presented by using data triangulation with multiple methods including classroom observations, student and teacher interviews, concept surveys and document analysis in order to enhance confidence in the ensuing findings. The creditability was additionally increased by the process of member checking to verify the possibility of data.

To Increase transferability of data, the classroom and school environment, background of teachers and students, classroom organization and setting, as well as teacher and student interaction in the classroom, which affect teaching and learning were described in a detailed and thick description to allow the readers to evaluate the appropriateness with other contexts or situations.

For enhancing dependability, the researcher reported any changes during the unit implementation to allow the readers to understand what factors in the context were changed, and how those changes were interpreted for providing a clear description of the design and procedure.

Finally, to address confirmability, the details of data collection and data analysis were described in rich details. To confirm the fact and logic of data in this study, the feed-backs from the advisory committee were used to improve the trustworthiness of the data.

Summary

Research methods were designed to respond to the research questions which were proposed to develop the learning unit and enhance the students' understanding of species diversity. Qualitative case study was used as the methodological basis of this study. The description of three biology teachers, who collaborated with three science educators, and a scientist in designing, implementing, and evaluating an learning unit focused on species diversity concepts and community funds of knowledge was significant of this study. Three students of each teacher were interviewed about the learning species diversity based on community funds of knowledge. The procedure of this study consisted of three phases which include a) exploring current situation in teaching and learning species diversity concept including high school students' knowledge, teachers and community, b) exploring community funds of knowledge to develop a species diversity learning unit, c) implementing and evaluating the impact of species diversity learning unit based on community funds of knowledge. The interview data was used to triangulate the survey data to get the students' understanding of species diversity. Teacher interviews were conducted for the teachers' teaching reflection. They were interviewed at the end of their teaching period after every observation. The observations were used to collect data concerning actual teaching and learning practices in the three classrooms. The teaching reflection was analyzed thematically to give key elements of the effect of the implementation of the learning

unit. In addition, these three cases were cross analyzed to describe the pattern of the development that constrain or facilitate the teaching of the learning unit.

CHAPTER IV

DEVELOPMENT OF THE SPECIES DIVERSITY LEARNING UNIT

Introduction

This chapter discusses the exploratory phase and the design and development of the Species Diversity Learning Unit [SDLU]. In the exploratory phase, the results and discussion were presented in three studies. The first was on teachers' and students' opinions on the current state of teaching and learning species diversity in Thailand in the 2005 academic year. The second study explored the existing situation of the community funds of knowledge about species diversity in February 2006. The third study was on students' understanding about the concepts related to species diversity. At the end of this study, the implications of the findings for teaching and learning are discussed. In the design and development of the Species Diversity Learning Unit [SDLU], the SDLU aims to promote scientific understanding of species diversity and improve the teaching and learning of species diversity. The development of the SDLU is guided by the findings from the exploratory phase, social constructivism and socio-cultural perspective of learning, and recommended species diversity teaching strategies from literature. The process of the unit design and development is then discussed. Afterwards, the characteristics of the SDLU, including content organization, teaching and learning activities, and the assessment strategies, are detailed in this chapter.

Exploratory Phase

The State of Teaching and Learning about Species Diversity

This study aimed to explore the teachers' and students' current practices of teaching and learning, needs, and problems in teaching and learning about species diversity concepts during the 2005 academic year (Promprasit, Jantrararotai and

Yutakom, 2008). Five teachers from five schools in the Ratchaburi Province and 15 of their students were interviewed in-depth about the current state of teaching and learning which included the use of curriculum, teaching preparation, teaching methods, measurement and evaluation, and problems and needs of teaching and learning species diversity. Three selected teachers and their classrooms were a purposive sampling to participate in the implementation of the Species Diversity Learning Unit [SDLU].

Results

The current state of teaching and learning about species diversity is presented in terms of the use of curriculum, teaching preparation, teaching methods, measurement and evaluation, as well as the problems and needs of teaching and learning species diversity. Following are the details of the current state of teaching and learning.

The information from teachers and students was consistent that classroom lectures were mainly used to teach species diversity. Most teachers introduced species diversity by describing all the details about species diversity content and using transparencies and pictures of living things with traditional teaching. The teacher preparation and practices did not focus attention on the students' prior knowledge about species diversity. Students used IPST books and took notes about the lecture to learn about species diversity. Group discussion of students was not found in the classroom. Real media was not presented in the teaching process. In measurement and evaluation, all of the teachers assessed their students' learning by observing, testing and reviewing students' reports or notebooks. Species diversity concepts were taught separately from the local community. Teachers were not using local resources to teach species diversity concepts. Some students did not understand because they never saw and were unfamiliar about samples of organisms before.

The teachers and students mentioned that there was a lot of content on species diversity to learn. Lecture was the best way for teaching and learning in a limited

time. Students said that teaching only focused on existing content in the IPST textbook. Teaching and learning did not use the knowledge about species diversity from the local community. Students could not explain and use knowledge gained from learning to solve problems about species diversity that occurred in their community.

Students wanted to learn a variety of activities rather than listening to lectures by their teachers. Moreover, they wanted to learn the importance of species diversity in the real world and also to learn real examples of living things in their community, especially local biota.

The Existing Situation of Community Funds of Knowledge about Species Diversity

The purpose of this study was to explore the existing situation of community funds of knowledge related to species diversity in the students' community, especially in terms of the importance about species diversity. Two village leaders and two sub-district administrators in the Ratchaburi Province were interviewed about the importance, problems and needs of species diversity within their community in February 2006. The information from the interviews was collected by using memory banking**.**

Results

From memory banking and interviews with them, most of them said that local people are farmers who grow many kinds of crop plants and trees such as rice, cones, cucumbers, peas, jackfruit, acacia, mango and lemon and they also have many kinds of animal farms such as pig farms, chicken farms and cow farms. There are many local products and local wisdom such as preserving food, Thai herbs, and silk and cotton production that are related to using products from plants and animal, improving the quality of people in the community. People also use herbs to treat diseases. This knowledge was derived from their ancestors. In addition, they use plants and animals

in different traditions such as the Loy Kratong Festival, the Songkran Festival and Teacher's Day.

In regard to the problems and needs of people in the community about species diversity, all community leaders mentioned that the main problems in their community were the soil degradation caused by chemical fertilizers, crop disease caused by the repetition of the same crops and insect pests. Moreover, most crops are planted with the same species in the same area. People used chemicals to increase productivity. They had to use chemicals for their agricultural crops that ended up causing weakened health in farmers.

All community leaders need to develop their community understanding about species diversity. They want people to know about the importance of species diversity and conservation, and to encourage farmers to use biological materials instead of chemicals as well as using organic fertilizer or manure for soil improvement. Recently they had the district of agriculture officials educate the farmers to use biological materials instead of chemicals, making manure and crop rotation. This knowledge is necessary and beneficial to people and living things in the local community.

Students' Understanding of the Concepts of Species Diversity

This study aimed to explore students' understanding of species diversity concepts. One hundred and twenty three students from three science classrooms in Grade 12 (age 17-18 years old) from a public secondary school in the Ratchaburi Province in the 2005 academic year were presented with a Species Diversity Concept Survey [SDCS], which consisted of 14 open-ended questions. The concepts were developed to investigate the following areas: definition of species diversity, classification, Kingdom Animalia, Kingdom Plantae, Kingdom Protista, Kingdom Fungi, Kingdom Monera, definition of species and conservation of species diversity. The Data items from the concept survey was analyzed and categorized into 5 groups. Students had studied the concepts of species diversity. The students were taught by teachers regarding the concepts of species diversity following the National Science

Content Standards and School-based Curriculum. The following sections report on the results of the students' understanding of the concepts of species diversity, as shown in Table 4.1.

Table 4.1 Percentages of students' understanding in each category of species diversity concepts

Concept	Percentages of the Students' Understanding				
	SU	**PU**	**PU-SM**	**SM**	**NU**
Definition of species diversity	15	**49**	28	5	3
Classification	10	14	**42**	33	1
Kingdom Animalia	6	**41**	30	22	1
Kingdom Plantae	10	**52**	26	12	0
Kingdom Protista	5	16	29	**40**	10
Kingdom Fungi	4	10	**43**	22	20
Kingdom Monera	0	14	25	**36**	25
Definition of species	10	31	**51**	6	2
Conservation of species diversity	9	**48**	42	0	1

Note: SU = Sound Understanding, PU = Partial Understanding, PU-SM = Partial Understanding with Specific Misunderstanding, SM = Specific Misunderstanding, NU = No Understanding

Species diversity is one component of the concept of biodiversity. Species diversity means the difference between the number of living things or species contained in an ecological community. The results showed that only 15 % of students had a sound understanding. 49 % of students had a partial understanding. Students understood that species diversity was independent from other components of biodiversity such as genetic diversity and ecological diversity.

The concept of classification, such as scientific classification, is a method of taxonomists to group and categorize organisms such as kingdom, phylum or species. The results showed that 42 % of students had a partial understanding with a specific misconception and 33 % of students had a specific misconception. In students' misconceptions about the classification concept, they tended to use habitat, movement, external morphology and characteristics of living things to classify organisms.

In the Kingdom Animalia, animals do not have cell walls and chloroplast. They can not make their own food. They can move and respond to stimuli. The criteria for classification of organisms in the animal kingdom can be determined by the number of germ layers, coelom, circulatory system, type of digestive tract, symmetry, segmentation, notochord and growth pattern of the embryo. The results showed that 41 % of students had a partial understanding. 22 % of students had a specific misconception. In students' misconceptions, they classified sponges and hydra as plants, bats as birds, earthworms as nematodes, and turtles as amphibians. Only 6 % of students had sound understanding.

For the Kingdom Plantae, organisms that contain chlorophyll are included. There are two main types of plants, vascular plants and non-vascular plants. The results showed that 52 % of students had a partial understanding. They understood plants cannot move and have green color containing chlorophyll. 12 % of students had a specific misconception. Students classified moss as an algae and cones as a plant's flower.

In the Kingdom Protista, algae are grouped as producers, and the single celled organism such as amoebas, euglenas and paramecium, are consumers. The results showed that 40 % of most high school students had a specific misconception. Students classified amoebas as bacteria, paramecium as animals and chlorella as plants. 29 % of students had had a partial understanding with a specific misconception in this concept.

In the Kingdom Fungi, bread mould and mushrooms, for example are grouped together. The results showed that 43 % of most high school students had a partial

understanding with a specific misconception. They understood that fungi are consumers, contain no chlorophyll and produce spores like a plant. 22 % of students had a specific misconception. Most of them classified mushrooms as plants.

In the Kingdom Monera, the members of this group are the bacteria and blue-green algae. Both these kinds of organisms lack an organized nucleus. The results in this study showed that 36 % of students had a specific misconception. Students classified bacteria as amoebas that were protists.

For the definition of species, species are organisms that interbreed and have fertile offspring, with the potential of interbreeding, reproductively isolated from other groups. 51 % of students had a partial understanding with a specific misconception. Students answered that horses and donkeys are the same species that can interbreed and produce a new species.

Conservation of species diversity means to preserve life in an environment or to provide living areas for various kinds of plants and animals. The concepts of species diversity are used to develop similar habitats to the natural ecosystem, to create conservation centers to protect life, such as the Botanical Gardens and Marine Aquaculture Center, to promote agriculture, and mixed farming. The results showed that 48 % of students had a partial understanding. Students gave reasons about the loss of species diversity as not from the effect of humans, but because it was natural law.

This study showed that Thai high school students had difficulty in all topics. The results revealed that most students had a partial understanding (PU) about the concepts of definition of species diversity, Kingdom Animalia, Kingdom Plantae and conservation of life. In the concept of conservation of life, the students did not mention the importance of living in the ecosystem, as well as ways to conserve species diversity. In the concept of classifications and Kingdom Fungi, most students had a partial understanding with a specific misconception (PU-SM) in that they preferred to classify organisms based on the conflicts between criteria of scientific classification. In addition, students had specific misconceptions (SM) about the concepts of Kingdom

Protista and Kingdom Monera. These concepts were challenging to the students' understandings, prior experiences and concepts. Students tended to use habitat, movement, external morphology and characteristics of living things to classify organisms. In teaching and learning species diversity, the teachers should examine students' prior knowledge about the classification of organisms. Students should practice observation skills and focus on concepts of morphology, ecology and evolution because they are the basic concepts for learning species diversity. In addition, Braund (1991) and Kattmann (2001) said that teachers should use real life examples and learning resources in their community to help students' understandings of the relationship between using species diversity and the conversation of life.

Implications of Three Survey Results for Designing the Unit

The findings from the exploratory phase have implications for teaching species diversity. The survey on student understanding of species diversity indicated that the students had some alternative conceptions of species diversity that might come from initial instruction. The survey on teachers' and students' opinions on the current state of teaching and learning the concepts of species diversity revealed that the teachers didn't use constructivist teaching methods. The teachers mainly preferred to use lecture and demonstration with the students to learn species diversity concepts. The teachers didn't give the students an opportunity to construct their learning. Species diversity concepts were taught separately from the local community. Some students had difficulty in understanding concepts of species diversity because they never saw and were unfamiliar with some samples of organisms that were found in textbooks. The survey on community members' opinions about the existing situation of community funds of knowledge related to species diversity in the students' community revealed that there were many species of animals and plants, local products, local wisdom, and traditions that were very important to students' everyday lives.

The students' alternative conceptions about species diversity, the current state of teaching and learning about the concepts of species diversity and the existing situation of community funds of knowledge related to species diversity in students'

community guided the researcher to plan activities that would promote these scientific concepts to students.

The next section will be a discussion on the design and development of the Species Diversity Learning Unit [SDLU] which promotes scientific understanding about the concepts of species diversity.

The Design and Development of the Species Diversity Learning Unit [SDLU]

This section discusses about guiding principles to the development of Species Diversity Learning Unit [SDLU], the process of the design and development of the SDLU and activities of the SDLU.

Guiding Principles to the Development of Species Diversity Learning Unit

The development of the Species Diversity Learning Unit [SDLU] was guided by the following principles.

Thai Student Difficulty in Understanding Species Diversity

The main findings on Thai student understanding of species diversity, as discussed in Chapter IV, reveals that the students had difficulties in understanding and alternative conceptions of species diversity including the definition of species diversity, classification, Kingdom Animalia, Kingdom Plantae, Kingdom Protista, Kingdom Fungi, Kingdom Monera, the definition of species and conservation of species diversity. It was found that the students tended to use habitat, movement, external morphology and characteristics of living things to classify organisms. Moreover, the students usually used their experiences to explain situations or memorized the concepts without understanding them. The research findings reported here and a review of relevant literature were used as guiding principles for the design and construction of the Species Diversity Learning Unit which focused on effective teaching strategies employed to promote students' learning and understanding.

Elicitation of Student Prior Knowledge about Species Diversity

The learning theory underpinning the development of the SDLU is based on social constructivism and socio-cultural perspectives of learning. Most of the activities in the lessons encouraged students' understanding by considering the importance of student prior ideas or knowledge. Students come to class with their own experiences and ideas about each concept under study. Student prior knowledge was shown as important for the teacher to find out. According to the National Science Curriculum (IPST, 2002), particularly the relevant science content standards, this study developed the Species Diversity Learning Unit for secondary schools use. Teaching species diversity concepts started with elicitation of students' prior knowledge and misconceptions that might have arisen from their ideas from school and their own culture. Students' prior knowledge should be considered and identified as important in planning species diversity lessons.

Student and Teacher Needs in Teaching and Learning Species Diversity

The survey on the current situation of teaching and learning species diversity in 2005 showed the problems of teaching and the need of teachers and students to use an alternative way of teaching and learning species diversity. The students mentioned that the teachers used lecturing to teach all topics of species diversity. Students said that teaching only focused on existing content from the book. Teaching and learning did not use knowledge about species diversity from the local community. They could not use knowledge gained from learning to solve problems about species diversity that occur in their community. The students wanted a new learning unit to be more active, collaborative and related to their community. They also would like to engage with hands-on/minds-on activities. Students wanted to learn a variety of activities rather than listening to lectures by teachers. Moreover, they wanted to learn the importance of species diversity in a real place and also to learn real examples of living things in their community.

Integrating Community Funds of Knowledge on Teaching and Learning

Community funds of knowledge in teaching aims to connect students' life outside the classroom within educational experiences. Community funds of knowledge also integrate cultural elements from the students' everyday experiences into the curriculum and classroom instruction. The development of the Species Diversity Learning Unit incorporates community funds of knowledge focused on students' cultural backgrounds, social patterns, common knowledge and the community needs. The unit should specifically focused on activities related to the cultures, lifestyle and symbols of the students. A culture familiar to the students can serve as a starting point and tool for helping students to develop a deeper understanding of scientific concepts. It employs knowledge from the child's culture and community to illustrate principles and concepts.

In particular, this study drew specifically on community funds of knowledge to design learning activities in the secondary science curriculum in response to the emphasis on relevancy in the Thai National Education Act 1999. Community funds of knowledge refers to those historically developed, accumulated strategies including skills, abilities, ideas and practices, and information that households use to survive (Moll, 1992; Gonzalez *et al*., 1995). There are various sources of community funds of knowledge, including community knowledge as well as students', parents' and community members' knowledge of agriculture, mining, economics, household management, medicine, religion and other familiar topics (Moll, 1992; Gonzalez, *et al*., 1995). From the survey on community funds of knowledge related to species diversity in the students' community in the exploratory phase, there were many species of animals and plants, local products, local wisdom, traditions and community problems and needs that were suitable to develop in the Species Diversity Learning Unit [SDLU]. This unit design takes into account community funds of knowledge emerging in the teaching and learning with species diversity and the production of species diversity in the students' community.

Having Regard to Culture and Society as Socio-Cultural Perspectives on Teaching and Learning

The socio-cultural perspectives of learning are used in this learning unit. Teaching needed to regard the society and culture influencing the students' learning in the classroom. Working collaboratively on activities in a small group, students have an opportunity to interact with their peers. In the interaction with their peers and collaborative group work, students may feel comfortable presenting their ideas, accepting the ideas of others and receiving feedback from their peers and teachers. Therefore, everyone in a group should have a contribution to the group. Additionally, teaching has to emphasize developing interactions between the teacher and students, as well as student to student interactions in the classroom. The teachers must continuously encourage and facilitate the students' group discussions or classroom discussions. The Species Diversity Learning Unit [SDLU] was developed based on Thai classroom contexts such as the number of students, the physical environment of the classroom, facilities and resources. In the implementation of SDLU practical in a real setting, it is flexible and has more opportunities for the teachers to adapt the activities to make them more appropriate in their classroom.

The Process of the Design and Development of the Species Diversity Learning Unit [SDLU]

The process of the development of the SDLU was influenced by the Thai National Education Act and the guiding principles that are related to Thai student learning outcomes from the exploratory phase.

The researcher analyzed the guidelines of the National Act B.E.2542 and the National Science Content Standards (IPST, 2002) for the development of a school science program in terms of the scope of species diversity for Thai science students. This included the sequence of content, expected learning outcomes, format of lesson plans, teaching and learning activities, learning materials and assessment strategies. The researcher then drew up the first draft of the SDLU and submitted the material to

an advisory committee for comments. The committee was comprised of three experts: a lecturer from the Faculty of Science, Kasetsart University, who specialized in teaching the concepts of species diversity; and two lecturers from the Faculty of Education, Kasetsart University, who had expertise in curriculum planning and design, teaching strategies and evaluation.

The three experts were invited to meet in the unit development and discuss about the overall structure of the SDLU. After receiving suggestions from three experts, the researcher revised and developed the SDLU. The final draft of the SDLU consisted of lesson plans, the student manual and instructional materials to guide students to successfully meet the expected outcomes. Then the SDLU was prepared and distributed to the biology teachers who participated in this study.

Workshop and Revision

The workshop was then set up for the three biology teachers who would implement the intervention on the December, 2005, during the 2006 academic year. The three teachers who participated in the workshop were those in the first phase of the study. The advisory committee was also invited to the workshop. In the workshop, the teachers were presented with the research outcomes from the first phase of the study and introduced to the guiding principles, the organization of the learning unit and timeline. The teachers' feedback on lesson plans, instructional materials and assessment were necessary to improve the learning unit to fit with their classroom contexts. At the end of the workshop, the researcher discussed data collection, the researcher's role and the workshop as a support session during the implementation.

Species Diversity Learning Unit

The Species Diversity Learning Unit is developed for teaching advanced biology in Level 4, Grades 10-12, based on the National Science Curriculum of Thailand. There are three science sub-strands being integrated in the teaching unit:

Sub-strand 1: Living Things and Living Processes

Standard Sc 1.2: The student should be able to understand the processes of reproduction and inheritance, evolution of living things, biodiversity, technological applications that impact on man and the environment, carry out investigative processes, have a scientific mind, communicate what is learned and apply the knowledge gained.

Sub-strand 2: Life and the Environment

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

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

Sub-strand 8: Nature of Science and Technology

Standard Sc 8.1: The student should be able to use the scientific process and scientific mind in investigation, solve problems, know that most natural phenomena have definite patterns explainable and verifiable within the limitations of data and instrumentation during the period of investigation, understand that science, technology and the environment are interrelated.

Learning outcomes

Knowledge

The students would be able to:

1. describe the importance and benefits of organism classification.

2. describe the development of binomial nomenclature by Carl Linnaeus and the importance of a scientific name.

3. explain the meaning of species.

4. analyze and summarize the problems and causes of environmental and natural resources in school and community.

5. summarize the key principles in the identification of living things in five kingdoms; monera, protista, fungi, plantae and animalia and the importance of utilization. Advantages and disadvantages of organisms in the five kingdoms impact on ecosystems and human life.

6. discuss and present the relationship between the survival of life and species diversity in the community.

7. assess the importance of species diversity. Conservation of species diversity in the community was discussed.

8. propose the use of living things and solving environmental problems of species diversity in the community.

Process skills

The students would be able to:

1. make a list of creatures and sampling the organisms in their community.

2. survey and present about common names and scientific names of the organisms in their community.

3. create a dichotomous key to classify organisms.

4. observe and identify living things into categories using the similarities and differences of organism morphology.

5. observe and describe characteristics of living things in their community and organize the living things into groups.

6. promote the creation of species diversity in schools and their community

7. explore and apply knowledge gained from the classification of organisms in everyday life.

8. use scientific equipment such as microscopes and magnifying glasses to explore and observe the organisms in the five kingdoms.

Attitude

The students would be able to:

1. use the sample of living things and describe the benefits of sampling the local organisms.

2. be aware of the value of species diversity and utilization by humans that impacts society and the environment.

3. recognize the acquisition of scientific knowledge about the diversity of life.

4. promote the creation of species diversity in schools and their community.

Content Organization

The Species Diversity Learning Unit [SDLU] is composed of eight lesson plans, and takes 20 periods (50 minutes per period) of teaching. The content of the SDLU and the sequence is quite similar to those outlined in the biology teacher manual from the IPST. However, the SDLU has some concepts in addition to the biology teacher manual, such as conservation of species diversity in the local community. The comparison of species diversity content and organization between the IPST biology textbook and the Species Diversity Learning Unit is briefly outlined in Table 4.2.

Table 4.2 Comparison of Species Diversity Content and Organization between the IPST Biology Textbook and the Species Diversity Learning Unit

IPST Biology Textbook	SDLU
Topic 1: Biodiversity • Components of biodiversity	Topic 1*: Species diversity in the community • Definition of species diversity • The importance of species diversity • Comparison of the living things in each ecological system
Topic 2: The study of biodiversity • Classification • Scientific name • Species identification method	Topic 2*: Scientific name • Characteristics of scientific name • Comparison of scientific name and local name • The importance of scientific name
Topic 3: Origin of life • Origin of prokaryote • Origin of eukaryote	Topic 3*: Definition of Species and Classification of living things • Definition of species • Comparison of prokaryote and eukaryote • Criteria of classification of living things

Topic 4: Kingdoms of living things
• Criteria of classification in five kingdoms:
  • Kingdom monera
  • Kingdom protista
  • Kingdom plantae
  • Kingdom fungi
  • Kingdom animalia
• The importance of species diversity in human activities, society and environment
	Topic 4*: Dichotomous key
	• How to use dichotomous key as a method of species identification

Topic 5: Biodiversity in Thailand • The status and importance of biodiversity	Topic 5*: Kingdom Animalia • Characteristics of animals • Criteria of animal classification • The importance of animals in the community
Topic 6: Loss of biodiversity • The cause of the loss of biodiversity	Topic 6*: Kingdom Plantae ▪ Characteristics of plants ▪ Criteria of plant classification ▪ The importance of plants in the community

Table 4.2 (Cont'd)

IPST Biology Textbook	SDLU
	Topic 7*: Kingdom Protista, Kingdom Fungi and Kingdom Monera ▪ Characteristics of protista, fungi and monera ▪ Criteria of protista, fungi and monera classification ▪ The importance of protista, fungi and monera in the community Topic 8*: Conservation of species diversity in the local community • The importance of species diversity conservation in the community • The problems with species diversity in the community

Note: * In SDLU, it is called a lesson

Source: IPST (2003)

Lists of Proposition Concepts Proposition

Definition of Species Diversity

Species diversity is one component of the concept of biodiversity. Species diversity means the difference between the number of living things, or species, contained in an ecological community.

Scientific Name

Scientific name is a unique name for organisms that scientists around the world use. Carl Linnaeus chose to use a two-word naming system. He adopted the binomial nomenclature scheme, using only the genus name and the specific name or epithet which together form the species name (IPST, 2003). The scientific name is written in italics or underlined, for example *Anopheles sundaicus* or Anpheles sundaicus.

Classification of Organisms

The concept of classification, such as scientific classification, is a method taxonomists use to group and categorize organisms. The criteria of scientific classification include fossils, comparative anatomy and morphology.

Definition of Species

Species refers to the order of the smallest classification of organisms. The same species have the most common characteristics, such as the structure and function of organs and a close relationship of ancestors. Most important to note of same species, they can breed in the together and the next generation will not be sterilized.

Kingdom Animalia

Animals do not have a cell wall or chloroplast. They cannot make their own food. They can move and respond to stimuli. The animal kingdom is divided into 9 phylums: Phylum Porifera, Phylum Cnidaria, Phylum Platyhelminthes, Phylum Nematoda, Phylum Annelida, Phylum Arthropoda, Phylum Mollusca, Phylum Echinodemata, and Phylum Chordata. The criteria for classification of organisms in the animal kingdom can be determined the number of germ layers, coelom, symmetry, embryonic development and segments.

Kingdom Plantae

The kingdom includes organisms that contain chlorophyll. There are five main types of plants: non-vascular plants, vascular plants, seeds, flowers and fruit. The plant kingdom is divided into 9 Divisions: Division Bryophyta, Division Psilophyta, Division Lycophyta, Division Sphenophyta, Division Pterophyta, Division Coniferophyta, Division Cycadophyta, Division Ginkgophyta, and Division Anthophyta.

Kingdom Protista

Protista is the simplest of the eukaryotic cells (an organism whose cells contain complex structures enclosed within membranes) such as protozoa, amoeba, euglena and paramecium, which are single celled organisms. Some protists perform photosynthesis like plants, such as algae, while others move around and act like animals. However, protists are neither plants nor animals.

Kingdom Fungi

The general characteristics of fungi are that they are not similar to plants because fungi don't contain the pigment for use in photosynthesis. Fungi are decomposers and eukaryotic cells. The structure of fungi contains hypha, mycelium and rhizoids instead of roots. For example, bread mould and mushrooms are grouped together in this kingdom.

Kingdom Monera

Monera comprises a prokaryotic cell organization (organisms without nucleus membranes). Living thing in Kingdom Monera included the bacteria, blue-green algae (cyanobacteria or blue-green bacteria).

Conservation of the Species Diversity

Conservation of species diversity means to preserve living things in an environment such as the following examples.

1. To create a conservation center to protect life and to develop an environment similar to the natural ecosystem, such as the Botanical Gardens, Marine Aquaculture Center, etc.

2. To promote agriculture, mixed farming and to provide various kinds of plants and animals a habitat.

Activities of the Species Diversity Learning Unit

The Species Diversity Learning Unit [SDLU] is composed of eight lesson plans. The description of the activities in each lesson is briefly outlined as follows.

Lesson One: Species Diversity in the Community

This lesson aims to introduce the definition of species diversity to students and enable students to explain species diversity in their community. The lesson begins with finding out the students' prior knowledge on species diversity, the teacher shows pictures of species diversity in a variety of ecological systems to the students and asks them to explain and compare the living things in each picture (e.g., what is the same or different with others). The students are asked to see a video about national parks and discuss about ecological systems and organisms that live in them. Each group of students has the opportunity to plan and conduct the investigation of species diversity around in the school by using students' worksheets to collect data. The findings of this section are categorized in groups of organism such as animals, plants and others. Finally, each group is asked to discuss in groups and present their findings in the classroom.

Extra Study: Fieldtrip

This fieldtrip aims to investigate and collect data about species diversity in local resources such as a park, river and farm that can be easily found in students' community. Each group of students has the opportunity to investigate living things that live in each local resource in terms of which kind of living thing, importance, problems and needs, through us of a data collection form. Memory banking can be used as well. The findings are used as basic data for student learning activities in lessons two through four. This activity is conducted on the weekend.

Lesson Two: Scientific Name

This lesson aims to promote student understanding about the characteristics of scientific name, and the comparison of the common name and the scientific name. The teacher shows a papaya or other kinds of fruits that can be found in the school and students' community and asks students, "*What is the local name and common name that students know?*" In this question, students understood that there are many local names for each species. Then, students are asked to discuss about some people who have misunderstood the local names of each species and to find ways to solve this problem. The teacher then divides students into groups and asks students to study the history, principles and characteristics of scientific names in the worksheet. Students in each group are asked to find the scientific name of living things from the collected data of the students' investigation in their community by using animal and plant books of Thailand. Students are also asked to produce scientific name plates, one student/one plate. The data of memory banking is used in this step as well. Finally, students are asked to test about scientific names. The importance and characteristics of scientific names are discussed in the classroom.

Lesson Three: Definition of Species and Classification of Living Things

The aim of this lesson is to introduce the concepts of species and classification. This lesson had two parts. In the first part, the lesson begins with exploring students' prior ideas about classification using worksheets. A game matching between world areas and the sequence of organism classification is used for motivating student learning. Students are asked to discuss about each sequence of scientific classification. Each group of students discusses the criteria scientists used to classify the organism. The criteria of scientific classification include fossils, comparative anatomy and morphology. In the example of comparative anatomy, students then see pictures of a bat's wing, a bird's wing and a butterfly's wing and are asked to describe their structures. These structures show the difference between mammals, birds and insects. These activities assist students to understand the criteria of scientific classification. Students in each group are asked to identify living things from the data collected

through their investigations in their community, into groups based on the criteria of scientific classification using worksheets. The teachers and the students then discuss the criteria of scientific classification and key characteristics of each group of organisms. In the second part, the teacher shows pictures of a mule and asks students to explain the characteristics and its parents. The teachers and the students discuss to conclude the definition of species. Concept maps are used for assessing student understanding about the classification and species concepts.

Moreover, each group of students plans the investigation about species diversity in their community by use of memory banking. The topics should be present in each of the five kingdoms of organisms, including kingdom animalia, kingdom plantae, kingdom protista, kingdom fungi, and kingdom monera, that are related in importance, problems and needs of students' community. This activity is conducted on two weekends. The data findings from memory banking are used as basic data for students learning activities in lessons five through eight.

Lesson Four: Dichotomous Key

This lesson aims to introduce students to understand the identification of the dichotomous key. The lesson begins with finding out the students' prior knowledge on identification by using worksheets. Students have the opportunity to identify materials by using their own criteria. Students' criteria are presented in the classroom. The teacher asks students to do this activity again and challenges them to identify by materials in pairs. Comparison in pairs is a key characteristic of the dichotomous key. In groups, students are asked to use the dichotomous key to identify the insects or other organisms on the worksheets. The teachers and the students discuss to conclude the meaning and characteristic of the dichotomous key.

Lesson Five: Kingdom Animalia

This lesson aims to promote students' understanding on the concept of the kingdom animalia and focuses on the criteria of animal classification that are concerned with scientific classification. The activity begins with a review of students'

prior knowledge about animals by questioning and using worksheets. Students are asked to present the characteristics of animals. The teacher and students then discuss to conclude about the key characteristics of animals. This can assist students to understand more about animals. Students are divided into groups with 5 or 6 students in each group. A jigsaw technique was used to encourage students to play a role in the small group work. Each student would take the role of an expert in their group, and they therefore had a chance to share their ideas with the other students. In this activity, students are asked to study about the six criteria of animal classification including the numbers of germ layers, symmetry, coelom, embryonic development and segments. In expert groups, they are divided into six groups of criteria of animal classification. Students come to expert groups to work on worksheet. Each student then comes back to their home group and presents their concept to the group. The teacher uses memory banking and prepares many kinds of animals that can be found in the students' community and asks students to discuss the six criteria to classify animals into each phylum. Then, each group of students is asked to present the findings of the investigation using memory banking related to the concept of animals. The importance, problems, needs and conservation about animals should be presented. Students have an opportunity to organize a bulletin board to present their findings from memory banking. Finally, the teacher and students discuss about the importance of animals in their community.

Lesson Six: Kingdom Plantae

This lesson aims to assist students' understanding of the concept of kingdom plantae and enable students explain the criteria of plant classification. The lesson begins with finding out the students' prior knowledge about plants through questioning and using worksheets. The teacher and students then discuss the key characteristics of plants in groups and the whole class. Each group of students is asked to study and discuss with their friends using a round table activity about the criteria of plant classification. The teacher also uses memory banking and prepares many kinds of plants that could be found in the students' community and asks students to classify these plants into each division. Then, each group of students is asked to present the

findings of the investigation using memory banking related to the concept of plants. The importance, problems, needs and conservation about plants should be presented. Students have an opportunity to create a poster to present their findings from memory banking.

Lesson Seven: Kingdom Protista, Kingdom Fungi and Kingdom Monera

The main purpose of this lesson is to introduce the concepts of the kingdom protista, kingdom fungi and kingdom monera. This lesson begins by exploring students' prior ideas about the concept of protista, fungi and monera by using worksheets. A jigsaw technique, as cooperative learning, was used to encourage students to participant in small group work. This activity provided the opportunity for the students to share their concepts of the kingdom protista, kingdom fungi and kingdom monera to their friends. Then students may observe and perform laboratory activities that lead them through the exploration and analysis to understand the characteristic of the three groups of organisms. Finally, each group presented their findings of the investigation using memory banking related to the concepts of protista, fungi and monera. The importance, problems, needs and conservation about the three groups should be presented. Students have an opportunity to create a poster and bulletin board to present their findings from memory banking.

Lesson Eight: Conservation of Species Diversity in the Local Community

This lesson aims to encourage students to construct an understanding of the importance of conservation of species diversity in the local community. This lesson begins with the exploration of students' prior ideas and feelings through questioning. The teacher shows some pictures of deforestation and water pollution and asks students to explain and share their own ideas with their friends and the whole class. Students have an opportunity to create a school wide news program to present the importance of conservation about species diversity based on their information that was found in memory banking and interview sessions. Finally, a round table activity was

used for assisting students to explain the importance of conservation in their community.

The concepts and the activities of all lessons are summarized in Table 4.3.

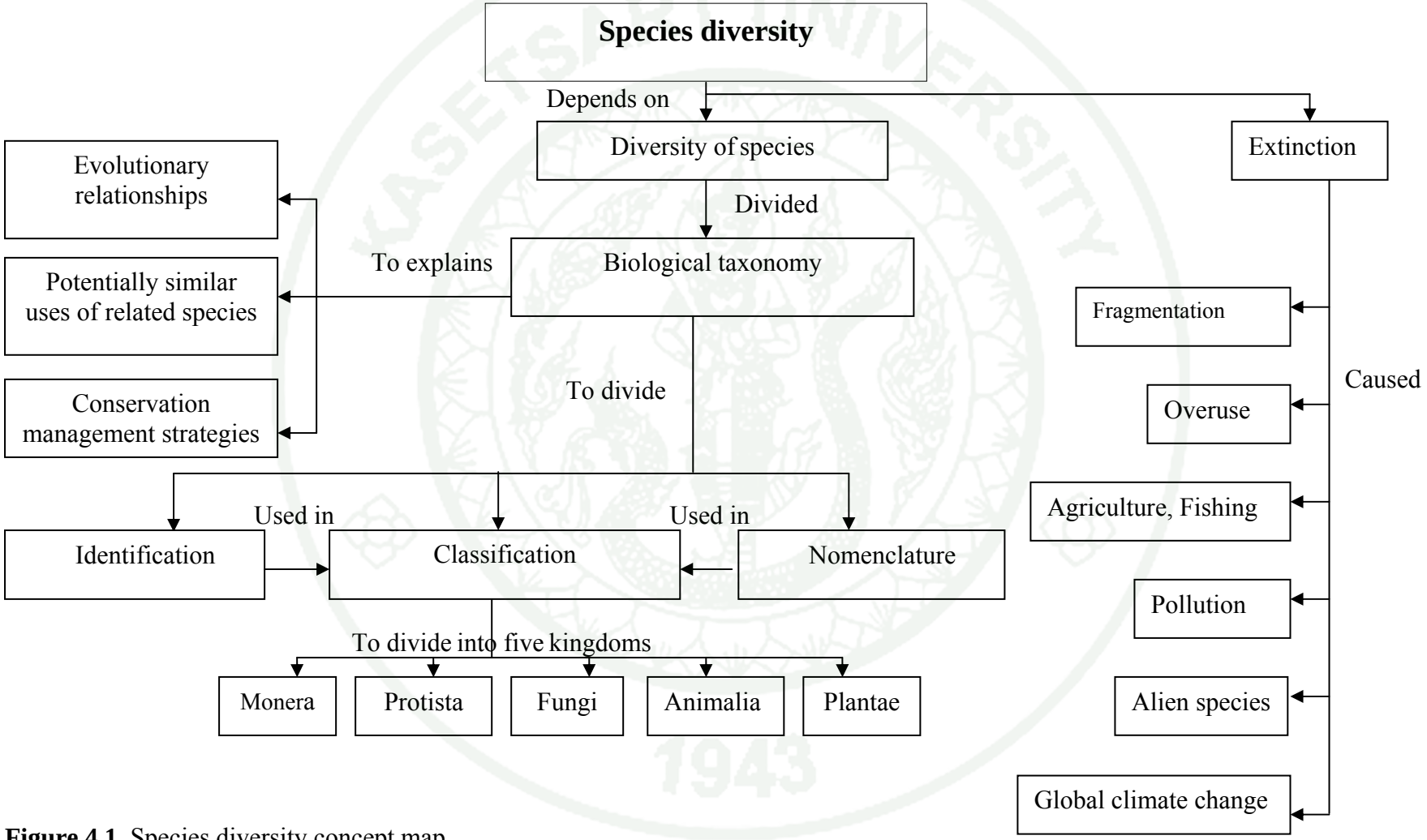

Figure 4.1 Species diversity concept map

Table 4.3 Species diversity lesson plans

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessment
Lesson One: Species Diversity in the Community	2	1. Survey and present species diversity and local recourses in the community. 2. Prepare a list of local organisms and collect samples of local wildlife. 3. Aware of using samples of wildlife and tell the benefits of collecting organisms from their community.	1. Species diversity refers to a group of organisms that consists of various species who live in a variety of ecosystems. 2. There are several strategies to collect samples of organisms, such as preserving them dry. It depends on the appropriateness of each species. The advantage of the collecting organisms is the example: • to facilitate the study on the structure of organisms. • to see the changing of organisms from past to present.	1. Explore individual student prior knowledge about species diversity. 2. Compare the living things in each ecological system. 3. Investigate species diversity around the school. 4. Identify groups of organisms such as animals, plants and others. 5. Group work; to collect data in students' community using memory banking.	1. Work sheet: collect samples of life. 2. Memory banking. 3. Equipment for sampling life. 4. Video.	1. Observe the students' answers to the questions. 2. Observe participation in the discussions, presented activities in groups and classes. 3. From the work sheets and memory banking, to collect organisms that live in the ecosystem. 4. From the sheets on collecting life.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Two: Scientific Name	1	1. Explain the meaning and the importance of scientific names. 2. Describe the development of binomial nomenclature of Carl Linnaeus and explain the difference between local name and scientific names. 3. Survey and present about the name of local organisms. 4. Explain the importance of common names and scientific names.	1. Scientific name is a unique name scientists around the world use that is the combination of two terms. The first name (capitalized) is the genus of the organism. The second is it specific name or specific epithet. The genus name is written first, always capitalized, underlined or italicized. The specific name is written second, never capitalized, always underlined or italicized. The example of scientific name of a horse is *Equus caballus* or Equus caballus.	1. Identify prior knowledge about scientific names. 2. Compare the local name and scientific name. 3. Group work; to study the history, principle and characteristic of scientific names and to produce scientific name plates.	1. Work sheet on the name of the local flora and fauna. 2. Memory banking. 3. A scientific name test. 4. Pictures of plants and animals such as papaya and a dragonfly.	1. Observe the students' answers to the questions. 2. Observe participation in the discussion, presentation activities in groups and classes. 3. From the work sheets and memory banking on the name of the local flora and fauna. 4. From a test of scientific names.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Three: Definition of Species and Classification of Living Things	3	1. Explain the meaning of the word "species". 2. Explain the meaning and the importance of identification of an organism. 3. Observe and identify living things into categories using the similarities and differences of appearance. 4. Observe and describe characteristics of living things in their community and divide them into groups. 5. Awareness of the knowledge obtained from the classification of organisms and how that can be applied to everyday life.	1. Species, the species is an interbreeding or potential interbreeding, group of populations reproductively isolated. 2. Classification of an organism is a method by which biologists group and categorize organisms by biological type such as kingdom, phylum (division), class, order, family, genus and species. 3. The criteria of scientific classification include fossil, comparative anatomy, and morphology.	1. Explore students' prior ideas about classification and species concepts. 2. Game; matching sequences of organism classification. 3. Discuss the criteria of scientists to classify organisms. 4. Compare and identify living things by collecting data. 5. Group and classroom discussion about classification and species concepts. 6. Designs an investigation about species diversity in their community.	1. Work sheet of the classification of living things. 2. Memory banking. 3. Pictures: butterflies, birds, bats, catfish, mule, horse, and donkey.	1. Observation of students' answers to questions. 2. Observation of participation in activities in both groups and class. 3. Work sheet classification of organisms.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Four: Dichotomous Key	1	1. Explain the meaning and the importance of identification of a dichotomous key. 2. Creating and using a dichotomous key 3. Classify organisms. 4. Awareness of the knowledge and benefits of identification of a dichotomous key.	A dichotomous key is the unknown organism, often presented as an organized written description of the characteristics and it is constructed by a series of couplets.	1. Finding out the students' prior knowledge about identification of a dichotomous key. 2. Identify the insects or other organisms using a dichotomous key. 3. Group discussion about meaning and characteristic of a dichotomous key.	1. Work sheet on the dichotomous key to classify materials and insects. 2. Magnifying glasses. 3. Materials: pen, pencil, eraser, ruler, etc. 4. Pictures or samples of insects: dragonfly grasshopper, bug, etc.	1. Observation of students' answers to questions. 2. Observation of participation in activities in both groups and class. 3. Work sheet on the dichotomous key to classify materials and insects.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Five: Kingdom Animalia	5	1. Identify key principles of identification in each phylum of the kingdom animalia. 2. Discuss and present the importance of the animal kingdom in Thailand and their community. 3. Tell the benefits and dangers of animals and examples of use of local fauna. 4. Use scientific instruments, such as magnifying glasses, to observe and classify species diversity in the kingdom animalia. 5. B e aware of the reduction of species diversity in the animal kingdom and to propose ways to solve the problem.	1. Animals do not have cell walls and chloroplast. They can not make their own food. They can move and respond to stimuli. The kingdom animalia is divided into 9 phylums which are 1) Phylum Porifera 2) Phylum Cnidaria 3) Phylum Platyhelminthes 4) Phylum Nematoda 5) Phylum Annelida 6) Phylum Arthropoda 7) Phylum Mollusca 8) Phylum Echinodemata and 9) Phylum Chordata based on germ layers, symmetry, coelom, embryonic development and segments.	1. Explore students' prior knowledge about animals. 2. Use the jigsaw technique for teaching and learning. 3. Group discussion about the six criteria to classify animals. 4. Present the findings of the investigation using memory banking. 5. Organize bulletin boards to present their findings.	1. Work sheet on the criteria for the classification of animals. 2. Memory banking. 3. Microscopes. 4. Magnifying glasses. 5. Examples of animals in students' communities.	1. Observation of students' answers to questions. 2. Observation of participation in activities in both groups and classes. 3. Worksheet on the criteria for the classification of animals. 4. Worksheet on the study and exploration of living characteristics.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Six: Kingdom Plantae	3	1. Identify key criteria for the classification of organisms in the plant kingdom. 2. Describe and presents the importance of the plant kingdom in the local community and nation. 3. Give examples of using plants and habitats of local plants. 4. Tell the importance of plants to other living things, including the promotion of local conservation.	1. Plants are living things that: 1) can create their own food. Because plants have chloroplast, which have chlorophyll for using photosynthesis; 2) cannot move; 3) have cell walls; and 4) are made of several cells together as tissues. 2. Criteria for identification of plants can be determined from the characteristics of vascular tissue, seeds and flowers. 3. The plant kingdom is divided into 9 Divisions, which are: 1) Division Bryophyta 2) Division Psilophyta 3) Division Lycophyta 4) Division Sphenophyta 5) Division Pterophyta 6) Division Coniferophyta 7) Division Cycadophyta 8) Division Ginkgophyta 9) Division Anthophyta.	1. Finding out the student prior knowledge about plants. 2. Round table activity is used to discuss the key characteristics of plants. 3. Group work; to classify plants. 4. Present the findings of the investigation. 5. Create a poster to present their findings.	1. Worksheet on the classification of plants. 2. Worksheet: 'What is a plant?' 3. Memory banking. 4. Microscopes. 5. Magnifying glasses. 6. Examples of plants in the students' community.	1. Observation of students to answer questions. 2. Observation of participation in activities in both groups and class. 3. Worksheet on the classification of plants. 4. Worksheet: 'What is a plant?' 5. Exhibition or poster.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Seven: Kingdom Protista, Kingdom Fungi, and Kingdom Monera	3	1. Tell classification criteria and the characteristics of the kingdoms monera, fungi and protista. 2. Describes and present the importance of monera, fungi and protista in the local community and nation. 3. Use scientific equipment to identify and observe the diversity of the kingdoms monera, fungi and protista	1. Monera comprises the living things with a prokaryotic cell organization (organisms without nuclear membranes). Monera includes the bacteria, and blue-green algae (cyanobacteria or blue-green bacteria). 2. Fungi do not have pigment for using photosynthesis. Fungi are decomposers and eukaryotic cells. The structure of fungi is called hypha, mycelium and rhizoids instead of roots. 3. Protists are the simplest of the eukaryotic cells. Protists have a single cell or multiple cells Protists can complete the act of life in a single cell.	1. Explore students' prior ideas about the concepts of protista, fungi, and monera 2. Use the jigsaw technique for teaching and learning. 3. Observe and perform laboratory activities. 4. Group discussion about the characteristics of the three groups of organisms. 5. Create a poster and bulletin board to present their finding from memory banking.	1. Worksheet about bacteria, fungi and protista. 2. Worksheet on the classification of the kingdoms monera, fungi and protista. 3. Memory banking. 4. Microscopes. 5. Magnifying glasses. 6. Examples of monera, fungi and protista that can be found in the students' community.	1. Observation of students to answer questions. 2. Observation of participation in activities in both groups and class. 3. Worksheet on the examination of students' knowledge about bacteria, fungi and protista. 4. Worksheet on the classification of living things in the kingdoms monera, fungi and protista.

Table 4.3 (Cont'd)

Lesson	Duration (periods)	Learning objectives	Concepts	Learning activities	Materials	Assessments
Lesson Eight: Conservation of Species Diversity in the Local Community	2	1. Explore and explain the problems in the local environment and natural resources. 2. Provide guidelines for conservation of the environment and natural resources in students' community. 3. Maintain and utilize the environment and natural resources of the school and community by using scientific knowledge and technology, as well as taking action to solve problems in the local environment. 4. Awareness of conservation of both species diversity and natural resources in the students' community.	Conservation of species diversity means to protect species diversity in its natural habitat that we can view as follows: • to create conservation centers to protect wildlife and to develop environments similar to natural ecosystems, such as the Botanical Gardens, Marine Aquaculture Center, etc. • to promote agriculture, mixed farming and to provide various kinds of plants and animals habitats together, conserving living things.	1. Explore student's prior ideas and feelings about the importance of conservation of species diversity. 2. Create school news to present the importance and conservation about species diversity. 3. Round table activity for assisting students to explain the importance of conservation in their community.	1. Worksheet on news from the community. 2. Memory banking. 3. Pictures about forestry and deforestation. 4. Future board paper.	1. Observation of students answering questions. 2. Observation of participation in activities in both groups and class. 3. Worksheet on the news from the community.

Summary

This chapter discussed the exploratory phase and design and development of the Species Diversity Learning Unit [SDLU]. The findings from the exploratory phase, students' difficulty in understanding species diversity concepts, teachers' and students' needs, and community funds of knowledge about species diversity have implications for teaching and learning species diversity. The design and development of the Species Diversity Learning Unit [SDLU] is based on guiding principles, i.e., the development process, and its content and activities. The schools could adopt or adapt the unit to suit their needs. A description of the implementation of the Species Diversity Learning Unit is presented in the next chapter. In the next chapter, the unit implementation and evaluation phase, the implementation and impact of the SDLU in regards to the three biology teachers have been described as three case studies.

CHAPTER V

SPECIES DIVERSITY LEARNING UNIT IMPLEMENTATION

Introduction

This chapter discusses the implementation of a learning unit on species diversity which drew on community funds of knowledge. This section starts a discussion of the implementation of the learning unit with three case studies of three biology teachers, Mrs. Pim, Mrs. Yanee and Mrs. Suda. This chapter includes a description of the teachers' school contexts, background information, classroom settings, beliefs about teaching and learning, the implementation of the learning unit, students' understanding of species diversity concepts and the effects of the Species Diversity Learning Unit with each teacher's implementation. The implementation is shown in terms of how the three teachers implemented the unit and how their students participated in the learning activities. After three cases' implementation is presented, a cross case analysis of the effects that facilitated and constrained the implementation of species diversity learning unit through community funds of knowledge is provided.

Case Study One: Sunshine School

School Contexts

The first public secondary school was called the "Sunshine School". It was located in a suburban area of the Ratchaburi province, education area two. There was a big mountain in front of the school. There were also rice fields, cow farms and agricultural areas around the school. Students attending this school came from low socioeconomic backgrounds. The entire population of the school was approximately 1,200 students and 70-80 teachers. The school had seven classrooms in level 3, Grades 7-9, and three classrooms in level 4, Grades 10-12. Each grade 7-12 classroom had 35-40 students.

Every morning, during 7.50-8.30, students and teachers began by singing the national anthem, and by clasping their hands and giving thanks to the country, to Buddha and to the king, which upholds the Buddhist faith. The students spent ten minutes before class to meet their advisors. Then, the teaching period started at 8.30 a.m. and finished at 16.10 p.m. There were seven hours of teaching periods and one hour of lunchtime.

In the science department, there was a weekly teacher meeting on Thursday. The head of the department informed all science teachers about science news and activities in the school and launched a discussion on how to better teach science, how to solve students' learning problems in science and students' discipline behaviors teachers found during their instruction.

1. Teacher and Student Background

1.1 Teacher Educational Background and Teaching Experience

Mrs. Pim was about 55 years old. Her formal education was a Bachelor of Education degree, majoring in biology. Her teaching experience on the species diversity content in high school was approximately 27 years. She had taught about species diversity in grade ten and she had also taught science for Grade 7 and 9. She had twenty teaching periods a week in total.

1.2 Mrs. Pim's Student Information

Mrs. Pim's grade 10 biology classroom contained 17 boy and 25 girls who studied biology three 60-minute periods a week. The grade point average [GPA] in the biology class was 2.91 (Table 5.1). She described the class as having mixed ability students. The students' opinions towards learning biology varied considerably. Twenty five students would like to learn biology for everyday life, while twelve would like to learn biology for examinations, and five students did not like to attend the biology class because it required too much memorization.

Table 5.1 Number of students in each grade point average

Grade Point Average in Biology	Students (number)
(GPA 4.0)	5
(GPA 3.5)	5
(GPA 3.0)	16
(GPA 2.5)	11
(GPA 2.0)	4
(GPA 1.5)	-
(GPA 1.0)	1
(GPA 0)	-

There were three students who were purposively selected to be studied in depth concerning their development of species diversity understanding. The selection was based on gender, age, biology achievement, attitudes towards biology and parents' careers by using a questionnaire.

Dokkaew was a sixteen year old girl. Her grade point average in biology was 3.00 and her GPA in all subjects was 2.75. She thought that biology was necessary in her everyday life. She likes participating in activities rather than listening to a lecture. Her parents are farmers.

Mali was a sixteen year old girl. She would like to study biology because she would like to be a doctor. Her grade point average in biology was 4.0 and her GPA in all subjects was 3.50. She liked teaching based on activities, discussions and problem solving rather than listening to a lecture. Her father is a doctor and her mother is a teacher.

Bouhrong was a seventeen year old boy. He did not like studying biology because it required too much memorization. He suggested that receiving an opportunity for sharing ideas would be a better way of studying. His grade point average in biology was 2.50 and his GPA in all subjects was 3.00. His father is a small business owner and his mother is a house wife.

1.3 Classroom Setting

Mrs. Pim began to implement the teaching unit on January 3rd, 2006 in a laboratory which contained nine student tables with the dimensions 100 x 150 x 80 cm. Mrs. Pim's desk and an overhead projector were in front of the chalkboard. At the back of the classroom, there was one equipment cupboard and one bookcase. On the right side of the classroom, there were five computers for student work and searching for information. On the left side of the classroom, there were three sinks and windows.

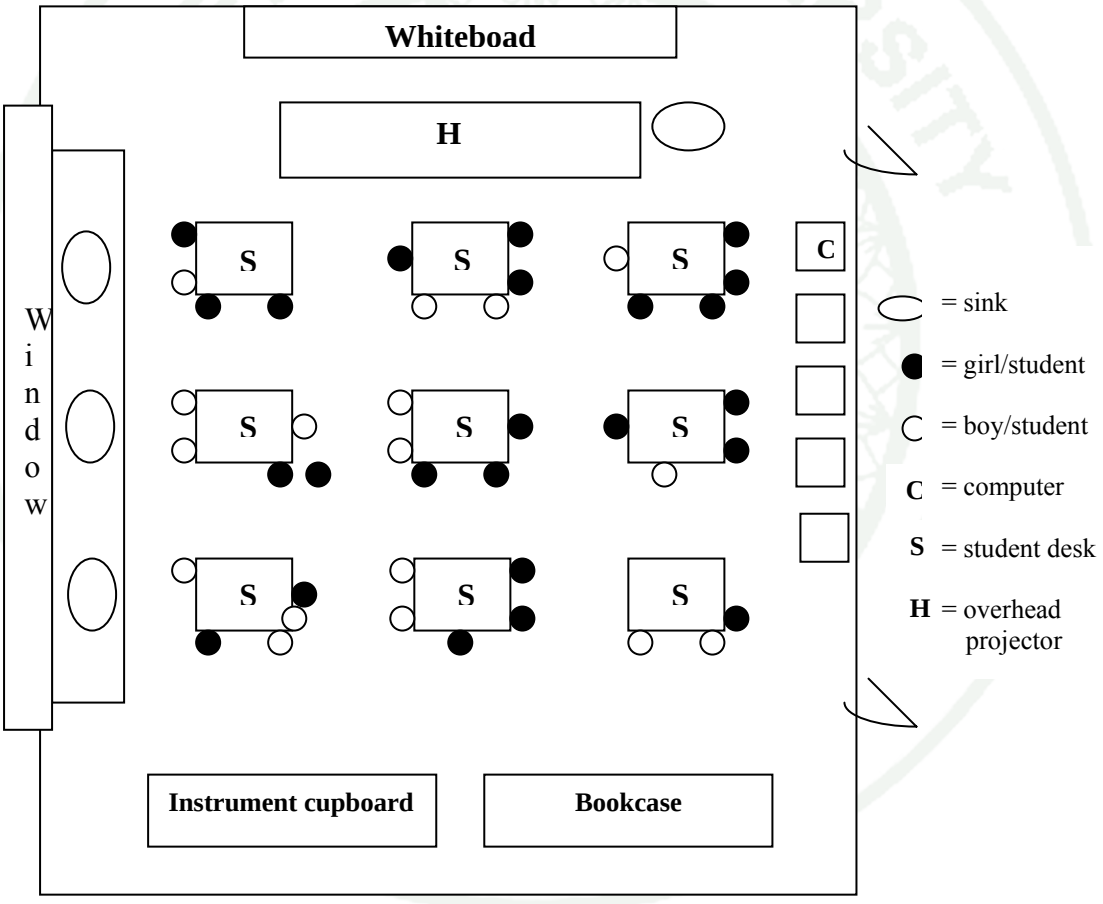

Figure 5.1 Mrs. Pim's classroom setting

2. Teacher's Thinking about Science Teaching and Learning

From an interview before using the learning unit, Mrs. Pim used lectures to present the main concepts for students' learning and she let students work in groups to do activities. Mrs. Pim mentioned that teaching through demonstration and explanation might not develop the students learning as well in biology, but these strategies could present the information in time limit given. She thought that students could learn by themselves and the teacher could assign student work in groups to search for information that could help students better learn. Mrs. Pim's students had to memorize biological vocabulary. In addition, she mentioned that students loved to participate in hands-on activities; however, they were unable to construct their own explanations. She felt that listening to the teacher was necessary for students to learn. Mrs. Pim said, "…lecture can teach all of concepts in time. If students do more activities, they cannot learn all of the concepts because there is not enough time."

Moreover, Mrs. Pim believed that student work in groups was emphasized in the teaching and learning of science. The interaction between students and their friends would encourage the students to succeed in doing activities. Mrs. Pim would like the students to form their groups independently to participate in the activities. She noted that students in her classroom were still unfamiliar with active learning. She also mentioned that students liked listening and copying what she said and wrote on the board.

Mrs. Pim also believed that biology could be learned everywhere. She was enthusiastic about the importance of organisms in the students' community. She strongly believed that the best way to learn science was through good samples. She gave an example of activities that showed her student learning. She said that she asked her students to explore and record kinds of organisms that they found within the school when she taught about species diversity.

3. Mrs. Pim's Implementation of the Learning Unit and the Students' Understanding

Mrs. Pim's implementation of the curriculum has been described in terms of the teacher's practices in the classroom in parallel with the impact on the students' understanding. Three of Mrs. Pim's students were assessed in depth in their conceptual understanding with respect to the concepts in the unit.

3.1 Mrs. Pim 's Practices

The description of Mrs. Pim's practices is provided in three sections according to aspects of the constructivist approach, community funds of knowledge and socio-cultural perspective that served as a basic framework of the species diversity learning unit.

3.1.1 Mrs. Pim's Instruction and Constructivist Approach

Before Mrs. Pim implemented the learning unit, the findings of the Introductory Species Diversity Concept Survey [SDCS] indicated that most students held misconceptions about animal and plant classifications. They classified organisms using habitat as the criteria. This misconception might come from their everyday experience (Kinchin, 2000). For example, in the classification of organisms, Mrs. Pim investigated the students' prior knowledge and experiences about classification of plants and animals through discussion. For example:

Mrs. Pim:	According to your understanding, how many groups of animals could you classify?
Student:	We could classify animals into 3 groups; land, water and air.
Mrs. Pim:	What else?
Student:	…….
Mrs. Pim:	How many groups of plants could you classify?

Student: Plants could be classified into 2 groups; plants on land and plants in the water.

The findings indicated students' held an alternative conception, in scientific classification. Teaching with an emphasis on connecting students' prior knowledge was a basis to develop the understanding about species diversity.

In implementing the species diversity learning unit, Mrs. Pim started her lesson by engaging students' attention and eliciting their prior knowledge. She raised questions about the criteria of classification and encouraged students to share real life experiences at the beginning of the lesson. In an example of correcting students' misconceptions in lesson 3, "Classification of Living Things", Mrs. Pim encouraged students by using pictures of humans, cats, and bats, and then asked, "Why are humans, cats, and bats classified into same group?" Then she launched a group discussion about what characteristics were similar and different. She moved around the classroom and assisted them to discuss about co-characteristics of humans, cats and bats. After Mrs. Pim' teaching practice, most of the students appeared to correct their misconceptions and students could construct their own knowledge. Therefore, questions were used in Mrs. Pim's teaching to promote students' learning and to encourage students to describe what they observed and explain ideas in their own words. She also asked probing questions to the students' to have them think deeper about the concept. In addition, the classroom observations and interviews confirmed that students' understanding was enhanced by working in groups, because the students were given time for discussing their findings and making conclusions within their group. This helped students understand the species diversity concepts.

3.1.2 Mrs. Pim's Instruction and Community Funds of Knowledge

Evidence from classroom observations and teacher interviews indicated that Mrs. Pim started her teaching with students' real life experiences with living things in their community, allowed students to conduct investigations on species diversity, and asked relevant questions in making connections to everyday life. The

students were engaged through questions that drew on community funds of knowledge and their experiences. At the beginning, students were asked to share experiences and develop further investigations on relevant topics. These included students' own experiences about local organisms and using organisms in their community. Mrs. Pim also mentioned that using topics or experiences familiar to students' engaged student interests and students paid more attention while participating in learning activities. The evidence came from an interview with Mrs. Pim after finishing the lesson of Kingdom Plantae. She said, "…using animals and plants from the students' community makes students' understand. Students can link concepts to their every day lives. They are interested in real organisms more than ones in the textbook."

Mrs. Pim introduced the lesson by using living things in the local community to examine students' prior knowledge and motivate students' interest. After students developed their own understanding, Mrs. Pim asked related questions to help them apply what they learned in school to real situations. Mrs. Pim's responses indicated that she focused her teaching on encouraging students to give relevant examples and reasonable explanations about the concepts related to their community. Moreover, Mrs. Pim provided evidence to support the value of everyday language that students and their parents used in naming organisms. For example, in the lesson on "Scientific Names", Mrs. Pim brought a papaya that grew near school and asked students about everyday language, "How many names of papaya do you know?" Students said the local names were "marakoo, bughung and lokoo" and that these names defined papaya in different areas. These finding make it difficult to identify organisms. Therefore, living things should have one standard name that can be called a scientific name for people all around the world.

In lesson six, Kingdome Plantae, Mrs. Pim divided students in groups to emphasize students' abilities. In groups, students had the responsibility in cooperative learning. Students had to investigate plants in their community. Students used "memory banking" as a tool to collect data from the community. It emphasized many different things such as the environment, economy, education, and religion/beliefs. Also students asked local people for basic information. For example,

one group of students selected to investigate bananas in their community. They gave the reason of selecting bananas because their community had bananas in all local areas. People in the community used bananas in many ways such as the banana fruit to make some food and the banana stem to use in the Loy Kratong Festival. In addition, the students' community had many species of bananas. When students finished their banana investigation, Mrs. Pim also let students find the scientific name of banana. Then, Mrs. Pim assigned students to develop nameplates of plants or trees that were investigated in the school and asked students think about how to put the nameplates on the stems of the trees. This question needed students to understand about conservation.

Moreover, students also had the opportunity to study outside, like through fieldtrips in their community. They could see the species diversity and established awareness in conservation of species in their community. Mrs. Pim used living things in the students' community that could make students understand concepts and awareness of species diversity in her class. She also used learning resources (local plants and animals) and environmental situations around students' places, their school and community to teach in the unit and activated students to discuss the importance and conservation of species diversity in their community.

3.1.3 Mrs. Pim's Instruction and the Socio-Cultural Perspective of Learning

The school society that influenced the learning was regarded as new teaching about species diversity. The interactions between the teacher and students were improved to support students' classroom participation. Thai students were unfamiliar with direct discussion with their teacher (Chapter II). Mrs. Pim conducted friendly conversations with students. Moreover, she appeared to improve her interactions with students. The friendly interactions between the teacher and students, help students learn species diversity based on their society and culture in the classroom. Moreover, she gave more opportunities for students to think and discuss between themselves in groups. Mrs. Pim used group discussion in her classroom. She challenged the students to make a decision or answer the questions through group

discussion. The students shared their answers and worked together with their friends to create a final explanation. The observation and interview with students indicated that they were familiar with discussing the ideas with the teacher. The students also asked the teacher again when they really did not understand the concepts.

Students' positive attitudes towards learning in groups in the classroom were found after Mrs. Pim's implementation. In an interview with Bowhoung, he said, "I like cooperative learning because all members in the group have a role to conduct the activity, such as conductor, presenter and recorder. I also have opportunities to discuss and present my ideas with friends."

3.2 An Example of " Kingdom Animalia" Lesson

The follow learning activities provide an example of Mrs. Pim's instruction emphasizing community funds of knowledge and socio-cultural perspectives of learning. This lesson aims to investigate and classify living things in the animal kingdom.

At the beginning of the lesson, students were engaged with an activity to elicit their prior knowledge about the characteristics of animals. Students were asked to observe with pictures of animals and other living things. Students were then asked to tell whether other pictures of living things were animals or not and why?

Mrs. Pim:	What is it?
Students:	A bird.
Mrs. Pim:	Is it an animal?
Student:	Yes, it is an animal.
Mrs. Pim:	Why is the bird an animal?
Student:	It can fly.
Mrs. Pim:	Fly! Airplanes can also fly, so are they like an animal?
Student:	A bird is an animal because it can lay eggs,

respond to stimuli, and move.

Mrs. Pim: Yes…very good.

After completing the activity about what the characteristics of animals were, Mrs. Pim asked students to sit in small groups and engage actively in exploring the criteria of animal classifications by using the cooperative learning technique called jigsaw. In the classroom, students were divided into two groups (a home group and an expert group). In the expert group, they were divided into the six groups of the criteria of animal classification such as germ layers, coelom, circulatory system, type of digestive tract, symmetry and segmentation. Students came to the expert group to work collaboratively and record their study on a worksheet about the criteria of animal classification. When students finished in the expert group, they came back to the home group and wrote down other group members' findings from the expert group. During the activity, Mrs. Pim walked around the classroom and asked students in each group to share ideas with their peers. She used questioning to facilitate her students' explanations on the criteria of animal classification. Mrs. Pim asked students to compare their findings in each criterion. It led students to develop understandings of animal classification based on scientific criteria.

After that Mrs. Pim asked all students to study the criteria of animal classification. Students were encouraged to investigate animals in their community using memory banking. Examples of the memory banking from the students' investigation is shown in Table 5.2.

Table 5.2 Students' investigating about Cow in community

Cow					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultura practices**
Cow is distributing seed of plant as well. Cow dung are used as fertilizer to plants growing.	Cow was used every part of body; meat and milk to consume, horn to make jewelry, and leather to produce bag or shoes	Cow was a vertebrate mammal. Cow was representati ve to study about digestive system of ruminant animal. The developmen t of cow's species could resistant to disease.	Meat was a protein source for people. Milk has high calcium.	Some religious belief that cow was a vehicle of god. The cow used in rituals associated with the cultivation of rice.	Most people has raised cattle for many reasons some for consumer, some for commercial purposes.

Mrs. Pim asked students to classify animals that were recorded in the students' investigations. Students compared the characteristics of animals based on scientific criteria in their group. An example of the students' conversation is described below:

Student one: What is the phylum of a cow?

Student two: I think that a cow may be in phylum chordata.

Student one: Why?

Student two: It has vertebra, a closed circulatory system, bilateral symmetry, and milk for its baby.

Student one: Ah…yes. Cows have milk.

Student one: I think that cows are in the class mammalia of the phylum chordata too.

Student two: Yes...I agree with you.

Moreover, Mrs. Pim asked students to explore and study about animals in the community such as mammals in terms of the importance and factors that affected the decreasing diversity of organisms. Students used memory banking to record information and shared ideas that were collected by other students in the classroom.

During the last twenty minutes of the lesson, Mrs. Pim assessed students' understanding of concepts by asking students to memorize and talk about key characteristic in each phylum of animal classification. Students discussed the criteria for classification of animals and summarized the definition of animals in the animal kingdom by using pictures, tables and the board.

4. Effect of the Implementation of the Learning Unit on Students' Understanding the Concepts of Species Diversity

4.1 Students' Understanding about Species Diversity

From the concept survey before implementing the unit, most students had alternative conceptions about the kingdom animalia, kingdom plantae and kingdom protista, and half of the students had no understanding about kingdom fungi and kingdom monera classification and species concepts, as shown in Table 5.3. After the implementation of the Species Diversity Learning Unit based on community funds of knowledge, the data from the survey, observation and interviews indicated that most of Mrs. Pim's students developed an understanding in all concepts of species diversity.

Table 5.3 Frequency and percentages of students' categories of responses concerning species diversity in concepts pre-post survey

concept		Frequency and percentages of students' categories of responses				
		SU	PU	PU-SM	SM	NU
Definition of species diversity	**pre**	3 (7.1%)	9 (21.4%)	7 (16.7%)	-	23 (54.8%)
	post	13 (31.0%)	21 (50.0%)	4 (9.5%)	-	4 (9.5%)
Kingdom Animalia	**pre**	-	-	-	27 (62.3%)	15 (35.7%)
	post	12 (28.6%)	18 (42.9%)	-	3 (7.1%)	9 (21.4%)
Kingdom Plantae	**pre**	-	-	-	24 (57.1%)	18 (42.9%)
	post	10 (23.8%)	20 (47.6%)	-	5 (11.9%)	7 (16.7%)
Kingdom Protista	**pre**	1 (2.4%)	-	-	20 (47.6%)	21 (50.0%)
	post	13 (31.0%)	16 (38.0%)	2 (4.8%)	4 (9.5%)	7 (16.7%)
Kingdom Fungi	**pre**	1 (2.4%)	-	-	10 (23.8%)	31 (73.8%)
	post	11 (26.2%)	23 (54.8%)	2 (4.8%)	-	6 (14.3%)
Kingdom Monera	**pre**	-	-	-	-	42 (100 %)
	post	16 (38.1%)	13 (31.0%)	-	5 (11.9%)	8 (19.0%)
Definition of Species	**pre**	2 (4.8%)	9 (21.4%)	6 (14.3%)	1 (2.4%)	24 (57.1%)
	post	10 (23.8%)	18 (42.9%)	9 (21.4%)	-	5 (11.9%)

Note: SU = Sound Understanding, PU = Partial Understanding, PU-SM = Partial Understanding with Specific Misunderstanding, SM = Specific Misunderstanding, NU = No Understanding

The survey, observation and individual interviews with three students strongly supported the development of students' understanding about species diversity.

4.1.1 Students Understanding about the Definition of Species Diversity Concepts

Students understood about the meaning of species diversity concepts better. From the survey before implementing the unit, it was found that 54.8 percent had no understanding of these concepts. 21.4 percent of students had partial understanding. They used characteristic of living things to answer this question. For example, "There was diversity of living things in one area because they are much different in body size, eating, and etc" (student 23). Only three students had sound

understanding. After implementation of the Species Diversity Learning Unit based on community funds of knowledge, the results show that 50 percent had partial understanding about the meaning of species diversity. 31 percent had sound understanding. From the interview with Mali before the implementation of the unit, she had partial understanding about the definition of species diversity. She said, "Living things live together that have interdependence." After implementation of the unit, it was found that Mali had a sound understanding about this concept. She said, "Species diversity is a group of living thing including the diversity of species that live together in a diversity of ecosystems."

4.1.2 Students' Understanding about Kingdom Animalia

From the survey and interviewing students about animals and animal classification before implementing the unit, the results showed that 62.3 percent had specific misconceptions about animal classification. They used the habitat of animals in classification. For example of a student's answer, "We could classify animals into three groups that are land animals, fish/marine animals and flying animals." Some students (15 students) did not answer the question. After implementing the unit, it was found that 28 students had sound understanding about animal classification into groups. They used tissue layers, coelom, etc. However, three students had specific misconceptions and 21 percent had no answer.

4.1.3 Students' Understanding about Kingdom Plantae

In students' concept survey before implementing the unit about plants and plant classification, the results showed that 57.1 percent had specific misconceptions about this concept. They classified plants into two groups, which were plants in land and plants in water. Also there was 42.9 percent that had no answer. After implementation of the unit, 23.8 percent had a sound understanding in this concept. They used plant characteristics such as being vascular, flowers, and fruit. 47.6 percent had a partial understanding of this concept.

4.1.4 Students' Understanding about Kingdom Protista

Students understood about protista classification better. From the concept survey of students before implementing the unit, the results showed that 50 percent had no understanding and 47.6 percent had specific misconceptions. They used characteristics that could be seen to classify during this question. For example, “Chlorella is a plant, paramecium and amoeba are animals” (student 20). After the implementation of the unit, it was found that students improved their understanding about protista classification. From the concept survey and interview, it was found that 38 percent had a partial understanding and 31 percent had a sound understanding. For example, “Paramecium, amoeba and chlorella are not in either the plant or animal kingdoms because they are unicellular organisms. I can see them by using a microscope” (student 40). Only 9.5 percent had specific misconceptions in this concept.

4.1.5 Students’ Understanding about Kingdom Fungi

From surveying the concept of fungi classification before implementing the unit, the results showed that 10 students had specific misconceptions in this concept. For example, one student answered, “Mushrooms are plants because mushrooms have stems like plants and they can also not move” (student 10). 73.8 percent had no answer in this concept. After the implementation of the unit, it was found that 26.2 percent had a sound understanding. In addition, 54.8 percent had a partial understanding. Dokkaew was interviewed about this concept before implementing the unit. She explained, “Mushrooms are plants because they have stems like a tree and they cannot move and produce food by themselves.” She used characteristics that can be seen, such as how the mushroom looked like a tree. After she had experience in the unit, Dokkaew improved and had a sound understanding of this concept. She said, “Mushrooms are not plants because they do not contain chlorophyll that can produce food. They consist of hypha and are decomposers.”

4.1.6 Students’ Understanding about Kingdom Monera

From the survey before the implementation of the lesson, in regards to students' knowledge of monera classification, the results showed that all students had no answer in this concept. After implementing the unit, the result shows that 38.1 percent had a sound understanding. For example, student answered, "Bacteria are prokaryotic cells that have no nuclear membrane" (student 5).

4.1.7 Students' Understanding about Definition of Species

In the survey, students' concepts about species before the implementation of the unit, the results show that 57.1 percent had no understanding and 21.4 percent had a partial understanding. For example, one student answered, "Horses and donkeys are the same species that can interbreed and produce a new species" (student 10). After implementation the unit, 23.8 percent had a sound understanding in this concept. For example, "In general, species cannot interbreed with other species but horses and donkeys have similar sex organs. Due to their close relationship so they can interbreed but the offspring will be an infertile animal" (student 32).

4.2 Students' Thinking about Conservation of Species Diversity

Applying the accepted scientific knowledge about species diversity to conservation of living things was found through survey and interview with students before implementation of the unit. Most students thought that species diversity was important to human life. For example, "We can apply the knowledge from species diversity in every day life, such as food and medicine."

In addition, students gave reasons about the loss of species diversity as not being affected by human life because it was natural law. However, half of the students agreed to encourage people to know about how to converse species diversity.

After implementation of the Species Diversity Learning Unit based on community funds of knowledge, most students thought that species diversity was important for ecological balance and to make careers for people. In an interview, Dokkaew stated, "...I think that my home has more species diversity because my home is near a mangrove forest. There are many trees and animals. The forest has benefits for many little animals for life. Also people in my community are fisherman."

In terms of the relationship of species diversity, most of the students said that the extinction of a species can affect other species too. Humans destroy the habitat of living things through processes such as deforestation. From one question about the local news, "Why would a tiger came to eat cows of people in the community!" Mali answered this question, "...when humans destroy the forest that is a habitat of living things, include tigers' food, a tiger has to find some food in other areas." However, students think that the news is very common because tigers are carnivores. Students use the concept of a food web to explain this question.

In conversation of species diversity, most students thought that the community should improve species diversity to conserve living things in their community. An individual interview with Dokkaew provided an example of a story which strongly supported the findings. She suggested that her group would like to conserve the organisms in their community. "..Our group learned more about animals and plants in our community, such as scientific names and usefulness. I need to develop and conserve them."

In summary, from observation of teacher instruction, students' learning and interviews with three students, the data from students supported students' understanding about organism classification. They can define and classify in a correct way. They used criteria in biological science, such as structures, to classify organisms. In addition, they explain key characteristics of living things including conservation of living things.

In addition, the data also show that three students like to learn about real living things and through hands-on activities. In the teaching of Mrs. Pim, she used living things in the students' community that could make it easier for students' understanding. Moreover, serious respect of the teacher was adapted through a friendly relationship between students and the teacher. They liked to learn in groups because they had interaction in groups. The observations and interviews with students indicated that they were familiar with direct discussion by the teacher. Also, the students asked the teacher again if they really did not understand the concepts.

5. Factors Influencing the Implementation

The factors that facilitated Mrs. Pim in the implementation of the learning unit included her beliefs and understanding about community funds of knowledge, socio-cultural perspectives, teacher content knowledge and pedagogical content knowledge. However, teacher preparation and students' ability were obstacles for her implementation.

5.1 Facilitating Factors

Throughout the interview with Mrs. Pim during and after the implementation, she discussed her strong beliefs and understanding about community funds of knowledge, socio-cultural perspectives of learning, teacher content knowledge and pedagogical content knowledge. These influenced Mrs. Pim's implementation in all aspects of these approaches in order to develop students' understanding about species diversity concepts.

5.1.1 Teacher's Beliefs and Understanding about Community Funds of Knowledge

Mrs. Pim also believed that teaching based on community funds of knowledge improved students' understandings of new concepts and helped them to make relationships between school and their community. As a result of starting the lesson with local organisms and experiences, it appeared that students could see the

connection between what they learned in school and their community. After finishing species diversity in the local community and conservation lesson, Mrs. Pim also mentioned that using examples, experiences and knowledge in the students' community helped students' understanding about conservation of species diversity concepts in real-life situations.

5.1.2 Teacher's Beliefs and Understanding about Socio-cultural Perspectives of Learning

Mrs. Pim also mentioned ideas that represented her beliefs and understanding about socio-cultural perspectives of learning**,** including the interaction between teacher and students, students and their friends and also students' diverse abilities and learning styles**.** Before implementation of the learning unit Mrs. Pim said that students normally were quiet when she asked questions about their ideas. After Mrs. Pim commented that friendly interactions could foster students' confidence in sharing ideas in the classroom, students did not worry as much about making mistakes when they talked about organisms that were familiar to them. Ms. Pim also mentioned that students learned better in active involvement by using observation and working collaboratively in groups through hands-on and minds-on activities. Students had changed their behavior into active learners**.** They were able to ask questions, present their ideas and discuss the topics with their teacher and friends.

5.1.3 Teacher Content Knowledge and Pedagogical Content Knowledge

Mrs. Pim's strong content knowledge and pedagogical content knowledge facilitated her instruction which provided students opportunities to conduct investigations about their own interests and ask probing questions for student discussion. Moreover, she also asked her students to give reasonable explanations about key concepts related to their real life situations.

5.2 Constraining Factors

Throughout the discussion with Mrs. Pim during and after the implementation time, there were two factors that constrained the learning unit implementation. These factors included teacher preparation and students' ability.

5.2.1 Teacher Preparation

Mrs. Pim was the head of the science department, and throughout the implementation of the unit it appeared that Mrs. Pim did not have enough time to prepare her teaching in terms of content and the learning process that would be taught in each lesson. Moreover, Mrs. Pim mentioned that there were many steps to ask the school principal in order to provide students an experience outside of school. Mrs. Pim suggested that the way to link knowledge in the community was to invite local experts to teach and demonstrate in schools.

5.2.2 Students' Ability

Students' ability in reading, writing and learning vocabularies were key factors that constrained unit implementation. Mrs. Pim mentioned that students encountered difficulties in learning vocabulary words and technical terms such as ‘phylum’, ‘division’ and ‘species’. Furthermore, students' ability in writing and reading was an obstacle to their learning. Writing to record and explain was a difficult task for students. Moreover, some students were not interested in the learning activities because they were hard to read and understand. Mrs. Pim helped students by asking questions until students understood what they should do.

Case One Summary

In this case study, Mrs. Pim's strong beliefs and understanding about community funds of knowledge, socio-cultural perspectives, and content knowledge and pedagogical content knowledge impacted her teaching and the learning about

species diversity. Mrs. Pim also understood about teaching approaches and her teaching science background facilitated and supported her implementation of the learning unit. Mrs. Pim's practice is provided in three aspects of the constructivist approach, community funds of knowledge and socio-cultural perspectives of learning which focused on incorporating the students' community to share and investigate living things in their community. Community funds of knowledge about species diversity were used as a starting point for learning, and then students were allowed to make decisions to conduct investigations based on their own interests about species diversity through group work. Moreover, students were asked questions about how to conserve species diversity in the students' community and make connections to their everyday lives. The results showed that Mrs. Pim changed her behavior from lecturer to facilitator. She emphasized hands-on activities and gave more opportunities for students to think and discuss among themselves in groups. However, Mrs. Pim emphasized that students should memorize some technical terms of biology. She said, "When learning species diversity, one has to know the technical terms for further study in higher biology education." Mrs. Pim's implementation was successful in improving the understanding of species diversity concepts and their relationship to everyday life. Moreover, Mrs. Pim mentioned that most of the students paid more attention in learning activities when they became confident in doing activities and sharing ideas that were familiar to them with their teacher and friends in the classroom. However, completing the implementation was constrained by Mrs. Pim's preparation time and students' ability in this case.

Case Study Two: Starlight School

School context

The second public secondary school was called the “Starlight School”. It was located in a suburban area of the Ratchaburi province, education area two. It was near the community. The Mae Klong River was in front of the school. There were many rice fields around the school. Most students came from low socioeconomic backgrounds. The entire student and teacher population of the school was comprised of approximately 800 students and 56 teachers. The school had six classrooms each in level 3, grades 7-9, and two classrooms each in level 4, grades 10-12. Each grade 7-12 classroom had 25-35 students.

Every morning, during 7.50-8.20, students and teachers began singing the national anthem and clasping their hands and giving thanks to the country, to Buddha and to the king. They listened to explanations about news and events from the teacher and student representatives. The students spent ten minutes before class to meet with their advisors. Then, the teaching period started at 8.30 a.m. and finished at 15.30 p.m. There were six hours of teaching periods and one hour of lunchtime.

1. Teacher and student Background

1.1 Teacher Educational Background and Teaching Experience

Mrs. Suda was about 39 years old. She graduated with a Bachelor of Education, majoring in teaching science. Her teaching experience on species diversity concepts in high school was approximately 3 years. In the second semester, she had taught species diversity for grade eleven and also taught about biology for Grade 10 and 12. In total, she had eighteen teaching periods a week.

1.2 Mrs. Suda's Student Information

Mrs. Suda's Grade 11 biology class contained 10 boys and 18 girls who studied biology during three 50-minute periods a week. The grade point average [GPA] in biology for this class was 2.89. Mrs. Suda described the class as a mix ability of students. The students learned biology 2 periods per week on Wednesday.

Table 5.4 Number of students in each grade point average

Grade Point Average in Biology	Students (number)
(GPA 4.0)	2
(GPA 3.5)	5
(GPA 3.0)	13
(GPA 2.5)	3
(GPA 2.0)	4
(GPA 1.5)	-
(GPA 1.0)	1
(GPA 0)	-

There were three students who were selected purposively to be studied in depth concerning their development of species diversity understanding. The selection was based on gender, age, biology achievement, attitudes towards biology, and parents' careers by using a questionnaire. Champa, Prawit and Pikul were selected for this study.

Champa was a seventeen year old girl. Her grade point average in biology was 3.00 and her GPA in all subjects was 2.90. She mentioned that biology was necessary to learn about living. She likes hand-on activities rather than listening to a lecture. Her parents are a farmer and fisherman.

Prawit was a seventeen year old boy. His grade point average in biology was 2.00 and his GPA in all subjects was 3.00. He did not like studying biology because it had many words and needed too much memorization. He likes hand-on activities and

working in a group. It is the best way to learn science. His father is an engineer and his mother is a teacher.

Pikul was a sixteen year old girl. Her grade point average in biology was 4 and her GPA in all subjects was 3.27. She would like to study biology because biology was necessary for everyday living. She likes listening to teacher's explanations rather than reading books. She did not like participating in activities. Her parents are merchants.

1.3 Classroom setting

Mrs. Suda began to implement the teaching unit on the 4th of January, 2006 in the school laboratory which contained nine student tables, with the dimensions 200 x 150 x 80 cm. Mrs. Suda's desk and an overhead projector were in front of the chalkboard. At the back of the classroom, there was one instrument cupboard. On the left side of the classroom were two sinks and windows.

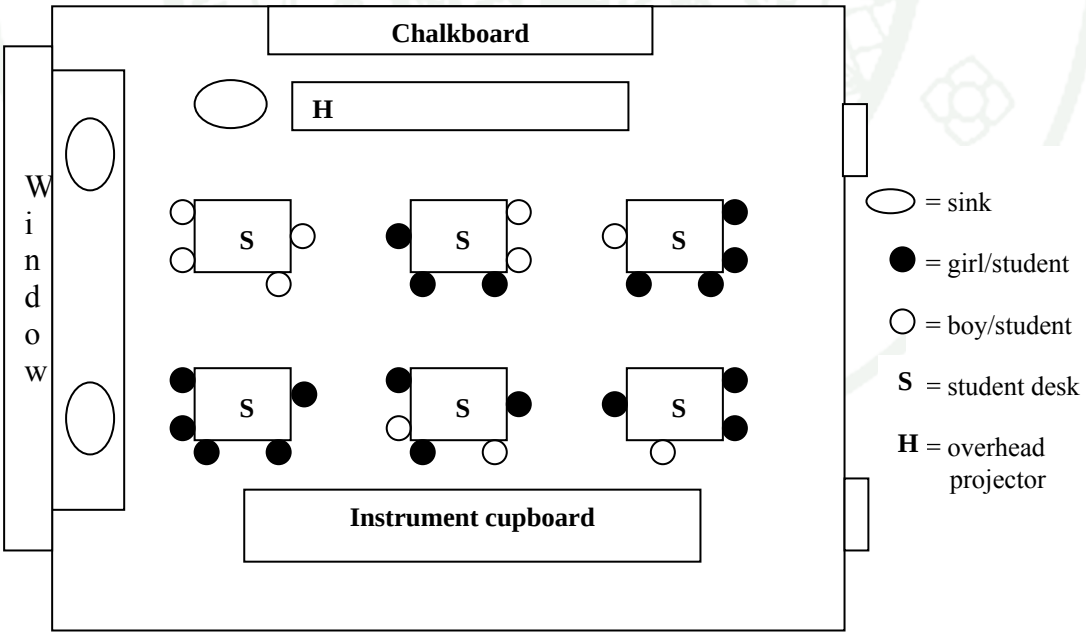

Figure 5.2 Mrs. Suda' s Classroom Setting

2. Teacher's Thinking about Science Teaching and Learning

According to the classroom observations and discussion with Mrs. Suda during informal interviews throughout the study, Mrs. Suda believed that teaching science by lecturing could not develop the students' understanding of all science concepts. Also she believed that students can develop their own knowledge through hands-on activities such as observation and conducting experiments. Students would like working in groups and formulating their own explanations themselves rather than having the teacher telling them directly. An interview response of Mrs. Suda can be seen below:

> "Teaching that emphasizes student activities encouraged the students' thinking and expression of their understanding. If students had misunderstanding, the teacher can solve this problem by explaining the correct concepts for students' understanding immediately."

However, Mrs. Suda also mentioned that students could not do all activities in science because there were problems with equipment and chemicals in the laboratory. She selected key activities when teaching biology.

Mrs. Suda believed that students' interaction between students and their friends with the teacher as facilitator would promote the students to learn science better. Mrs. Suda was emphasizing the importance of students' interactions in learning activities and encouraging group discussions and classroom discussions. She would like the students to form their group independently to participate in the activities and discussions. She mentioned that students in her classroom could learn more in groups. They would like to talk and participant in activities, actively learning in the classroom. She also expected that competent students in the groups could help other students.

Throughout the discussion with Mrs. Suda, she believed that learning biology used the community that could encourage students to learn concepts related to their lives. However, Mrs. Suda mentioned that teaching in a way that provided students an

experience outside school was limited because it required time and money. She felt that schools did not have funding to support this kind of activity. Mrs. Suda hoped that there were more opportunities for students to participant in her teaching activities in and out of school.

3. Mrs. Suda's Implementation of the Learning Unit and the Students' Understanding

Mrs. Suda's implementation of the curriculum has been described in terms of the teacher's practices in the classroom paralleled with the impact on the students' understanding. Three of Mrs. Suda's students were studied in depth to assess their conceptual understanding with respect to the concepts in the unit.

3.1 Mrs. Suda's Practices

The description of Mrs. Suda's practices is provided in three sections according to aspects of the constructivist approach, community funds of knowledge and socio-cultural perspectives of learning that served as a basic framework of the Species Diversity Learning Unit.

3.1.1 Mrs. Suda's Instruction and the Constructivist Approach

Before Mrs. Suda implemented the learning unit, the findings of the Introductory Species Diversity Concept Survey [SDCS] and interview illustrated that her students held alternative misconceptions in all concepts of species diversity. In the concept of Kingdom Animalia, most of the students used the knowledge from their experiences in everyday life. For example, from an interview with students about animal classification, they answered, “Birds and bats were arranged in the same group because all of them can fly.” This survey and interviews with students consequently indicated some alternatives of students’ conceptions of Kingdom Animalia.

In the correction of students' misconception, Mrs. Suda implemented the unit following the instructional guidelines in the teacher manual. She perceived her role as facilitator for students learning. Mrs. Suda's classroom observations and interviews strongly indicated that she corrected students' misconceptions about animals and animal classification before students received formal teaching. In lesson 5, she provided a picture of animals and asked students to work in groups and consider the internal and external structures of each animal. She did not provide explanations or explain concepts for students' conclusions. She asked questions and assisted students' discussions in groups about what characteristics were similar and different. She tried to encourage students to think about relationships between evidence and explanations. After Mrs. Suda corrected the misconceptions about animal classification, most of the students appeared to correct their misconceptions and students could explain and construct their own knowledge related to scientific concepts. Classroom observations and the interviews indicated that Mrs. Suda started her lessons by engaging students' interests, eliciting their prior knowledge and sharing their real life experiences. Mrs. Suda provided opportunities for students to formulate their own explanations in groups and encouraged them to present their findings to the whole class. She also tried to ask probing questions to get the students to think deeper about the concepts. This evidence reflected her belief that students could construct their own knowledge. Students were encouraged to participate actively in hands-on activities and construct own knowledge of species diversity concepts.

3.1.2 Mrs. Suda's Instruction and Community Funds of Knowledge

From classroom observations and teacher interviews, Mrs. Suda accepted teaching on community funds of knowledge as an activity in her classroom. She mentioned that the opportunities for students to use local organisms and knowledge related to species diversity in the classroom fostered students' understandings. In every lesson, Mrs. Suda also used examples of organisms in the students' community and asked stimulating questions for students' interest. Students

were allowed opportunities to conduct investigations about species diversity in their community and shared experiences and knowledge to explain their findings.

For example, in lesson 5 on "Kingdom Animalia", Mrs. Suda divided students into mixed ability groups. She asked students to be responsible in the cooperative learning. Students had opportunities to conduct investigations about living things around their school and homes. They used memory banking to collect data about species diversity in their community. In this lesson, students were interested to investigate careers in the community, such as fisherman. This was the main career of the students' investigation in their community. Students found that there were many kinds of aquatic animals such as fish, shells, turtles and shrimp, and they also found a problem with water pollution that should be discussed in the classroom. The findings from students' investigations were prepared in teaching and learning activities. Mrs. Suda challenged student to consider key characteristics of each animal and classification of these animals in the phylums of the animal kingdom. She also asked questions related to problems and needs in the students' community and asked students to share ideas and discuss solutions. Mrs. Suda mentioned that students learning concepts that were familiar to them engaged students understanding and awareness of the importance of organism conservation in their community.

3.1.3 Mrs. Suda's Instruction and Socio-Cultural Perspectives of Learning

Mrs. Suda's instruction emphasized collaborative activities. Mrs. Suda provided evidence that she valued in classroom interactions. She mentioned that students had constructed their own knowledge through active participation in learning activities and they benefited greatly by sharing ideas with their peers. Mrs. Suda reported that she expected students to be able to learn from each other through working together in groups. She felt that the interactions between students and their friends would encourage the students to learn better and develop social skills. Moreover, Mrs. Suda's interview responses indicated that she believed that opportunities for students to acquire knowledge out of school enhanced students'

communications skills with parents and local experts, as they asked more questions related to local topics. Students' interviews also supported this assertion. They said that they loved being part of group work in sharing ideas and conducting experiments.

3.2 An Example of the "Kingdom Plantae" Lesson

The follow learning activities provide an example of Mrs. Suda's instruction emphasizing on community funds of knowledge and socio-cultural perspectives. This lesson (Lesson 6) aimed to investigate and classify living things of the plant kingdom**.**

At the beginning of the lesson, students were engaged in an activity to elicit their prior knowledge about the characteristics of plants by using a worksheet titled "What is the Plant?" Mrs. Suda emphasized her students' classroom participation in the exploration of their own plants. Students were exploring many examples of plants and non-plants and they were then asked to tell whether each example was a plant or not and why?

Mrs. Suda:	What is it?
Students:	Mushrooms.
Mrs. Suda:	Is it a plant?
Student:	Yes, it is a plant.
Mrs. Suda:	Why are mushrooms plants?
Student:	They have a leaf, stem and roots.
Mrs. Suda:	Where does mushrooms' food come from?
Student:	I don't know.
Mrs. Suda:	Where does a plant's food come from?
Student:	From photosynthesis.
Mrs. Suda:	What is photosynthesis?
Student:	Photosynthesis is the process of converting light energy to make sugar. The process of photosynthesis takes place in the chloroplasts, specifically using chlorophyll.

Mrs. Suda: Yes…very good

Mrs. Suda: Mushrooms are plants aren't they?

Student: No.

Mrs. Suda: Why?

Student: Mushrooms are not plants because they do not have chloroplasts and chlorophyll and they also use degradation to get food.

When students completed the activity about what plants were, Mrs. Suda asked students to discuss about the criteria of plant classification by using a student worksheet "Classification of Plants". Students were asked to study about the key characteristics of plants in each division of the plant kingdom, such as vascular system, seeds and flowers. Mrs. Suda required students to participate in discussions and formulate their own explanations about the criteria of plant classification. She did not tell students answers. Each group of students worked collaboratively to gather evidence on a worksheet and write down other group members' ideas or responses about the criteria of plant classifications.

After students understood about the characteristics and criteria of plant classification in each division of the plant kingdom, students then actively investigated about plants in their community by using memory banking. One important plant was selected by students to investigate in their community, which was rice. Students gave the reason why they selected rice since most people were farmers. Mrs. Suda then asked students to plan an investigation based on how to ask about rice with local people for basic information as community funds of knowledge. Examples of memory banking from the students' investigations are shown in Table 5.5 below.

Table 5.5 Students' investigating about Rice in community

Rice					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**
Rice is plants that create oxygen for the environment. The use of chemical fertilizers and insecticide for increasing production of rice is main cause of soil degradation and reduced species diversity.	Rice is an important economic crop in Thailand in the past to the present. Rice cultivation is the main occupation of people in the community. People used rice in several purposes of food, trading, and industry.	Rice is crop that is monocotyledon. Rice is divided into two categories that are non-glutinous and glutinous rice.	Rice is an important major carbohydrate source in Thai people life. The use of chemical insecticide for growing production of rice is main cause of cumulative toxins in the farmer.	All farmers respect and esteem about rice. Farmers to pay respect and worship rice before rice farming that belief in Buddhism of Thai society.	Thai rice planting divided into two seasons are rained rice and off-season rice. In the past, farmers use water buffalo for farming. There is currently using the machine to increase productivity.

After students' investigated, Mrs. Suda asked students to compare the characteristic of plants based on scientific criteria and to classify plants that were recorded through memory banking. These students' investigations allowed her to ask probing questions about the importance of farmers, problems and needs of rice farming. An example of a conversation where Mrs. Suda helped to clarify students' understanding of rice farming in their community is described below.

Mrs. Suda: What is main career concerning plants in your community?

Students: Farmers.

Students: Rice farming.

Mrs. Suda: How has rice farming changed from the past to the present?

Student:	In the past, farmers used water buffalos for farming. Now, they use machines to increase productivity.
Mrs. Suda:	What else?
Student:	There is currently the use of chemical fertilizers and insecticides for growing production of rice
Mrs. Suda:	What happens when the farmers use chemical fertilizers and insecticides for their farms?
Student:	Soil degradation and a reduction of good organisms in their farms.
Mrs. Suda:	How about the farmers?
Student:	Weak health
Mrs. Suda:	How can we help them?
Student:	To find information about biological materials instead of chemicals and to present this to the farmers.
Mrs. Suda:	Oh! Excellent.

Mrs. Suda asked students to discuss about conservation of plants that are related to their community. Students were encouraged to make connections between examples and applications in everyday situations. Moreover, Mrs. Suda gave opportunities for students to create exhibitions about the importance of Thai rice which included benefits, problems and needs that promoted their school and community.

During the last fifteen minutes of the lesson, Mrs. Suda accessed students' understanding of the concepts by using a discussion about the key characteristics and criteria of classification in each division of plant classification. Mrs. Suda then asked students to discuss what issues were not clear.

4. Effects of the Implementation of the Learning Unit on Students' Understanding the Concepts of Species Diversity

4.1 Students' Understanding about Species Diversity

From the concept survey before implementing the unit, most of the students had alternative concepts about Kingdom Animalia, Kingdom Plantae and Kingdom Protista, and half of the students had no understanding about Kingdom Fungi, Kingdom Monera and species concepts that are shown in Table 5.6. After the implementation of the Species Diversity Learning Unit based on community funds of knowledge, the data from the survey, observations and interviews indicated that most of Mrs. Suda's students developed an understanding about species diversity concepts.

The survey, observations and individual interviews with the three students strongly supported the development of students' understanding about species diversity concepts. The students could correct their misconceptions, which are described below.

Table 5.6 Frequency and percentages of students' categories of responses concerning species diversity in concepts pre-post survey

concept		Frequency and percentages of students' categories of responses				
		SU	**PU**	**PU-SM**	**SM**	**NU**
Definition of species diversity	**pre**	2 (7.1%)	7 (25.0%)	5 (17.9%)	2 (7.1%)	12 (42.9%)
	post	9 (32.1%)	13 (46.4%)	3 (10.7%)	-	3 (10.7%)
Kingdom Animalia	**pre**	-	4 (14.3%)	9 (32.1%)	10 (35.7%)	5 (17.9%)
	post	14 (50.0%)	5 (17.9%)	-	3 (10.7%)	7 (25.0%)
Kingdom Plantae	**pre**	-	-	7 (25.0%)	11 (39.3%)	10 (35.7%)
	post	12 (42.9%)	11 (39.3%)	-	2 (7.1%)	3 (10.7%)
Kingdom Protista	**pre**	1 (3.6%)	-	6 (21.4%)	9 (32.1%)	12 (42.9%)
	post	8 (28.6%)	11 (39.3%)	2 (7.1%)	3 (10.7%)	4 (14.3%)
Kingdom Fungi	**pre**		5 (17.9%)	-	8 (28.6%)	15 (53.5%)
	post	8 (28.6%)	13 (46.4%)	1 (3.6%)	1 (3.6%)	5 (17.9%)
Kingdom Monera	**pre**	-	4 (14.3%)	-	1 (3.6%)	23 (82.1%)
	post	11 (39.3%)	8 (28.6%)	-	4 (14.3%)	5 (17.9%)
Definition of Species	**pre**	1 (3.6%)	6 (21.4%)	3 (10.7%)	4 (14.3%)	14 (50.0%)
	post	15 (53.5%)	6 (21.4%)	3 (10.7%)	3(10.7%)	1 (3.6%)

Note: SU = Sound Understanding, PU = Partial Understanding, PU-SM = Partial Understanding with Specific Misunderstanding, SM = Specific Misunderstanding, NU = No Understanding

4.1.1 Students Understanding about the Definition of Species Diversity Concepts

Students understood about the meaning of species diversity concepts better. From the survey, before implementing the unit, it was found that 42.9 percent had no understanding of these concepts. 25 percent of students had a partial understanding. They used the characteristics of living things to answer the questions. Only two students had a sound understanding. After implementation of the Species Diversity Learning Unit based on community funds of knowledge, the results showed that 46.4 percent had a partial understanding about the meaning of species diversity. 32.1 percent had a sound understanding. The interview with Champa after implementing the unit found that she had a partial understanding about the definition

of species diversity. She said, “I see the diversity of living things in my local community that live together in a variety of ecosystems.”

4.1.2 Students’ Understanding about Kingdom Animalia

From the survey and interviews with students about animals and animal classification before implementing the unit, the results showed that 35.7 percent had specific misconceptions about animal classification. Most students classified organisms by using knowledge from their everyday lives. For example, “Bats were arranged in the group of class aves because they can fly like birds.” 17.9 percent of the students did not answer the questions. After implementing the unit, the results showed that 50 percent had a sound understanding about animal classification into groups. They used scientific criterions to classify them. However, three students had specific misconceptions and 25 percent still had no answer.

4.1.4 Students’ Understanding about Kingdom Plantae

In students’ concept survey before implementing the unit about plant and plant classification, the result showed that 39.3 percent had specific misconceptions about this concept. Students classified plants by using their own knowledge about plant habitats. There was also 35.7 percent of the students that had no answer. After implementing the unit, 42.9 percent had a sound understanding of this concept. They could describe about plant characteristics such as being vascular, flowers and fruit to classify into groups of Kingdom Plantae.

4.1.4 Students’ Understanding about Kingdom Protista

From the concept survey and interviews of students before implementing the unit, the results showed that 50 percent had no understanding and 47.6 percent had specific misconceptions. They used characteristics that can be seen to classify for this question. For example, one student answered, “Chlorella, paramecium and amoeba are not both plants and animals, but may be bacteria” (student 14). After

implementing the unit, the results showed that students understood about protista classification better. The results showed that 28.6 percent had a sound understanding and 39.3 percent had a partial understanding. Students could describe the differences between protista and other living things. A student said about this concept, “They are neither plants nor animals because paramecium, amoeba and chlorella are unicellular organisms” (student 3).

4.1.5 Students’ Understanding about Kingdom Fungi

According to the concept survey about fungi classification before implementing the unit, the results showed that students could not describe characteristics of fungi in terms of the scientific views. 28.6 percent of students’ answers had specific misconceptions in this concept. Prawit was asked to describe what the characteristics of fungi should be, for example, and he replied, “Mushrooms are plants because they have fiber like plants.” Moreover, there was 53.5 percent that had no answer in this concept. After implementation of the unit, it was found that 28.6 percent had a sound understanding. In addition, 46.4 percent had a partial understanding. Prawit improved and had a sound understanding in this concept. He said, “Mushrooms are not plants because they don’t have chlorophyll to use in photosynthesis.”

4.1.6 Students’ Understanding about Kingdom Monera

Before the implementation of the unit about monera classification, most of the students had no answer in this concept. After implementing the unit, the results showed that 39.3 percent had a sound understanding. One student answered, “Bacteria have different characteristics from other organisms, which includes not having a nuclear membrane” (student 1).

4.1.7 Students' Understanding about Definition of Species

In the survey on students' concepts about species before implementing the unit, the results show that 14.3 percent had specific misconceptions. For example, Pikul answered, "They are the same species, because the donkey's structures looks like the horse's structures." After implementing the unit, 53.5 percent had a sound understanding in this concept. Pikul described species concepts, during an interview, "Different species cannot interbreed but in the case of horses and donkeys, they can interbreed but their offspring will be an infertile animal."

According to classroom observations, teacher interview and student interviews with three students, students developed their understanding about species diversity through participating in all lessons. The data from students support students who can describe and classify characteristics of each kingdom by using scientific views. In addition, Mrs. Suda felt that species diversity based on community funds of knowledge developed students' understanding and connection of species diversity concepts in and out of school. Mrs. Suda's interview provided evidence that students like to learn about real living things and do hand-on activities. Three students mentioned that they learned more in groups and sharing ideas with their friends. Moreover, evidence supported the conclusion that the learning unit as implemented by Mrs. Suda was successful in improving students' understanding and communication skills. Through sharing and exchanging their ideas with the teacher and their friends, students showed better understanding about species diversity concepts.

4.2 Students' Thinking about Conservation of Species Diversity

Relating species diversity based on community funds of knowledge to conserve the environment was found in Mrs. Suda's classroom practice, each group of students had discussed using species diversity knowledge from the environment in the school and the community. Students' work, observations and interviews indicated that students attempted to understand the importance of species diversity for human life and to make ecological balance. Champa said during an interview, "…my home is

near a river. There are many kinds of aquatic animals and aquatic plants. People in my community are fisherman and farmers." In terms of the relationship of species diversity, students said that the farmers used chemical fertilizers and insecticides for their farms. These actions had an impact to destroy many organisms such as microorganisms in soil, aquatic animals and plants, as well as others. It is a big problem and needs to be resolved for ecosystems. Students mentioned that conservation and soil restoration by using biological materials can improve species diversity in rice farming and for human health. In conversation of species diversity, most of the students thought that the community should improve species diversity to conserve living things in their community. Pikul's interview provided an example of conservation of organisms in their community. "…Our community is an agricultural society that depends on nature as species diversity. If our community loses its species diversity, we cannot live in the community normally. Therefore, we need to develop and conserve species diversity for a sustainable economy and social development."

5. Factors Influencing the Implementation

The factors that facilitated the implementation of the learning unit of Mrs. Suda included the teacher's beliefs and understanding about the constructivist approach, community funds of knowledge and socio-cultural perspectives. However, teacher preparation and teacher content knowledge were obstacles for her implementation.

5.1 Facilitating Factors

Throughout the interview with Mrs. Suda during and after the implementation time, she discussed a strong belief and understanding about the constructivist approach**,** community funds of knowledge and socio-cultural perspectives of learning. This influenced Mrs. Suda's implementation in all aspects of these approaches in order to develop students' understanding about species diversity concepts.

5.1.1 Teacher's Beliefs and Understanding about the Constructivist Approach

Mrs. Suda mentioned her belief that the constructivist approach is more focused on student involvement in the construction of knowledge through hands-on and minds-on activities and development of the scientific skills of observation. According to Mrs. Suda, emphasis on the students' prior knowledge influenced student learning and active learning in the classroom, which included conducting investigations, using techniques to gather data and constructing explanations. Mrs. Suda described her beliefs about the constructivist approach as follows.

"The constructivist approach provides student opportunities in hands-on activities. It is not a good way to teach the concepts of species diversity by lecture. It should be focused on students' perceptions and doing activities. Students could construct correct concepts through this participation. For example, at the beginning I showed a picture of a living thing and asked about the criteria of classification and they could not answer correctly, but when they were allowed to participate and observe directly about key characteristics of each criterion, they could explain and classify the differences correctly."

In addition Mrs. Suda noted that, "Teaching should give time for students to answer the questions, promote students to the correct answer and be interested in the students' incorrect answers in context. I accepted my student's prior knowledge, and asked students to compare between their knowledge and scientific knowledge."

5.1.2 Teacher's Beliefs and Understanding about Community Funds of Knowledge

Mrs. Suda believed in the idea that integrating species diversity based on community funds of knowledge positively affected the implementation. Mrs. Suda reported that the learning unit could develop students' understanding of concepts

of species diversity. Students could learn science concepts and social issues within learning activities. Learning about species from a local expert enhanced the linkage between what they learned in school and applications to real life. Mrs. Suda mentioned that organisms in our surroundings could be used for teaching biology, and cultural knowledge could be taught for students' understanding about conservation of species diversity in their community.

5.1.3 Teacher's Beliefs and Understanding about Socio-Cultural Perspectives of Learning

Mrs. Suda also mentioned ideas that represented her beliefs and understanding about socio-cultural perspectives**,** including the interactions between the teacher and students, as well as students and their friends**.** Mrs. Suda commented that interactions can make students' understand through working collaboratively in groups and sharing ideas in group discussions and the classroom**.** Mrs. Suda felt that the diverse abilities of students in groups could help students' understanding about species diversity concepts. Student who have high abilities and more experience, were helped in explaining the concepts to the low ability students in their groups.

5.2 Constraining Factors

Throughout the discussion with Mrs. Suda during and after the implementation time, there were two factors that constrained the learning unit implementation. These factors included teacher preparation and content knowledge.

5.2.1 Teacher Preparation

Mrs. Suda commented that she didn't have enough time to prepare her teaching in terms of content and learning processes because of school events or activities, e.g., school sports day and science day, and her special work, such as attending conferences in and outside the school. Also, Mrs. Suda's students were usually required to participate in the school events. Then, she asked the students to get loads of work (reading and doing worksheets).

5.2.2 Teacher Content Knowledge

The low content knowledge of Mrs. Suda reduced opportunities for student learning activities based on their own interests. From classroom observations and an interview with Mrs. Suda, it was found that she felt uncomfortable when she taught species diversity concepts following the teacher manual and when she encouraged students with complex problems. Mrs. Suda came to the researcher and asked what the right answer was and what she should do for teaching activities before starting the lesson. Moreover, she was not comfortable in teaching the concept of plant classification. In the lesson about "Plant Classification", students were assigned to share ideas about kinds of plants to classify from the nine divisions of the plant kingdom. For example, students discussed about local plants such as lemon grass, acacia and ginger that were difficult to identify into divisions of the plant kingdom. Mrs. Suda felt that she was uncomfortable and lacked the content knowledge to explain this to her students. She then came to ask the researcher for help with this problem.

Case Two Summary

In this case study, Mrs. Suda's beliefs and understanding about the constructivist approach, community funds of knowledge and socio-cultural perspectives influenced her teaching activities. Mrs. Suda's beliefs about learning through real examples and situations led to a focus on hands-on activities in which students were active learners who participated in groups, and then corrected students' mistakes or misunderstandings. Mrs. Suda exerted to facilitate and provide students in constructing their own knowledge, developing connections and applications of science concepts to real life situations. Mrs. Suda's weak content knowledge and perception on students' abilities and lack of good preparation had a direct influence on the teaching and learning about species diversity in this learning unit. However, she was not confident in her knowledge about species diversity concepts when she implemented the learning unit, but instead tried to keep the learning unit according to a rigid plan. Moreover, Mrs. Suda was interested in student-teacher interactions for

improved learning and happiness in the classroom study. Most of the students paid more attention and were enthusiastic about participating in learning activities in groups.

Case Study Three: Moonlight School

School context

The third public secondary school was called the “Moonlight School”. It was located near the boundary of the province, in suburban Ratchaburi, education area two. There were two pig farms and agricultural areas around the school. Students came from low socioeconomic backgrounds to attend this school. The population of the school was approximately 1,700 students and 97 teachers. The school had six classrooms each in level 3, grades 7-9, and four classrooms each in level 4, grades 10-12. Each grades 7-12 classroom had 25-35 students.

Every morning, during 7.30-8.20, students and teachers began their day by singing the national anthem, and clasping their hands and giving thanks to the country, to Buddha and to the king. They listened to explanations about news and events from their teachers and student representatives. The students spent ten minutes before class to meet their advisors. Then, the teaching period started at 8.30 a.m. and finished at 15.30 p.m. There were six hour long teaching periods and one hour of lunchtime.

1. Teacher and Student Background

1.1 Teacher Educational Background and Teaching Experience

Mrs. Yanee was about 50 years old. She graduated with a master’s degree in science, majoring in biology. Her teaching experience with species diversity in high school was for approximately 10 years. She had taught about species diversity with grade twelve students and she had also taught science and biology for grade 7, 9, 10 and 11 students. In total, she had twenty teaching periods a week.

1.2 Mrs. Yanee's Student Information

Mrs. Yanee's Grade 12 biology class contained 10 boys and 28 girls who studied biology three 50-minute periods a week. The grade point average [GPA[in biology for this class was 2.80. Mrs. Yanee described the class as mixed ability of students. The students learned biology three periods per week on Thursday and Friday.

Table 5.7 Number of students in each grade point average

Grade Point Average in Biology	Students (number)
(GPA 4.0)	3
(GPA 3.5)	7
(GPA 3.0)	10
(GPA 2.5)	12
(GPA 2.0)	4
(GPA 1.5)	-
(GPA 1.0)	2
(GPA 0)	-

There were three students who were selected purposively to be studied in depth concerning their development of an understanding of species diversity. The selection was based on gender, age, biology achievement, attitudes towards biology and careers of their parents by using a questionnaire. Preecha, Chaba and Thong Kwao were selected in this study.

Preecha was a seventeen year old boy. His grade point average in biology was 4.0 and his GPA in all subjects was 3.52. He aimed to study, particularly for taking the university entrance examination. He liked studying biology because he wanted to be a doctor. Also he liked hand-on activities and working in groups. It was the best way to learn science. His parents owned a small private business.

Chaba was an eighteen year old girl. Her grade point average in biology was 3.00 and her GPA in all subjects was 2.50. She mentioned that biology was necessary

to learn about living things. Her biology learning focused on attempting to remember all the content of biology. She liked listening to a lecture rather than hand-on activities. Her parent was an industrial employee.

Thong Kwao was a sixteen year old girl. Her grade point average in biology was 2.50 and her GPA in all subjects was 3.00. She disliked studying biology, but liked studying Chemistry and English. She disliked teaching that emphasized lecture. She liked participating in activities. Her mother was a banking officer and her father was a lawyer.

1.3 Classroom Setting

Mrs. Yanee began to implement the teaching unit on the 7th of January, 2006 in the school laboratory which contained nine 200 x 150 x 80 cm student tables. Mrs. Yanee's desk and an overhead projector were in front of the chalkboard. At the back of the classroom, there was one instrument cupboard. On the left side of the classroom were four computers and windows. On the right of the classroom were three sinks.

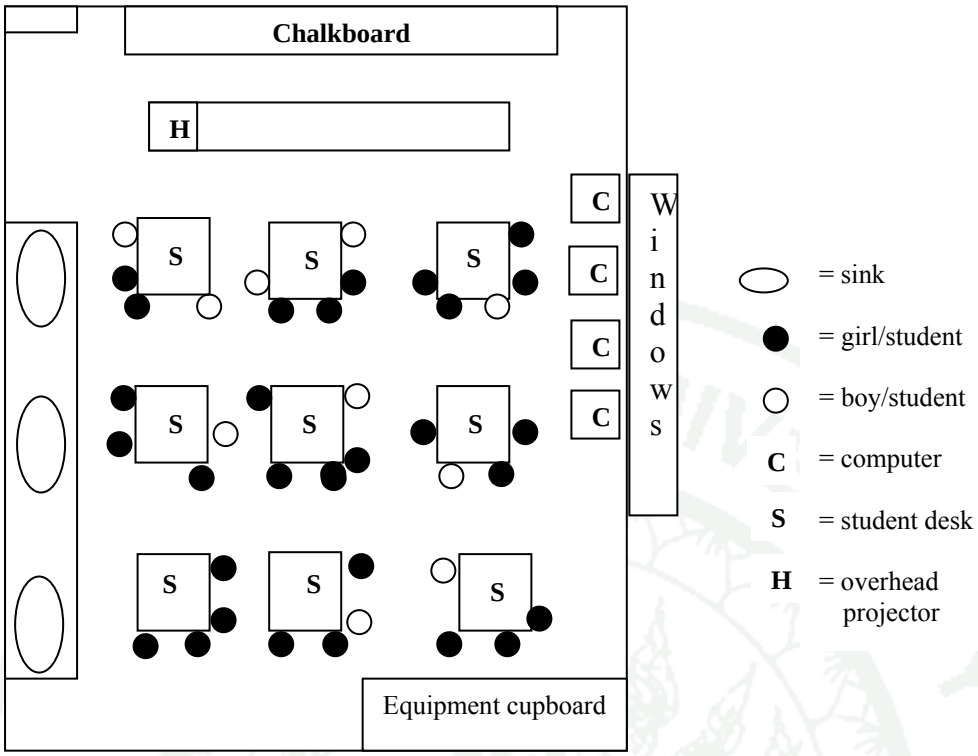

Figure 5.3 Mrs. Yanee' s Classroom Setting

2. Teacher's Thinking about Science Teaching and Learning

Classroom observations and the discussion with Mrs. Yanee indicated that her teaching emphasized students being well behaved in classroom learning. Students should be quiet and not move when she taught. Mrs. Yanee's style of teaching used a lot of lecturing. She perceived that students could not learn without directly telling all the concepts in science. In addition to the lecture, she used her experience in teaching biology based on IPST textbook. She believed that students would learn by repeating the concepts written in papers. They could remember in order to achieve high scores in the examination.

Mrs. Yanee was not enthusiastic about the importance of students' interactions in learning activities. She asked students to work in groups only in the laboratory and she would like students to form their groups independently to participate in the activities. Moreover, Mrs. Yanee felt that students not only discussed about science

concepts but also they talked about unrelated concepts with their friends during the teaching period.

According to a discussion with Mrs. Yanee, she believed that learning biology was up-to-date and related in their lives which could encourage students' understanding. However, she mentioned that students had less opportunity in learning experiences outside of school because this activity required time. She felt that the school had more activities and events. Mrs. Yanee also mentioned that the Internet and community news were good learning resources for students searching for information.

3. Mrs. Yanee's Implementation of the Learning Unit and the Students' Understanding

Mrs. Yanee's implementation of the curriculum has been described in terms of the teacher's practices in the classroom in parallel with the impact on the students' understanding. Three of Mrs. Yanee's students were studied in depth to assess their conceptual understanding with respect to the concepts in the unit.

3.1 Mrs. Yanee's Practices

The description of Mrs. Yanee's practices is provided in three guiding principles according to aspects of the constructivist approach, community funds of knowledge and socio-cultural perspectives of learning that served as a basic framework of the species diversity learning unit.

3.1.1 Mrs. Yanee's Instruction and the Constructivist Approach

Before Mrs. Yanee implemented the learning unit, the findings of the Introductory Species Diversity Concept Survey [SDCS] and interview illustrated that her students held alternative misconceptions about organism classification. Most students classified organisms by using the knowledge from their experiences. For example, "Bacteria are invertebrate animals that cannot be seen with the human eye."

This survey and interviews with students indicated some examples of alternative of students' conceptions of organism classification.

Classroom observations and interviews indicated that Mrs. Yanee consistently corrected the students' misconceptions about animal classification. She appeared confident to elicit students' misconceptions using the worksheet "What Are Bacteria?" in Lesson 7. All students would be expected to match and to discuss the pictures of bacteria and non-bacteria. She corrected the misconceptions, gave her brief comments and wrote the right answers on the board, and questioned students in the whole class for making decisions on the concepts. There were no students' discussions and students' explanations in her classroom. After Mrs. Suda's correcting the misconceptions, according to the survey and interviews with students, this study found that the some students incompletely corrected the misconception about the concepts of classification.

Classroom observations and the interviews indicated that Mrs. Yanee started her lesson by enhancing the understanding about species diversity concepts which appeared to be focused on through lecturing. Mrs. Yanee believed that students must learn from teachers. Also, she perceived her role of teaching as covering species diversity content for students' to complete worksheets and the examination. Mrs. Yanee mentioned that students develop understanding about concepts after they received explanation and guiding by her. She felt that students could not construct their explanations and needed her guidance. She normally asked guiding questions that followed the worksheet. Probing questions were not asked to get the student to think deeper about the concept. She provided explanations for students' conclusions. Students' correct answers and the participation in learning activities were assessed by the teacher. These aspects of teaching were teacher-centered in nature.

3.1.2 Mrs. Yanee's Instruction and Community Funds of Knowledge

From classroom observations and teacher interviews, Mrs. Yanee accepted teaching about students' real life for activities in her classroom. She

mentioned that the opportunities for students to use local organisms and knowledge related species diversity in the classroom and fostered students' understandings. In every lesson, Mrs. Yanee also used examples of organisms in the students' community and asked guiding questions for students' conducting investigations about species diversity in their community.

For example, in lesson 7 about "Classification of Monera, Fungi, and Protista Kingdoms", Mrs. Yanee divided students into groups. She asked students to be responsible in their cooperative learning. Students also asked students to conduct investigations about living things around school. Memory banking was used to collect data in this activity. In this lesson, students were interested to investigate the school's pool. Students also collected some water from pool and brought it to the classroom. Then, they used a microscope to see microorganisms in the water. Students found that there were many kinds of microorganisms that they needed to identify. The findings from students' investigations were prepared in teaching and learning activities. Mrs. Yanee provided student with an activity as a student project and asked them to consider the key characteristics of each kind of microorganism. She also asked questions to students' problem solving to improve the quality of water and asked students to share ideas and plan the way they did the experiment. Mrs. Yanee mentioned that students improved scientific skills through students' projects and experiments and also engaged students understanding about concepts related their community.

3.1.3 Mrs. Yanee's Instruction and Socio-Cultural Perspectives of Learning

According to classroom observations and the interview with Mrs. Yanee, she integrated that she emphasized teaching for taking the National Entrance Examination. The teaching focused on abstract concepts or definitions. Also, the teaching had less emphasis on group discussion and cooperation learning. Following Mrs. Yanee's practices, this study found that students were still unfamiliar with the practices. They still were not confident to participate in the learning activities. The

observation and interviews also indicated that the students seriously respected the teacher. They did not appear to be excited to share their ideas in groups and whole class discussions without the teacher's facilitation. Mrs. Yanee mentioned that students did not construct their own knowledge through active participation in learning activities and sharing ideas with their peers. Mrs. Yanee reported that her students were always able to talk about other things when working together in groups.

3.2 An Example of "Conservation of Species Diversity in the Local Community" Lesson

The follow learning activities provide an example of Mrs. Yanee's instruction emphasizing community funds of knowledge in teaching. This lesson (Lesson 8) aims to investigate species diversity and conservation in the local community**.**

At the beginning of the lesson, students were engaged with an activity by using the worksheet "Community News" in which Mrs. Yanee emphasized her students' classroom participation in the exploration of their own experiences. Students were exploring many examples of using species diversity in their community with the teacher's guidance, as illustrated below.

Mrs. Yanee:	What are careers in your community?
Students:	Rice farming, pig farming.
Mrs. Yanee:	Which one has problems in students' community?
Student:	Pig farming.
Mrs. Yanee:	Why?
Student:	It makes air pollution and also wastewater.
Mrs. Yanee:	How can you get more information?
Student:	Observe and investigate the real situation.
Mrs. Yanee:	Good…let's start by planning to conduct investigations on the worksheet.

Student: Yes… (boys/girls).

When students completed the activity about planning to investigate their community, Mrs. Yanee asked students to work in groups following student worksheet. Students were asked to prepare equipments and consider important issues to investigate in real situation.

After students understood about planning and how to investigate and how to ask about pig farming with local people, students then actively investigated pig farming in their community by using memory banking. One important consideration was who students would investigate their community to find out what are the important points and problems about species diversity. An example of memory banking on students' investigations is shown in Table 5.8 below.

Table 5.8 Students' investigating about Pig farming in community

Pig farming					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**
Pig farms create many environmental problems such as air pollution and water pollution in community. The problems were caused by pig's food particles and excrement.	Pork is an important in economy that is source of protein for Thai people. In term of reducing production costs, pig's excrement is useful for plant growth used as fertilizer.	6 Pig is a mammal. Pork has high protein and fat source. Biogas is made from fecal matter from pig farm.	People eat pork for getting nutrients and energy. Some people liked to eat raw pork causes of pathogenes is Respiratory disease.	People believed that eating pork as a cause of hair loss	In the past, Thai society raised pig to feed in their family. Now, they raised pig for meat industry. They did not consider about environmental problems in their community.

After students' investigations, Mrs. Yanee asked students to compare the importance of pig farming and environmental problems related in their community that were recorded through memory banking. These students' investigations allowed her to ask guiding questions about the importance of pig farming, problems and needs. An example of a conversation where Mrs. Yanee helped to clarify students understanding of pig farming in their community is described below.

Mrs. Yanee:	Why is pig farming important in your community?
Students:	For food and careers.
Mrs. Yanee:	What else?
Student:	……(noisy)
Mrs. Yanee:	What happens when a pig farm is built in your community?
Student:	Air pollution and wastewater were produced.
Mrs. Yanee:	What is the impact with the environment and people?
Student:	The wastewater reduced species diversity in natural water sources and people have weak health because air pollution and wastewater from the farm caused respiratory diseases.
Mrs. Yanee:	Ok. Good information. Let's start the next step following the worksheet.
Student:	Yes….

Mrs. Yanee asked each group of students to discuss about the ways to solve problems and conserve species diversity in their community. She also asked students to do an activity as a science project. Students, as scientists, conducted the activity by starting problems or issues, creating hypotheses, collecting data or doing experiments, and making conclusions. Moreover, Mrs. Yanee then gave the opportunity for students to create an exhibition in the school newspaper about the

students' findings in their projects that was then promoted in school and their community.

During the last twenty minutes of the lesson, Mrs. Yanee accessed students' projects in each group by using students' presentations briefly, especially about their conducting project and their findings. Mrs. Yanee then gave scores and asked students to discuss what issues were not clear.

4. Effects of the Implementation of the Learning Unit on Students' Understanding the Concepts of Species Diversity

4.1 Students' Understanding about Species Diversity

From the concept survey before the implementing the unit, most of the students had alternative conceptions in the concepts of Kingdom Animalia, Kingdom Plantae, Kingdom Protista and Kingdom Fungi, and most of the students had no idea about Kingdom Monera concepts as shown in Table 5.9. After the implementation of the Species Diversity Learning Unit based on community funds of knowledge, the data from the survey, observation and interviews indicated that most of Mrs. Yanee's students developed an understanding about species diversity concepts. In all concepts of species diversity, they could use the scientific criteria, such as basic structures to classify organisms into groups. However, there are some students' misconceptions in some concepts of species diversity after they participated in the learning activities.

Table 5.9 Frequency and percentages of students' categories of responses concerning species diversity in concepts pre-post survey

concept		Frequency and percentages of students' categories of responses				
		SU	PU	PU-SM	SM	NU
Definition of species diversity	**pre**	6 (15.8 %)	15 (39.5%)	2 (5.3%)	5 (13.2%)	10 (26.3%)
	post	10 (26.3%)	17 (44.7%)	8 (21.1%)	-	3 (7.9%)
Kingdom Animalia	**pre**	4 (10.5%)	10 (26.3%)	10 (26.3%)	9 (23.7%)	5 (13.2%)
	post	14 (36.8%)	10 (26.3%)	8 (21.1%)	5 (13.2%)	1 (2.6%)
Kingdom Plantae	**pre**	2 (5.3%)	8 (21.1%)	7 (18.4%)	14 (36.8%)	7 (18.4%)
	post	12 (31.6%)	19 (50.0%)	2 (5.3%)	2 (5.3%)	2 (5.3%)
Kingdom Protista	**pre**	1 (2.6%)	5 (13.2%)	9 (23.7%)	16 (42.1%)	7 (18.4%)
	post	8 (21.1%)	11 (28.9%)	10 (26.1%)	7 (18.4%)	-
Kingdom Fungi	**pre**	2 (5.3%)	9 (23.7%)	8 (21.1%)	14 (36.8%)	5 (13.2%)
	post	8 (21.1%)	13 (34.2%)	9 (23.7%)	6 (15.8%)	-
Kingdom Monera	**pre**	-	4 (10.5%)	8 (21.1%)	9 (23.7%)	15 (39.5%)
	post	8 (21.1%)	16 (42.1%)	3 (7.9%)	4 (10.5%)	5 (13.2%)
Definition of species	**pre**	5 (13.2%)	8 (21.1%)	11 (28.9%)	10 (26.1%)	5 (13.2%)
	post	15 (39.5%)	14 (36.8%)	3 (7.9%)	3 (7.9%)	1 (2.6%)

Note: SU = Sound Understanding, PU = Partial Understanding, PU-SM = Partial Understanding with Specific Misunderstanding, SM = Specific Misunderstanding, NU = No Understanding

The survey, observation and individual interviews with three students strongly supported the development of students' understanding about species diversity concepts. Many students could correct the misconceptions that are described below.

4.1.1 Students Understanding about the Definition of Species Diversity Concepts

Students understood about the definition of species diversity concepts better. From the survey, before implementing the unit, it was found that 39.5 percent of students had a partial understanding in this concept. 26.3 percent of students had no understanding They used characteristics of living things to answer this question. 15.8 percent had a sound understanding. After the implementation of the Species Diversity Learning Unit based on community funds of knowledge, the results

showed that 44.7 percent had partial understanding about the meaning of species diversity. 26.3 percent had a sound understanding. The interview with Chaba after the implementation of the unit found that she had a sound understanding about the meaning of species diversity. She said, “Species diversity is diversity of living things that live together in ecosystems.”

4.1.2 Students’ Understanding about Kingdom Animalia

According to the survey and student interviews about animals and animal classification, before implementing the unit, the result showed that 26.3 percent had a partial understanding and a partial understanding with specific misconceptions about animal classification. Most of the students classified organisms by using knowledge from their own experience. For example of a student’s answer; “Bats and birds are vertebrate animals that are arranged in the same group of class aves because they have wings.” Some students, 23.7 percent, had specific misconceptions about the question. After implementing the unit, the results showed that 36.8 percent had a sound understanding about animal classification into groups. They used scientific criterions to classify them. However, 13.2 percent had specific misconceptions about this concept.

4.1.3 Students’ Understanding about Kingdom Plantae

From the students’ concept survey before implementing the unit about plants and plant classification, the results show that 36.8 percent had specific misconceptions about this concept. Students classified plants by using their own knowledge in everyday life. Also there was 21.1 percent that had a partial understanding. After implementing the unit, 50 percent had a partial understanding and 31.6 percent had a sound understanding in this concept. They could describe plant characteristics based on scientific knowledge such as vascular or not, flowers and fruit to classify into groups of the plant kingdom.

4.1.4 Students' Understanding about Kingdom Protista

In the concept survey and interviews of students before implementing the unit, the results show that 42.1 percent had specific misconceptions and 23.7 percent had a partial understanding with specific misconceptions. They used characteristics that can be seen to classify in this question. For an example of Preecha's specific misconception answer; "Chlorella, paramecium and amoeba are microorganisms of both plants and animals that cannot be seen with the human eye." After implementing the unit, it was found that most students understood about the protista classification concept better. The results showed that 28.9 percent had a partial understanding and 21.1 percent had a sound understanding. Students could describe the similarities and differences between protista and other organisms.

4.1.5 Students' Understanding about Kingdom Fungi

Before implementing the unit, the results showed that students could not describe the characteristics of fungi in terms of the scientific views. 36.4 percent of students answer had specific misconceptions in this concept. The survey and interviews with Chaba indicated that she described the characteristics of fungi like plants. For example, she replied that, "Mushrooms' structures are like plant structures because they have stems and leaves and also they are food for humans." After implementing the unit, the results showed that 34.2 percent had a partial understanding. In addition, there was 21.1 percent that had a sound understanding. Chaba improved and had sound understanding in this concept. She said "Mushrooms have no chlorophyll for producing food". However, 15.8 percentages had specific misconception in this concept.

4.1.6 Students' Understanding about Kingdom Monera

According to the survey and students' interviews before implementing the unit about monera classification, it was indicated that most students had no ideas about this concept. After the implementation of the unit, the results

showed that 42.1 percent had a partial understanding. For example, one student answered, “Bacteria don’t have a nuclear membrane. There are many shapes such as rod, coccus and spiral” (student 11).

4.1.7 Students’ Understanding about the Definition of Species

In the survey about students’ concepts of species before implementing the unit, the results show that 28.9 percent had a partial understanding with specific misconceptions. For an example of Thong Kwao’s answer, “They are different species, but the donkey’s structures look like the horse’s structures and they can breed.” After implementing the unit, 39.5 percent had a sound understanding in this concept, including Thong Kwao. She could describe species concepts in terms of scientific the view that donkeys and horses are difference species. They can interbreed but their offspring is a sterile animal.

According to classroom observations, the teacher interview and students’ interviews with Preecha, Chaba, and Thong Kwao, students developed their understandings about species diversity through participating in all the lessons. The data from students support students who can describe species diversity concepts related with scientific views such as structure, anatomy, and the physiology of organism. In addition, Mrs. Yanee felt that the species diversity based on students’ real lives through the community funds of knowledge developed students’ understanding better and her students like to learn about real living things and through hands-on activities in and out of school.

4.2 Students’ Thinking about Conservation of Species Diversity

Species diversity knowledge aimed at conserving the environment was found in Mrs. Yanee’s classroom practice. During every lesson, especially lesson 8, the students were asked to tell their own knowledge through memory banking about environmental situations around their places, school and community. Mrs. Yanee

formally asked the students to conduct the assignment as a science project. The students would design the project in the worksheet “Community News”.

Although conservation of species diversity appeared in the students practice during the scientific project, the interview indicated that students’ learning potential of the practice was guided by Mrs. Yanee’s practices. Students did not appear to relate more species diversity knowledge to conserve the species diversity and environment in their community. They thought that species diversity was important to human lives. However, interviews with her and the students indicated that she assigned conducting the science project outside teaching periods. There was little information about the value of species diversity knowledge to conserve living things and the environment in their community.

5. Factors Influencing the Implementation

The factors that facilitated of the implementation of the learning unit of Mrs. Yanee included the teacher's beliefs and understanding about community funds of knowledge and teacher content knowledge. However, teacher preparation and instructional approach were obstacles to her implementation.

5.1 Facilitating Factors

The factors that facilitated the implementation of Mrs. Yanee’s unit included teacher’s beliefs and understanding about community funds of knowledge and content knowledge. These influenced Mrs. Yanee’s implementation in order to develop students' understanding about species diversity concepts.

5.1.1 Teacher’s Belief and Understanding about Community Funds of Knowledge

Mrs. Yanee mentioned that learning species diversity used community funds of knowledge as an issue for teaching which encouraged students’ interests and understanding of the connection between species diversity knowledge to

their real lives and they could share experiences related to them. In the lesson on classification of species diversity, different information was gained from the assignment when students were asked to investigate and explain knowledge related species diversity from home or community and then bring them to share in classroom. After the implementation, Mrs. Yanee also mentioned that community funds of knowledge and experiences at home could be shared in school. She believed that species diversity based on community funds of knowledge is integrated in students' science projects. She mentioned that using in species diversity, problems or needs in the students' community could be used for science projects concerning students' familiarity and interest.

5.1.2 Teacher Content Knowledge

Mrs. Yanee's strong content knowledge facilitated her instruction that provided students' understanding with science concepts and conducting investigations in a corrected way and then she asked guiding and probing questions to clarify concepts which were difficult. Moreover, she also gave good examples and reasonable explanations about key concepts related to students' real lives for her student learning. As a result, students memorized the key concepts provided by the teacher. Teaching was expected, particularly for taking the biology examination.

5.2 Constraining Factors

Throughout the discussion with Mrs. Yanee during and after the implementation time, there were two factors that constrained the learning unit implementation. These factors included teacher preparation and teacher instructional approach.

5.2.1 Teacher Preparation

There were many school events and activities in the teaching periods. Mrs. Yanee commented that she did not have enough time to prepare her teaching in terms of learning outside of school. Moreover, Mrs. Yanee mentioned that

she was uncomfortable to provide students an experience outside school. This activity required time and money. Also she felt that the school and students' parents did not have funding to support this kind of activity.

5.2.2 Teacher Teaching Approach

In teacher teaching, the teacher believed that lecturing and guided questions to learn the experiment were the best way of teaching science. The teaching emphasized using student worksheets, reading assignments, guided inquiry and lecturing to enhance students' understanding. The classroom observations and interviews also indicated that she was not explicit in regarding students' prior knowledge to relate species diversity concepts in their community. The society and culture (in particular students' views about species diversity and interactions between teacher and students) and students and their friends were not considered in the teaching. Mrs. Yanee mentioned that the learning tasks, especially scientific projects, were done in particular for the biology achievement. She also mentioned that students still needed to listen and copy the lectures. Students could not develop active learning without Mrs. Yanee's practices.

Case Three Summary

In this case study, the teacher's content knowledge, beliefs of student learning, and some parts of community funds of knowledge impacted her teaching and the learning about species diversity. Her science background facilitated and supported her implementation of the learning unit. Mrs. Yanee had strong content knowledge but she emphasized on a teacher-centered approach to implement the learning unit. She believed that the lectures were consistently used to correct the students' misconceptions and to enhance the understanding about species diversity concepts. Also, it was found that the community funds of knowledge with species diversity were used to allow students in conducting investigations on their own interests on species diversity through scientific projects. The teacher did not emphasize development of social interactions. The interactions between students and friends, and friendly interactions between the teacher and students were not considered in her teaching. The

active learning was limited by the school events and activities. Teaching was expected, in particular for taking the examination. The findings indicated that the students incompletely developed an understanding of species diversity concepts through Mrs. Yanee's practices. However, Mrs. Yanee emphasized scientific ideas and was aware of the importance about scientific processes and methods. She also asked students to passively practice the scientific project based on species diversity knowledge related to environmental conservation in her teaching. The students felt uncomfortable and not relaxed during the learning activities. On the other hand, the findings indicated that they wanted to receive more opportunities to participate in classroom study. However, the implementation success was limited by the teacher's beliefs, teaching approach and teacher perception.

Cross Case Studies

The findings indicated that the three teachers implemented a Species Diversity Learning Unit [SDLU] which drew on community funds of knowledge differently. Mrs. Pim, Mrs. Suda and Mrs. Yanee, the three different biology teachers, differed in terms of teaching background, content knowledge and beliefs about teaching and learning. Therefore, the different ways in which the curriculum was implemented and factors which influenced the implementations and students' understanding from the implementation of the SDLU are also discussed below.

1. Teachers' Implementation of the SDLU about the Constructivist Approach

The teachers, who believed in the constructivist approach, appeared to focus on explicating and correcting the students' prior knowledge and misconceptions using several learning activities. For the implementation of the Species Diversity Learning Unit in these three classrooms, it was apparent that Mrs. Pim and Mrs. Suda were consistent with a constructivist teaching approach. For example, they developed the students' learning by eliciting student's prior knowledge, using hands-on and minds-on activities, emphasizing group and classroom discussion and collaborative learning. The teachers appeared to focus the instruction on a student-centered approach where students were active learners involved in the investigation and discovery on their own.

Moreover, Ms. Pim asked her students to describe and explain their investigation, and asked probing questions that encouraged students to share their ideas and discuss about relationships between evidence and explanations, and constructing explanations.

On the other hand, the teachers, who held misunderstandings about the constructivist approach and were unaware of the prior misconceptions and strongly believed in a teacher-centered approach, appeared to teach by emphasizing on lecturing. For example, Mrs. Yanee, who believed in a teacher-centered approach emphasized subject matter rather than providing learning opportunities based on students' prior knowledge and interests. After students were engaged in the investigation of species diversity, teacher conclusions normally appeared to provide key concepts by telling and explaining to students. Mrs. Yanee would not allow students to develop their explanations from their investigations but allowed them to memorize information provided without understanding.

These findings indicated that the participant teachers perceived that teaching and learning with students to construct their knowledge through participation in hands-on and minds-on activities, doing experiments, and conducting investigations could encourage the development of students' understanding. This suggestion was consistent with the goal of the National Education Act B.E.2542 (ONEC, 2000a) that Thai teachers should develop students' learning outcomes and be aware of the relationship of science concepts to everyday life.

2. Teachers' Implementation of the SDLU about Community Funds of Knowledge

The teachers who understood the importance of community funds of knowledge to focus on students' understanding used community knowledge that related to species diversity concepts. Also, the teacher perceptions of this teaching approach enabled students to relate and apply species diversity knowledge to conserve the environment. For example, Mrs. Pim and Mrs. Suda believed that science teaching should connect between science knowledge and students' community context. They

always used hands-on activities and minds-on activities based on the students' interests and allowed opportunities for students to investigate in order to develop science concepts, particularly in learning about species diversity in a students' community. As a result, the emphasis of a learning unit that drew on student connection between community and school science.

On the other hand, Mrs. Yanee who believed that community funds of knowledge were an issue for teaching, placed the importance on relevant subject matter and rarely used minds-on activities with hands-on activities and had little emphasis on students' thinking about the application of species diversity knowledge to every life. Mrs. Yanee originally offered the science project without discussion for the students. The students appeared to use unaccepted species diversity concepts to operate the project. She did not ask probing questions to encourage students to construct linkage between what they learned in the community and their experiences.

3. Teachers' Implementation of the SDLU about Socio-Cultural Perspectives of Learning

This study also found that the teachers who believed in socio-cultural perspectives of learning, and were interested in developing student interactions, appeared to regard students' learning culture and society in the classroom. For example, Mrs. Pim and Mrs. Suda believed that the interaction between students and their friends would encourage the students to learn. The teachers also encouraged students to participate in learning activities, group discussions and classroom discussions. The teachers also focused on collaborative learning that could improve students' understanding of concepts and motivate students to form closer relationships with one another in working together. Moreover, Mrs. Pim developed friendly relationships between the teacher and students, and students with each other. She consistently developed her content knowledge and friendly interactions between her and students. She also facilitated students' arguments in cooperative learning, experimenting, questions, and discussions. As a result, the students were found to be

confident in participation and they developed an understanding based on the new learning unit by themselves.

On the other hand, the teachers who emphasized teacher-centered approach perceived the student's role as a passive learner, and often focused more on telling key concepts to students. Although, Mrs. Yanee's instruction focused on group work, she did not encourage students to share ideas and learn from each other in groups. Her teaching often focused on lecturing abstract species diversity concepts to cover all content for taking the examination. This resulted in some students being ignored when working in groups and the students did not appear to prefer the teaching. Also, Mrs. Yanee's students did not have the same social skills in using communication as well as they were not confident in sharing ideas with the teacher and their friends.

4. Teacher Content Knowledge

The teacher's content knowledge of science affected enhancing the students' understanding of species diversity concepts. The teachers who did not have strong content of science were not confident to teach and evaluate understanding. Mrs. Pim was a teacher who had a strong content background. She consistently developed her content knowledge and was able to enhance the students' understanding based on the unit. Then, she allowed students to pursue their own interests, asked probing questions, and participated in cooperative learning, experimenting, and discussion. By contrast, the teachers who had intensive knowledge in science and focused on learning for taking the examination rarely adapted the teaching unit for enhancing the students' understanding. Mrs. Yanee was an example of the teachers described. Also, she focused on teaching abstract species diversity concepts and definitions to cover all content for the examination. She often asked the students to develop their understanding and complete the worksheets outside of teaching periods.

On the other hand, Mrs. Suda, who was not confident in the species diversity knowledge but was enthusiastic about the student interactions, mainly assigned students to work in groups to enhance students' understanding about species diversity concepts. According to the classroom observations and the discussion with Mrs. Suda,

she felt uncomfortable and did not relax when she encouraged students' understanding of the concept within learning activities. She asked students to develop a deeper understanding of species diversity concepts that were not found in her teaching.

5. Students' Understanding from the Implementation of the SDLU

The implementation of the SDLU by using community funds of knowledge could help students develop the scientific understanding of species diversity concepts. The teachers asked the students to apply the scientific concepts to explain the classification of organisms in their community. The students were asked to investigate the diversity of organisms, their importance to human activities and the environment in the community. Most of the students were interested in doing activities. They paid attention to the lessons. They found that the SDLU activities were interesting and helpful because the unit used learning activities and resources based on students' interests and knowledge base. Most of the students from the three schools paid more attention to the lessons than they had previously. The students were also encouraged to socially interact with each other and have a discussion to develop their understanding of species diversity. The students also enjoyed working and discussing in groups. The students loved to engage in hands-on activities and work with their peers. They said that the SDLU activities gave them a clear understanding of species diversity concepts.

Summary

This research conducted three case studies of teachers in three schools in the Ratchaburi Province. There were one hundred and eight students being taught with the Species Diversity Learning Unit which drew on community funds of knowledge. Nine students were studied in-depth. The studies included different ways that the three teachers implemented the learning unit that influenced students' understanding about species diversity concepts. The findings illustrated how the teachers implemented the Species Diversity Learning Unit in different ways based on their beliefs and understanding about the constructivist approach, community funds of knowledge, socio-cultural perspectives of learning, and content knowledge. The teachers who

believed in the constructivist approach, had strong content background and regarded students social and cultural ways of learning showed good preparation to implement the learning unit based on students' understanding, application of knowledge, and self confidence in their attention and interests. On the other hand, the teachers who strongly emphasized a teacher-centered approach and had a misunderstanding about teaching approaches rarely appeared to achieve the principles of the learning unit. The students could not develop an understanding about species diversity and still learned science passively by memorization in the classroom.

CHAPTER VI

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

Introduction

This chapter is a conclusion and discussion of how this research has been conducted to promote teaching and learning about species diversity which draws on community funds of knowledge in Thailand. The chapter starts with the research questions from the study. Also, conclusions about the development process of the Species Diversity Learning Unit regarding each research question are described. It starts with the exploration of students' understanding, community funds of knowledge, and then the impact of the intervention on teachers' teaching and students' learning. Finally, the recommendations of this study are provided.

Research Questions

1. What is the current situation of teaching and learning species diversity concepts in high school as perceived by students and teachers?
2. What are the community funds of knowledge about species diversity in students' community?
3. What happens when a Species Diversity Learning Unit based on community funds of knowledge is planned, implemented and evaluated?

3.1 What are the characteristics of the Species Diversity Learning Unit based on community funds of knowledge?

3.2 What do teachers change after implementing the Species Diversity Learning Unit?

3.3 What are students' conceptual understandings of species diversity resulting from the learning unit?

3.4 What facilitates and constrains the implementation of the Species Diversity Learning Unit?

Conclusions and Discussions

According to the National Education Act, Thai science education should provide opportunities for basic educational institutions to assume responsibility for constructing their own curriculum. This was done as a guideline of education which emphasizes learner centered approaches, self-development, and that basic education should be responsibly related to the needs of the community and society (ONEC, 2003). This study aims to develop the Species Diversity Learning Unit as a model to enhance the students' understanding of species diversity based on community funds of knowledge. The impact of the learning unit on the teachers and the students has been examined in three case study schools. The subjects were three biology teachers and their 108 high school students. They were from different public high schools located in the Ratchaburi suburban area. Nine of the students, three from each school, were also selected purposively to be studied in depth regarding their development of species diversity understanding. This selection was based on their gender, age, biology achievement, attitudes towards biology and their parents' careers.

The conclusions and discussions of this study were organized into three phases regarding the research questions. The first phase was to explore the current situation of teaching and learning species diversity concepts. The second phase was to explore community funds of knowledge to develop a Species Diversity Learning Unit enhancing students' understanding of the concepts of species diversity. The last phase was to examine the impact of the implementation of the unit on teacher instruction and students' learning. Also, the surveys, semi-structured interviews, classroom observations and students' work were the research methods used to collect and analyze data for finding out answers to the following research questions:

Research Question 1: What is current situation in teaching and learning species diversity concepts in high school as perceived by students and teachers?

This study aimed to explore the current practice of teaching and learning species diversity concepts in secondary school during the 2005 academic year (Promprasit, Jantrarotai and Yutakom, 2008). Five teachers from five schools in the Ratchaburi Province and fifteen students of these teachers were observed and interviewed about views of teacher's instruction and student's learning in species diversity concepts**.** The results showed that the state of teaching and learning about species diversity in school was not in accordance with the goals of the National Education Act in 1999 (ONEC, 2000a) and the National Science Curriculum (IPST, 2002), in that basic education should promote learner centered approaches and responsibly relate to the needs of the community and society. Teachers mainly used lecture and teacher-centered approaches to teach species diversity in the classroom. The teacher's teaching practices were not emphasizing the students' prior knowledge and misconceptions about species diversity. They normally provided key concepts and described all details about species diversity contents and they used IPST books and transparencies in their teaching. They also mentioned that species diversity had more content for students' learning. This is consistent with the research of the Ryman (1974a) and Braund (1998). Lecture was the best way for teaching and learning in a limited time. Students learned by taking lecture notes in their notebooks without discussion. Group discussions by students had rarely been found in classroom. The real examples of species diversity, such as organisms, were not presented in the teaching process. Teaching and learning species diversity concepts did not use the knowledge from the students' community. Students could not explain and use the knowledge of species diversity in their community. However, students mentioned that they wanted to participate in several learning activities rather than listening to lectures by teachers. Moreover, they wanted to learn real examples of living things and the importance of species diversity in real places.

In the students' understanding of the concepts of species diversity**,** this study aimed to explore students' understanding of species diversity concepts. One hundred

and twenty three grade 12 students (age 17-18 years old) from three public secondary schools in the Ratchaburi Province in 2005 academic year were presented with a Species Diversity Concept Survey [SDCS], which consisted of 14 open-ended questions. The concepts were developed to investigate the following areas: definition of species diversity; classification; Kingdom Animalia; Kingdom Plantae; Kingdom Protista; Kingdom Fungi; Kingdom Monera; species; and conservation of living things. The result showed that Thai high school students had difficulty in all topics. The results revealed that most students had partial understanding [PU] of the concepts of definition of species diversity, Kingdom Animalia, Kingdom Plantae, and conservation of living things. In the concept of conservation of living things, the students did not mention the importance of living things in the ecosystem as well as ways to conserve species diversity. In the concepts of classification and Kingdom Fungi, most students had partial understanding with a specific misconception [PU-SM] in that they preferred to classify organisms that conflicted with the criteria of scientific classification. In addition, students had specific misconceptions [SM] about the concepts of Kingdom Protista and Kingdom Monera. Students tended to use habitat, movement, external morphology and characteristics of living things to classify organisms. These concepts were challenging to the students' understanding and changed their prior experiences and concepts because some concepts or examples of species diversity did not relate to the students' community.

Research Question 2: What are the community funds of knowledge about species diversity in the students' community?

This study aimed to explore the current situation of community funds of knowledge about species diversity in students' community. Four community leaders were interviewed with topics in memory banking to collect data about species diversity about their community. The findings indicated that the students' community had many kinds of plants, animals and other living things, as well as local products, local wisdom and traditions related to species diversity that served as organizational material in this learning unit. From memory banking and interviews with community leaders, most of them said that most people were farmers who grew many kinds of

crop plants and trees such as rice, cones, cucumbers, peas, jackfruit, acacia, mango and lemon and there were many kinds of animal farms such as pig farms, chicken farms and cow farms. There were many local products and local wisdom, such as preserving food, Thai herbs, and silk and cotton production that were related to using products from plants and animals to improve the quality of people in the community. People also use herbs to treat diseases. This knowledge was derived from their ancestors. In addition, they used plants and animals in different traditions such as the Loy Kratong Festival, the Songkran Festival and Teacher's Day. Moreover, the memory banking of importance, problems and community needs about species diversity were presented. These findings, as community funds of knowledge, should be promoted in school for enhancing students' understanding about species diversity concepts related to their community.

Research Question 3: What happens when a Species Diversity Learning Unit based on community funds of knowledge is planned, implemented and evaluated?

Regarding sub-research question 1, **'**What are the characteristics of a Species Diversity Learning Unit based on community funds of knowledge?'**,** the development of a Species Diversity Learning Unit used knowledge from the local communities of learners. The unit was based on the 1999 National Education Act and focused on student's construction of knowledge. The learning unit started with the analysis of the content and expected learning outcomes which were used as background information to develop teaching and learning related to the students' community. The characteristic of a Species Diversity Learning Unit drew on community funds of knowledge based on the guiding principles for the developed unit. The principles included constructivist approaches, community funds of knowledge and socio-cultural perspectives of learning. For the first guiding principle, the teaching must provided learners to learn from practical experience in the situation and application of knowledge to prevent and resolve problems in a society or community of learners. The education emphasized the importance of the learning process to encourage the learners to develop themselves. The principles emphasized students' prior knowledge and students' learning to participate in hands-on and minds-on

activities such as cooperative learning, investigation, experimentation and discussion. The second principle was community funds of knowledge in teaching the learning unit. Moll (1992) argued that families in the community and their funds of knowledge represented a potential major social and intellectual resource for schools. In community funds of knowledge, Mercado and Moll (1997) said that learning to apply knowledge from home used collaboration with students, parents and people in the community to develop teaching and learning for students understanding and better learning. The importance of knowledge about species diversity in the community became part of the curriculum in school and was connected between school and community relations. Finally, teaching and learning wanted to regard the socio-cultural perspectives influencing the students' learning in the classroom. The perspectives focused on student participation in the society and culture including knowledge, and experiences of different individuals who interact within the social environment (Vygotsky, 1986). The students construct knowledge through social processes such as cooperative learning. To participate in the activities and action in the community is important to help students' better understand and construct knowledge (Rogoff, 1990; Edwards, 2000; Robbins, 2002). Therefore, interaction between teachers and students, and student to student should be emphasized in the classroom. Teachers will continue to promote and facilitate student group discussions or class discussions in the classroom for improved learning.

Regarding sub-research question 2, 'What do teachers change after implementing the Species Diversity Learning Unit?', the findings indicated that the three teachers had changed views and practices of teaching based on the Species Diversity Learning Unit differently.

Mrs. Pim, the teacher at the Sunshine School, believed and understood some aspects of the constructivist approach, community funds of knowledge and socio-cultural perspectives of learning before implementing the learning unit. She used lecture to present the main concepts for students' learning and she let students work in groups to do activities. She mentioned that instruction with teacher demonstration and explanation might not better develop the students' understanding of science. She

would also like the students to participate in groups, but she was not enthusiastic about the importance of students' differences in teaching activities. Moreover, Mrs. Pim strongly believed that the best way to learn science was through a sample of living things that related to the students' community. During and after implementation of the learning unit, Mrs. Pim expected that instruction using the activities in the teacher manual could be effective in her classroom. She would receive many teaching strategies for developing her own teaching style. The results showed that Mrs. Pim changed her behavior from lecturer to facilitator. She emphasized eliciting students' prior knowledge, misconceptions and hands-on activities. She also gave more opportunities for students to think and discuss among groups. She could adapt learning activities and examples of living things in the local community from the teacher manual to be suitable for her students and her classroom. However, Mrs. Pim still emphasized students' memorization of technical terms of species diversity content.

Mrs. Suda, the teacher at the Starlight School, believed and understood about the constructivist approach, community funds of knowledge and socio-cultural perspectives of learning before implementation of the learning unit. She believed that teaching science by lecturing could not develop students' understanding of all science concepts. Also she mentioned that students could develop their own knowledge through hands-on activities and participation in groups. She was emphasizing the importance of students' interactions in learning activities and encouraging group and classroom discussions. However, Mrs. Suda mentioned that the teaching practices that provided students an experience outside school could encourage students' understanding of concepts related to their lives, but it required more time and money. Classroom observations and interviews during and after implementation of the learning unit indicated that Mrs. Suda strongly believed and understood about students learning based on the constructivist approach. She focused on hands-on activities in which students were active learners who participated in groups, and then elicited students' prior knowledge and misunderstandings. She also extended, facilitated and provided students in construction of their own knowledge, developed connections and applications of science concepts to real life situations. However, she was not confident in her knowledge about species diversity concepts when she implemented the learning

unit, but instead tried to keep the learning unit according to a plan. She taught by following the activities as suggested in a teaching manual for the learning unit in all lessons.

Mrs. Yanee, the teacher at the Moonlight School, was less developed in the constructivist approach and aspects of socio-cultural perspectives before implementation of the learning unit. However, she believed in some aspects of community funds of knowledge for teaching. She mentioned that lectures were consistently used to correct the students' misconceptions and to enhance the understanding about species diversity concepts. She felt that students could not learn without direct exploration of all concepts in science. Interactions among students were not considered in her teaching. Also, Mrs. Yanee believed that the learning of biology should be up-to-date and related to their lives, which could encourage students' understanding. However, Mrs. Yanee emphasized scientific ideas and was aware of the importance about scientific processes and methods. During and after implementation of the learning unit, Mrs. Yanee emphasized a teacher-centered approach. Her science background facilitated and supported her implementation where she provided key concepts by telling and explaining to students. However, she found that the community funds of knowledge with species diversity allowed students to conduct investigations in alignment with their own interests on species diversity through scientific projects.

Regarding sub-research question 3, 'What are students' conceptual understandings of species diversity resulting from the learning unit?', after teachers taught using the three guiding principles, the findings indicated that the students understood species diversity in all concepts. The students could develop their understanding of species diversity concepts after they implemented several learning activities in the Species Diversity Learning Unit. The students then related species diversity concepts to the conservation of organism in their community. Also, there were attempts at correcting students' misconceptions and enhancing students' understanding of species diversity using community funds of knowledge and several teaching strategies that appeared to depend on the teacher's belief in students learning.

For example, Mrs. Pim and Mrs. Suda, who believed that the lecture, demonstration and explanation might not better develop students learning in biology, attempted to correct her students' misconceptions by using several learning activities such as investigations, cooperative learning and discussions. On the other hand, Mrs. Yanee, who did not believe in the constructivist approach and emphasized a teacher-centered approach, appeared to correct the misconceptions with an emphasis on lecturing. This teacher did not emphasize developing social interactions. The findings indicated that the students felt uncomfortable and did not relax in the learning activities. In addition, the students developed an incomplete understanding of species diversity concepts through Mrs. Yanee's practices. They could explain key concepts of species diversity, but they could not explain and apply species diversity knowledge related to their community.

Regarding sub-research question 4, 'What facilitates and constrains the implementation of the Species Diversity Learning Unit?', the findings indicated that the teachers' beliefs and understanding about the constructivist approach, community funds of knowledge, socio-cultural perspectives of learning and their content knowledge and background had influenced the implementation of the intervention. Such a statement is supported by the findings of Bell (1998) in that teachers had different beliefs, ideas, feelings and interests while teaching that could lead to different outcomes within the objectives of teaching. In comparisons among the teachers, four main points were found as described below.

First, the teachers' beliefs and understanding about the constructivist approach influenced their implementation and practices. Mrs. Pim and Mrs. Suda, who believed in student-centered instruction, appeared to provide students to develop ways to solve problems and formulate their own explanations. For example, they developed the students' learning based on prior knowledge, hands-on and minds-on activities, emphasized group and classroom discussion, and collaborative learning. They also gave opportunities for students to conduct investigations based on their own interests. However, Mr. Yanee believed in a teacher-centered approach, with less emphasis on students' prior knowledge and was unaware of students' misconceptions. She

emphasized lecturing and subject matter to provide students knowledge about species diversity concepts.

Second, the teachers who understood the importance of community funds of knowledge focused on students' learning to use community knowledge related to species diversity topics. For example, Mrs. Pim and Mrs. Suda always encouraged students to discuss connections between scientific knowledge and students' community context and apply species diversity knowledge to conserve the organisms in their community. The teaching based on the students' interests allowed opportunities for students to investigate as a basis for developing science concepts, particularly in learning about species diversity. On the other hand, Mrs. Yanee, who believed that community funds of knowledge was an issue for teaching, rarely emphasized students' thinking about the application of species diversity knowledge to everyday life. She used species diversity based on community funds of knowledge integrated into students' scientific projects.

Third, the teachers who believed and understood the socio-cultural perspectives of learning were interested in developing students' knowledge of culture and society in the classroom. For example, Mrs. Pim and Mrs. Suda encouraged students to participate in collaborative learning, group discussions and classroom discussions. They also motivated students to form closer relationships with one another while working together. Moreover, Mrs. Pim consistently developed her content knowledge and sociable interactions between her and her students. She also facilitated students' arguments in cooperative learning, experimentation, questioning, and discussions. Mrs. Yanee, who emphasized a teacher-centered approach, did not encourage students to share ideas and learn from each other in groups. She perceived the student's role as a passive learner. This resulted in some students not improving species diversity concepts, social skills and confidence in sharing ideas with the teacher and their friends.

Finally, in terms of content knowledge and background, the teachers who had strong content in science were more confident and able in their science instruction. For

example, Mrs. Pim had a strong background in science and pedagogical content knowledge. She provided more opportunities for students to think and investigate freely on their own and also asked probing questions for students understanding. However, Mrs. Yanee was a different example of the teachers described. She had intensive knowledge in science and focused on teaching abstract species diversity concepts and definitions to cover all content for the examination. On the other hand, Mrs. Suda, who had strong pedagogical content knowledge but a weak content background in science, felt uncomfortable and did not relax when she encouraged students' understanding of the concept within learning activities. However, she was not confident in the species diversity knowledge for teaching. She was also enthusiastic about the student interactions, and mainly assigned students to work in groups to enhance the students' understanding. The findings of this study suggest that not having enough science background and pedagogical content knowledge negatively influences teachers' abilities to implement the learning unit.

Recommendations

The development of a Species Diversity Learning Unit that draws upon community funds of knowledge to enhance students' understanding of the concepts of species diversity can make a difference in regards to school context and the students' community. The incorporation of students, parents, and community funds of knowledge and local wisdom about species diversity is used as a basis for developing science curriculum that is an example for science educators and teachers of how to develop a Species Diversity Learning Unit. However, community funds of knowledge provided a new perspective for the study of the students' community and households. Teachers must understand the impact of social, cultural, ethnical and all statuses on teaching and learning related to the students' community. The techniques of gathering data from community funds of knowledge such as interview items and memory banking in this study can be used.

In addition, Thai science teachers can also adapt a Species Diversity Learning Unit based on the National Education Act (ONEC, 2000a) and the National Science

Curriculum (IPST, 2002) in their classrooms. The implementation of the Species Diversity Learning Unit seemed to be successful in Thai classrooms for teaching and leaning about species diversity. However, it may not be suited to all teachers and to all science strands or subjects in other contexts.

Future Research

This study has shown how three biology teachers from different high schools have taught biology to promote students' understanding about species diversity through community funds of knowledge. The three case studies indicated that the teachers' learning beliefs, science content knowledge and backgrounds, and community funds of knowledge influenced their teaching practices. Correcting students' misconceptions and using community funds of knowledge appeared to enhance students' understanding of species diversity. Therefore, the next challenge for science educators developing a Species Diversity Learning Unit which drew on the community should be done parallel with teacher development. The efforts to understand the use of community funds of knowledge in teaching and learning and to help them to understand how community funds of knowledge can influence their teaching and students' achievements should be emphasized.

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APPENDICES

APPENDIX A

Species Diversity Concept Survey

Species Diversity Concept Survey

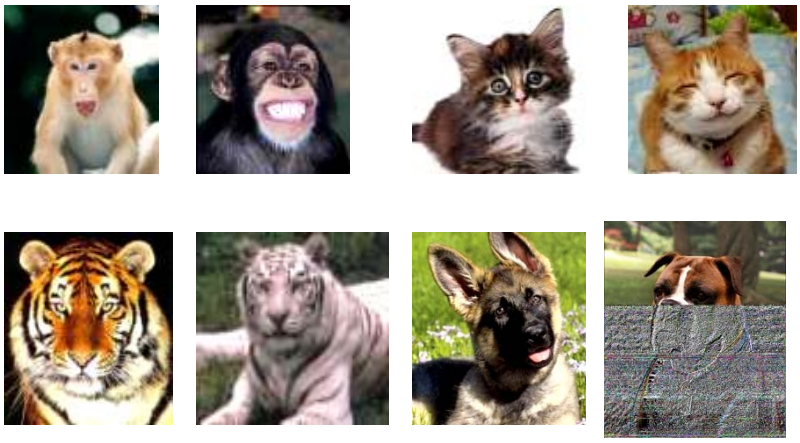
Name – surname _____.class_____No._____

School_____

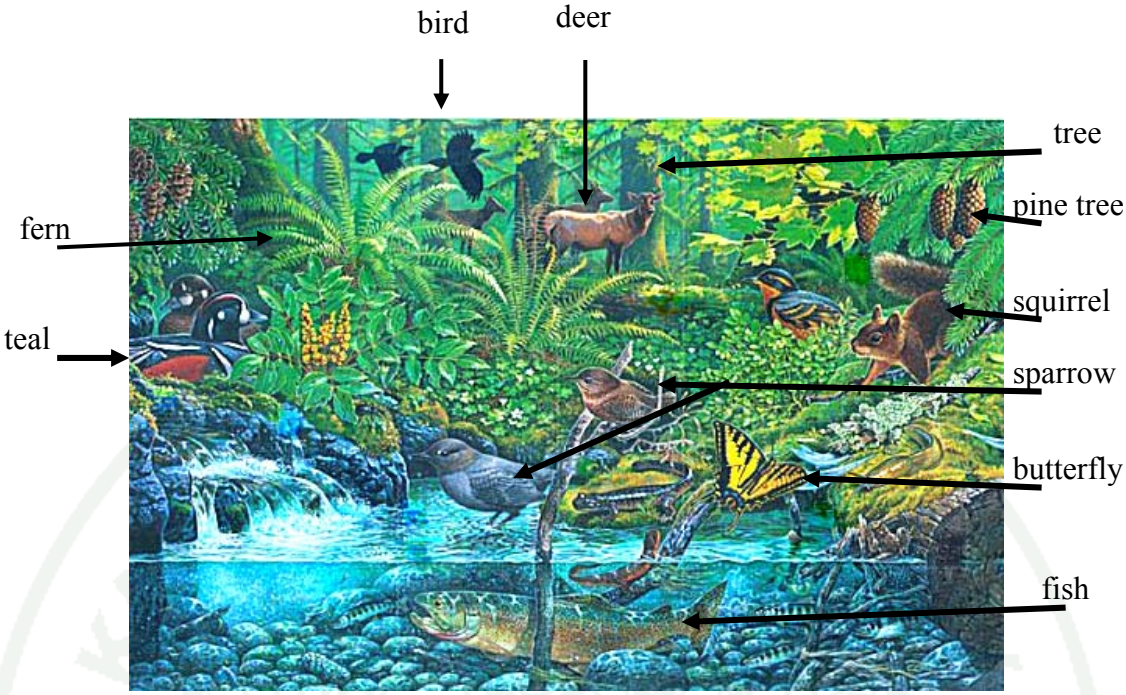
Date _____/_____/_____

Please circle the letters or words, and complete the answer of all questions.

1. Look at picture A and B and answer the questions



A.



B.

1.1 What are the similarities of the organism in picture A? and why? Please explain

_____

_____

_____

_____

_____

1.2 What are the differences of the organism in picture A? and why? Please explain

_____

_____

_____

_____

_____

1.3 If you want to classify the organism in picture B. How many groups are there? What are the criteria of your classification?

1.4 What is the meaning of species diversity in your understanding?

1.5 Are picture A and B representing the species diversity? and why? Please explain

2. This is the example of pictures of the organisms that found in Ratchaburi province. Use these pictures for answer the questions below.


sanke


snial


water Lilly


spider


crinoid


turtle


cycad


earth warm


Hangsingh


woman

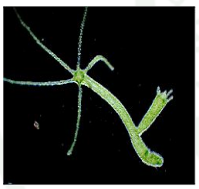

nematode


moss


sponge

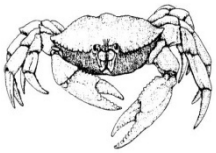

eel


pinus


hydra


ant


fern


crab


banana


bird


psilotum


bat


frog


tapewor

You have the assignment to classify these organisms by use the biological criteria

2.1 What pictures are plants?

2.2 How many plant groups can you classify? And What plants are in each group?

2.3 What pictures are animals?

_____

_____

_____

_____

2.4 How many animal groups can you classify? What animals are each group?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

2.5 Tick **X** item which are your criteria of classification

☐anatomy ☐ physiology ☐reproduction

☐embryonic development ☐biochemical process ☐genetic

☐ evolution

etc._____

3. A man does experiment about breeding between horse and donkey. The result found that it can produce new generation. However, the man uses new generation for breeding that can not produce next generation. Please help to explain this phenomenon for the man understanding.

_____

_____

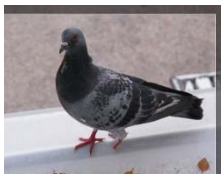
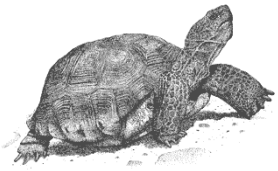
_____

_____

_____

4. Tick √ item which are vertebrate animal and give reasons for your choice.

	animals	**Yes**	**No**	**reasons**
4.1	 fish			_____ _____ _____ _____
4.2	 rat			_____ _____ _____ _____
4.3	 ant			_____ _____ _____ _____

	animals	Yes	No	reasons
4.4	 bird			_____ _____ _____ _____
4.5	 spider			_____ _____ _____ _____
4.6	 turtle			_____ _____ _____ _____
4.7	 children			_____ _____ _____ _____
4.8	 snack			_____ _____ _____ _____

	Animals	Yes	No	reasons
4.9	 toad			_____ _____ _____ _____
4.10	 earthworm			_____ _____ _____ _____

4.11 What characteristics of vertebrate animals should be?

_____

_____

_____

_____

_____

_____

4.12 What characteristics of invertebrate animals should be?

_____

_____

_____

_____

_____

_____

5. Tick √ item which are plants and give reasons for your choice.

	Organisms	Yes	No	Reasons
5.1	 coconut			_____ _____ _____ _____
5.2	 grass			_____ _____ _____ _____
5.3	 mushrooms			_____ _____ _____ _____
5.4	 alga			_____ _____ _____ _____

	Organisms	Yes	No	Reasons
5.5	 cycads			_____ _____ _____ _____
5.6	 fern			_____ _____ _____ _____
5.7	 chaipaseeda			_____ _____ _____ _____

5.9 What characteristics of plants should be?

_____

_____

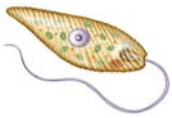
_____

_____

_____

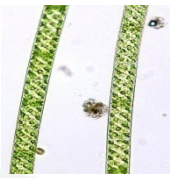
_____

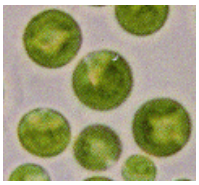
6. This is examples of organism found in Mae Klong River. Which organisms are animal, plant or not and explain the reasons.


euglena


paramecium


amoeba


spirogyra


chlorella

7. Many people want to know about mushrooms that are plant or not. Please explain correct information for them.

mushrooms

8. A pig framing uses microorganism for wastewater treatment. The owner wants to know the microorganism that is animal or not. Please help to explain correct answer for the owner.

Pig framing

bacteria

9.

This picture is Graho Fish (local name) found in Mae Klong River. People like to eat the fish because it is very delicious. This is the main cause to reduce amount of the fish nearly extinction. What impact to human and environment or not if the fish extinct from the river.

10. Students think that their community have species diversity or not and how impact in your everyday life?

11. Students think that species diversity knowledge can use to improve your community or not and How?

12. In Ratchaburi province, wildfire and agriculture main cause of deforestation. These cause have effect to species diversity or not and How?

13. Framer is the main career of people in Ratchburi province. They always have big problem about many pest to attack in their farm. They use chemical insecticides for solving this problem. Students think that this people action has effect to species diversity or not and How?

14. Ratchaburi province has many kinds of bats. The most people throught that bats are some kinds of birds and only eat fruit in their farms. Students think that the people opinions are correctly or not How?

APPENDIX B

Memory Banking

Memory Banking

Memory banking served as a tool for collecting and documenting of knowledge and socio practices that regarded to several referents; economic practices, religious practices, health practices, educational practices, and politic practices important to life in students' community (Nazarea, 1998)

Methods for Using Memory Banking

1. To define what issues are interested in community.
2. To conduct investigation and interviews with community members about issues or important organisms is found in community.
3. To collect data from investigation and interviews.
4. To conclude the data that is recorded into a memory bank chart.

Instruments

1. Notebook
2. Pencil or pen
3. Audiotape recoding
4. Camera
5. Memory bank chart

Appendix Table B 1 Memory bank chart template

Issues or important organisms					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

Memory Banking of Issues about Animals

Group…….. **Date**……

Group Members

1. Name…….....Surname…….....Class……No……
2. Name…….....Surname…….....Class……No……
3. Name…….....Surname…….....Class……No……
4. Name…….....Surname…….....Class……No……
5. Name…….....Surname…….....Class……No……

Appendix Table B 2 Memory Banking of Issues about Animals

Issue about Animals is_____					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

Memory Banking of Issues about Plants

Group…….. **Date**……

Group Members

6. Name…….....Surname…….....Class……No……
7. Name…….....Surname…….....Class……No……
8. Name…….....Surname…….....Class……No……
9. Name…….....Surname…….....Class……No……
10. Name…….....Surname…….....Class……No……

Appendix Table B 3 Memory Banking of Issues about Plants

Issue about Plants is_____					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

Memory Banking of Issues about Protistas

Group…….. **Date**……

Group Members

11. Name…….....Surname…….....Class……No……
12. Name…….....Surname…….....Class……No……
13. Name…….....Surname…….....Class……No……
14. Name…….....Surname…….....Class……No……
15. Name…….....Surname…….....Class……No……

Appendix Table B 4 Memory Banking of Issues about Protista

Issue about Protista is_____					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

Memory Banking of Issues about Fungi

Group…….. **Date**……

Group Members

16. Name…….....Surname…….....Class……No……
17. Name…….....Surname…….....Class……No……
18. Name…….....Surname…….....Class……No……
19. Name…….....Surname…….....Class……No……
20. Name…….....Surname…….....Class……No……

Appendix Table B 5 Memory Banking of Issues about Fungi

Issue about Fungi is_____					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

Memory Banking of Issues about Monera

Group…….. **Date**……

Group Members

21. Name…….....Surname…….....Class……No……
22. Name…….....Surname…….....Class……No……
23. Name…….....Surname…….....Class……No……
24. Name…….....Surname…….....Class……No……
25. Name…….....Surname…….....Class……No……

Appendix Table B 6 Memory Banking of Issues about Monera

Issue about Plants is_____					
Environment conditions	**Economic conditions**	**Education practices**	**Health practices**	**Religious practices and /or beliefs**	**Socio-cultural practices**

BIOGRAPHICAL DATA

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